

VOLUME 3
EMPLOYER'S REQUIREMENTS

Section 4 - Mechanical Works Requirements

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4. General Technical Specification for Mechanical Works

4.1 General

The following clauses shall specify general mechanical requirements and standards of workmanship for equipment and installations. These general specification clauses shall apply where appropriate except where particularly redefined in Volume III, Section 2, 'Particular Design and Process Requirements'.

4.2 Materials

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

The use of dissimilar materials in the Contract is to be avoided, but where unavoidable these materials shall be selected so that the natural potential difference between the does not exceed 250 millivolts. Electro-plating or other treatment of contacting surfaces shall be employed as necessary to reduce the potential difference to the desired limit.

All materials and material finishes shall be selected for long life under the climatic conditions at site. Materials used in ventilated or air-conditioned areas shall be selected to allow for the conditions expected in case of failure of the ventilation or air-conditioning.

4.3 Finish

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

4.4 Wrought Steels

Where not otherwise specified, wrought steel parts shall be selected from appropriate RS standards or other international recognized standards and be free from blemishes, shot or hammer marks.

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

4.5 Cast Iron

All grey iron castings supplied shall be to the appropriate grade in RS standards or other international recognized standards. All castings are to be free from blowholes, flaws and cracks.

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

4.6 Bronze

Where not otherwise specified, bronze shall be made of a strong and durable zinc free mixture to RS standards or other international recognized standards.

4.7 Aluminium and Aluminium Alloys

Due to the corrosive atmosphere, the use of aluminium or aluminium alloys requires the approval of the Engineer in all cases.

Alloys shall be of types used for marine applications where magnesium is the main addition.

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

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

4.8 Stainless Steel

Stainless steel shall be provided in accordance with RS standards or other international recognized standards.

4.9 Welding

4.9.1 General

All welding works shall be applied under most convenient working conditions, utilising modern, effective equipment and techniques and latest welding technologies. All welding shall be performed by welders qualified and experienced in the particular type of welding required. It shall be the responsibility of the Contractor to ensure that all welding operators are properly qualified and competent to carry out all required field welding.

Records of the welding procedures and welder performance qualification tests for work done shall be maintained by the Contractor for review by the Engineer.

The method and procedure adopted for welding in workshops and at site shall be approved by the Engineer before production starts.

4.9.2 Standards

Welded structures shall comply with the regulations set out in Document XV-5056E of the International Institute of Welding.

Furthermore, for the welding of carbon steel piping, RS standards shall apply or other international recognized standards, and for the welding of stainless steel piping, RS standards or other international recognized standards or Recommended Practices shall apply.

4.9.3 Welding of Carbon Steel

Manual, shielded metal-arc, submerged arc, gas metal-arc, flux-cored arc, gas tungsten arc, and other applicable welding processes and methods may be used in the construction and fabrication of welded carbon steel equipment. Prefabrication in workshop shall be used as far as possible.

4.9.4 Welding of Stainless Steel

The welding method, which shall be used, shall be the tungsten inert gas method (TIG) or the metal inert gas method (MIG) for both workshop welding and site welding. For workshop welding the metal arc, plasma method is also approved. Irrespective of the method chosen, the inner surface of the welds shall be protected by clean inert gas.

In order to guarantee high quality welded joints, piping and other quality stainless steel equipment shall as far as possible be prefabricated in the workshop.

4.9.5 Performance

The work shall be executed in accordance with the Standards and Practices referred to in the foregoing. Furthermore, for stainless steel welding the following shall be noted:

Only butt weld jointing of the pipes is allowed during the erection work.

Where butt welds are used, the penetration shall be completed, if necessary, with root run.

Backing rings shall not be used.

No surface defects reducing the corrosion resistance or discoloration of the surface will be accepted

After welding, the welds shall be carefully pickled and passivated.

The welds must be thoroughly washed in clean water after pickling and passivation.

Sand blasting will not be permitted for stainless steel.

4.10 Painting and Metal Protection

All items of equipment shall be painted or otherwise protected. The Contractor shall be responsible for bringing to the notice of all the various suppliers, the appropriate clauses concerning the painting and/or protection of their equipment.

All bright metal parts shall be covered before shipment with an approved protective compound and adequately protected during shipment to site. After erection, these parts are to be cleaned.

4.11 Chromium Plating

All chromium plating shall comply with RS standards or other international recognized standards.

4.12 Galvanising

Where steel or wrought iron is to be hot-dip galvanised, it shall be carried out by the hot-dip process and shall conform in all respects with RS standards or other international recognized standards.

Attention shall be paid to the detail of members in accordance with RS standards or other international recognized standards. Adequate provision for filling, venting and draining shall be made for assemblies fabricated from hollow section. Vent holes shall be suitably plugged after galvanising.

All surface defects in the steel including cracks, surface laminations, laps and folds shall be removed in accordance with RS standards or other international recognized standards. All drilling, cutting, welding, forming and final fabrications, unit members and assemblies shall be completed before the structures are galvanised. The surface of the steel work to be galvanised shall be free from welding slag, paint, oil, grease and similar contaminants. The articles shall be pickled in dilute sulphuric or hydrochloric acid following by rinsing in water and pickling in phosphoric acid. They shall be thoroughly washed, stoved and dipped in molten Zinc and brushed, so that the whole of the metal shall be evenly covered and the additional weight thereof after dipping shall not be less than 610 grammes per square metre of surface galvanised, except in the case of tubes to RS standards or other international recognized standards when it shall be 460 grammes per square metre.

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

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

During off-loading and erection the use of nylon slings shall be used. Galvanised work which is to be stored in the works or on Site shall be stacked so as to provide adequate ventilation to all surfaces to avoid wet storage staining. Small areas of the galvanised coating damaged in any way shall be restored by: Cleaning the area of any weld slag and thoroughly wire brushing to give a clean surface. The application of two coats of zinc-rich paint (not less than 90 per cent zinc, dry film), or the application of a low melting-point zinc alloy repair rod or powder to the damaged area, which is heated at 300°C.

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

4.13 Bolts, Nuts, Washers and Jointing Materials

All nuts and bolts shall be threaded in accordance with RS standards or other international recognized standards " and tolerances for materials coarse pitch threads" and fitted with 3 mm thick washers beneath bolt and nut.

All bolts, nuts, washers and anchor plates, except high tensile, for all ferrous parts shall be steel galvanised to RS standards or other international recognized standards, primed and painted after assembly and tightening.

All bolts, nuts, washers and anchor plates, for fastening galvanised components or aluminium alloy components shall be of stainless steel Grade according to appropriate RS standards or other international recognized standards and shall remain unpainted. PTFE washers shall be fitted beneath stainless steel washers for both bolthead and nut.

All bolts, nuts, studs and washers used in the construction of pumps shall be stainless steel.

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

All holding-down and anchor bolts, nuts, washers and anchor plates for use internally in areas not subject to contact with water or sewage shall be steel galvanised and all exposed surfaces shall be painted after assembly and tightening.

Drilled anchor fixings for use on concrete structures shall be of a chemical type approved by the Engineer. The positions of all drilled anchors in existing structures shall be approved by the Engineer and any Contractor proposing to use such fixings shall be deemed to have undertaken to supply, mark off, drill and fit.

All exposed boltheads 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 a half diameter of the bolt.

All jointing material shall be provided.

4.14 Foundations, Builders Facilities and Setting of Machinery

The Contractor shall ensure that the positions of foundations for machinery plinths, holding-down bolts and the setting of machinery are in accordance with the approved machinery drawings.

The Contractor shall, upon receipt of the necessary approved drawings for the machinery, carry out excavation work and the construction of all the necessary foundations and bases for the various items of plant, including the forming of holes and chases for pipework, steelworks, cabling, conduit, ragbolts and where necessary, the building-in of foundation bolts and sundry items of plant, all in accordance with the drawings. Spaces shall be left between the concrete and bedplates etc. for grouting and building-in.

The Contractor shall provide all necessary templates for fixing the positions of bolt holes, etc.

The machinery shall be mounted on flat steel packings of a thickness selected to take up variations in the level of the concrete foundations. The packings shall be bedded by chipping or grinding of the concrete surface.

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

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

The Contractor shall clean and generally make good the concrete and apply grout as appropriate once the pumps, motors, girders, etc. have been finally fixed and packed up.

4.15 Location and Alignment

Where separate items of interconnected plant, such as motors, couplings, gearboxes and similar items depend upon correct alignment for satisfactory operation, then each and every item shall be positively located in its correct position.

4.16 Steelwork General Requirements

The Contractor shall provide and fix all necessary steelworks, including platforms, gangways, stairways, ladders, hand railing, chequer plate and open mesh flooring, frames and curbing.

All steelworks shall be constructed in mild steel and shall be hot-dip galvanized after manufacture, except where otherwise specified.

All platforms, galleries and stairways necessary to permit proper access to the Plant for operation and maintenance, shall be provided and installed by the Contractor.

For all prefabricated metalwork, including multiple duct covers, external ladders, open mesh flooring, chequer plating, handrailing, staircases, structural steelworks and the like, the Contractor shall submit fabrication drawings for the approval of the Engineer prior to the manufacture of any of these items.

All steel shall be compliant with valid RS standards.

4.16.1 Handrailing

Handrailing shall be of galvanized mild steel hollow section. Handrailing shall include galvanized mild steel toe plates, 100 mm high by 3 mm thick positioned 10 mm above the platform level and fixed securely to the stanchions.

Stanchions and handrails shall not be less than 32 mm in diameter.

Horizontal handrails shall be 1100 mm high with an intermediate rail at a height of 550 mm. Handrail height shall be measured vertically from finished floor level to the handrail centreline.

Handrailing and fixings shall be designed to withstand a horizontal force at handrail level of 740 Newton per metre run. The deflection of rails shall not exceed 0.8 per cent of their span between stanchions and the deflection of stanchions shall not exceed 0.8 per cent of their height.

Sloping handrailing shall be as specified for horizontal handrailing but with the top rail 900 mm vertically above the line of pitch and stanchions vertical and spaced at not more than 1500 mm measured parallel to the line of pitch.

All mounting flanges shall be of a substantial construction, with horizontal flanges drilled for not less than three bolts with two bolts on a line parallel to and on the walkway side of the line of the handrailing and vertical flanges drilled for not less than two bolts the lines through the bolts being vertical. The stanchions shall be set at not more than 1500 mm centres. When provided in sections, handrailing shall be joined together with purpose made fittings secured by screws or grub screws.

All ladders, stairways or other openings shall be guarded using handrailing as appropriate. Access to ladders or openings shall be guarded by two galvanized hanging chains, which shall be secured at one end and detachable at the other.

The Contractor shall ensure that unless specified to the contrary all handrailing shall be of uniform appearance and manufacture.

Working drawings of handrailing shall be submitted by the Contractor for the approval of the Engineer.

4.16.2 Open Mesh and Chequer Plate Flooring

Open mesh flooring and gratings shall generally comply with RS standards except where specified otherwise. Such flooring and gratings shall be of rectangular mesh and 'non-slip' design and shall be mild steel and hot-dip galvanized off-site after manufacture.

Flooring shall be provided to span between the supporting members. Where necessary intermediate support members shall be provided and fixed.

Toe plates shall be provided around all cut-outs except where otherwise ordered by the Engineer.

Both the load bearing and transverse bars in rectangular flooring panels shall be positioned symmetrically around the centre lines of the panels in both directions, so that when the panels are fixed in extensive areas or in long runs, the bars of all panels are in line.

Chequer plate flooring shall be of the non-slip type, not less than 6 mm thick measured excluding the raised pattern.

The flooring shall be secured to its frame by stainless steel countersunk set screws.

All flooring shall be designed to carry a loading of not less than 400 kg per square metre and the deflection shall not exceed 0.2 per cent of the span and shall be provided with curbing at the edge of walkways.

All flooring shall be removable and set flush in frames of similar material. Where frames are to be fixed over openings the frames shall be provided with lugs for building-in.

Flooring shall be provided in sizes suitable for lifting and removal by one man and with the appropriate cut-outs to permit its removal without disturbing or dismantling spindles, supporting brackets, cables or pipework. Intermediate supporting members to give the required rigidity to the spanning edges of individual flooring sections over the wider openings and trenches shall be provided and bolted to suitable built-in fixings.

The members shall also be removable to afford clear access to the openings and trenches. The cost of these supporting members and fixings shall be deemed to be included in the Contractor's rates and prices.

Lifting keys shall be supplied for each location where regular lifting is to be undertaken.

4.16.3 Stairways

Stairways shall be detailed, fabricated and erected to the dimensions shown on the drawings and in accordance with RS standards or other international recognized standards to carry a load of 400 kg per square metre. Treads shall be open mesh fixed to the stringers, not directly to concrete.

Staircases shall be steel hot-dip galvanized off-site after manufacture and shall comprise stringers supporting the stair treads and shall be supplied complete with handrails and stanchions.

4.16.4 Ladders

Ladders shall be fabricated of mild steel and hot-dip galvanized at works after manufacture. The stringers shall be flat section not less than 65 mm x 13 mm spaced 380 mm apart and shall be flanged and drilled for wall fixing at both ends. The stringers shall be radiused over the top where they shall be not less than 600 mm apart. Ladders over 3,000 mm long shall have additional intermediate stays at not more than 2,500 mm centres.

Rungs shall be 25 mm diameter solid at 300 mm centres shouldered at each end and securely riveted into countersunk holes. Rungs shall be not less than 225 mm from the wall.

All ladders shall have safety cages, which shall be constructed of three flat vertical strips supported by flat hoops, with a diameter of 750 mm. The hoops shall be at approximately 700 mm centres and the first hoop shall be 2400mm above ground or platform level.

Where the rise exceeds 6,000 mm an intermediate landing shall be provided.

4.17 Pipework

Pipes, fittings and flanges shall be of the flexible joint type scheduled in this Specification or on the Drawings and shall comply with the appropriate Standards and for adequate pressure classification.

Flexible joints between pipes having integral sockets shall be formed by a shaped rubber gasket fitted within the socket or by a rubber of circular cross section (O-ring) placed on the pipe spigot. The type of flexible joint to be used shall be subject to the approval of the Engineer.

4.17.1 Transport and Storage

During transportation, the Contractor shall ensure that any precautions specified by the manufacturer of materials, plant and equipment for handling of their products are strictly adhered to.

The vehicles on which pipes are to be transported shall have a body of such length that the pipes do not overhang. This is particularly applicable to HDPE pipes in 6m or 12 m lengths.

During handling, the pipes shall not be dropped or allowed to strike one another or be rolled freely down inclines and they shall not be dragged on the ground.

All materials, including couplings and joints which are likely to deteriorate or be damaged by exposure of the elements, shall be stored in weatherproof building.

Pipes shall be stacked lengthways, clear of the ground and to a height of 2.0m or less having regard to the recommendation of the Manufacturer and the adequacy of the Contractor's stacking arrangement. The first layer shall be placed on a firm foundation of timber set level and the pipes firmly anchored to prevent spreading. Subsequent layers shall be placed using timber spacers. Timber spacings and nests shall be such that pipe flanges or sockets do not take any load.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the works.

Sufficient space shall be left between stacks to enable plant to pass between without causing damage to the pipes.

Each consignment of each material shall be stored separately so as to provide easy access for inspection. After they have been approved by the Engineer, consignment shall be used in the order in which they were delivered on Site.

4.17.2 Stainless Steel Pipes

Materials and Dimensions

The material shall comply with following standards:

- Stainless Steel: AISI 304 or corresponding (e.g. EN 10088-1...2, DIN 17006 WS No. 4301, SFS-EN 10088-2 - 1.4301);
- "Acid Proof" Steel: AISI 316 or corresponding (e.g. EN 10088-1...2, DIN 17006 WS No. 4436, SFS-EN 10088-2 - 1.4436).

The outside diameters shall comply with ISO-standards. In the following table the wall thicknesses (r = mm) are indicated for operation pressure under 1.0 MPa in standard applications for pipes and associated appurtenances:

DN	D	Pipe	Elbow	Reducer	T/main
40	48.3	1.6	2.0	2.0	1.6
50	60.3	1.6	2.0	2.0	1.6
65	76.1	1.6	2.0	2.0	1.6
80	88.9	1.6	2.0	2.0	1.6
100	114.3	2.0	2.0	2.0	2.0
125	139.7	2.0	2.0	2.0	2.0
150	168.3	2.0	2.0	2.0	2.6
200	219.1	2.0	2.0	2.0	3.2
250	273.0	2.6	2.6	2.0	4.0
300	323.9	2.6	3.2	2.6	5.0
350	355.6	2.6	3.2	2.6	5.0
400	406.4	2.6	4.0	3.2	6.3
500	508.0	4.0	5.0	4.0	8.0
600	610.0	4.0	6.3	5.0	10.0
700	711.0	5.0	6.3	6.3	10.0
800	813.0	6.3	8.0	6.3	12.5

For pipework where the occurrence of vacuum is anticipated or where the working pressure exceeds 0.6 MPa, the wall thicknesses shall be calculated individually according to the instructions for standards of the pressure vessels. The elbows for dimensions greater than DN 300 may be manufactured from pipe segments. For pipes DN 300 and smaller pressed elbows shall be used.

Tees shall always be factory made or produced with a collaring draw method. Extra welding joints shall be avoided by selecting and adjusting the tees to fit in pipework lengths. Small branches D:d = 4:1 and smaller may, however be manufactured on site without a collar.

Joints

The joints in the pipework shall be made by welding or with weldable collars and flanges, avoiding threaded joints. The threaded joints shall in any cases be limited to sizes DN 50 and under.

The flanges and collars shall be as follows:

Collars:

- Pressed collars may be used in pipework dimensions below DN 200 with pressures up to 1 MPa and/or dimensions below DN 400 with pressures up to 400 kPa;
- Collars formed of angle iron shall be used with pipework from dimension DN 200 or greater with pressures above 400 kPa;
- Smitten and formed collars or welding rings shall be used exclusively in pipework dimensions DN 200 or greater and pressures above 400 kPa.

Flanges:

- Galvanised steel flanges shall be used exclusively for dimensions DN 300 and greater;
- In the underground applications the loose flanges shall be of hot dip galvanised steel, painted with bituminous epoxy paint, two layers thickness 250 µm, metal surface cleaned of grease and dust with metal conditioner;
- If so requested by the Engineer the smaller size joints may also be equipped with galvanised steel flanges.

With actual pressures above 1 MPa and/or pipe dimensions over DN 800, the flanges shall be dimensioned according to EN1591-1.

With collars pressed of steel plate the gaskets shall be manufactured of canvas reinforced rubber, thickness 3 mm, in other applications rubber gaskets thickness 2 mm shall be applied.

The bolts and nuts in climatic stress application shall be of hot dip galvanised steel. Bolts and nuts shall conform to ISO-standards and the washers shall be of the same material same as bolts. The excess length of bolt in readily tightened joint shall be at least 1 mm (M 4 bolt) to 6 mm (M 8 bolt) and at most as long as the thickness of the bolt.

The hot dip galvanised flanges installed in climatic stress shall not be painted if not instructed by the Engineer.

The blind flanges shall be of hot dip galvanised steel and be equipped with liner insert against the medium manufactured of the same material as the pipe.

4.17.3 Cast Iron Pipes

The cast and ductile iron pipes and fittings shall comply with the relevant requirements (including grey cast iron and ductile iron). Flanged pipes and fittings shall be of at least pressure class PN 10, flanges according to relevant requirements.

The pipes and fittings shall be internally and externally hot bitumen coated and externally painted once over with matching primer for requested paint combination. The through pipes for concrete walls shall not be painted for the part remaining in the concrete. The inside of the pipes in underground pipelines shall be additionally cement mortar coated.

Gaskets and bolts as with stainless steel pipes. In underground and submerged application the bolts and nuts shall be painted once with epoxy bitumen after installation.

4.17.4 Plastic Pipes

Reference Standards

Unless otherwise specified, pipelines shall comply with the relevant Serbian Standards. The appropriate international standards may be used if they are compatible with or better than the existing Serbian Standards, with the prior approval of the Engineer

Standard	Subject
EN 681	Elastomeric seals for joints in pipework and pipelines.
EN12200	Polythene pipe for cold water services.
EN1452	uPVC pipes for cold potable water.
ISO11922	General requirements for dimensions and pressure ratings for pipe of thermoplastics materials.
EN ISO 8502	Part 0, Preparation of steel substrates.
EN 14161	Part I, Code of Practice for pipelines: Pipelines on land, general.

4.17.5 Not plasticised Polyvinyl Chloride (uPVC) Pipes

All uPVC pipes for sewerage purposes shall comply with relevant standards.

4.17.6 High density polyethylene pipes

High density polyethylene pipes (HDPE) shall be used for the construction of pipelines. These pipes shall be manufactured in accordance with standards defined in the Main Design and technical specifications.

4.17.7 Installation and Supporting

The supports of the pipes included in the Contract, which shall be installed into the tanks or alike to submerged stresses shall be constructed of stainless steel.

The supports shall allow the stripping down of valves and appliances without dismantling the supports.

The relevant regulation shall be observed on applicable parts:

- Pipe clamps and their billets;
- Hanging supports;
- Sliding supports, clamp forms and number plus c/c distance and dimensions of slide;
- Principle of fixed support with references to other standards. For stainless steel pipes the possible reinforcement of pipe surrounded by fixed support and axial fixing plates shall be calculated on a case by case basis.

The maximum distances between the supports for different dimensions for stainless and mild steels are presented in following table:

DN [mm]	c/c distance [m]
40	2.5
50	2.7
65	3.0
80	3.5
100	4.0
125	4.5
150	5.0
200	5.5
250	6.5
300	7.0
350	8.0
400 and greater	8.5

4.17.8 Polyethylene fittings

Polyethylene fittings to be supplied shall be of the electrofusion types and shall be as described below:

- Polyethylene electrofusion fittings shall have embedded heating coils with contact terminals or shall alternatively be supplied with electrofusion couplers;
- The fittings shall have deep insertion lengths with a wide fusion zone and a cold zone in the centre or shall alternatively be supplied with electrofusion couplers. They shall also have fusion indicators;

- The fittings shall be made of high density polyethylene and be of black colour to withstand 16 bars test pressure i.e. a nominal 10 bars pressure. They shall also have high tensile and compressive strengths with a density of approximately 0.9 g/cm³ at 23°C. Their melt index shall be within the range of 0.4 to 1.3 gm/10min. i.e. MFI 190/5 within the melt flow index groups 005 and 010;
- The fittings shall have a bar code label which can be read by the electrofusion equipment. They shall be compatible for electrofusion with HDPE pipes with melt flow index groups voltage within the range of 16 volt to 48 volt to suit the electrofusion welding equipment owned by the Public Utilities Corporation;
- Tapping tees shall be suitable for electrofusion on live mains with a metal threaded drive cutter of limited cutting depth to protect the opposite pipe wall from damage. The cutter shall also allow the disc cut from the pipe wall to be retained in the cutter and shall not produce debris while cutting through the pipe wall;

Electrofusion tapping tees and branching saddles shall comprise a lower half and upper half under and over the pipe bolted together prior to electrofusion.

4.17.9 Fitting of pipes, formative parts and survey manholes

Pressure polyethylene pipes are laid on sand or concrete bed.

There are two types of connecting polyethylene pipes:

- separable and
- inseparable connection

Separable connections are:

- connections with flange polyethylene tube and free flange;
- connections with tooth coupling and free flange;
- connections with grey cast collar;
- connections with tooth coupling, type SL 900.

Inseparable connections are welded connections.

Connecting with tooth coupling and free flange is to be applied when connecting PE smaller profile pipes to the water supply network. The pipe end gets aligned perpendicularly to the axis by fine saw and knife. Then a free flange is fixed on the pipe. After that the tooth coupling is drawn on to the end of the pipe by means of a device.

The pipe end on which the coupling is drawn must not be warmed-up or lubricated with anything. Pipe ends prepared in such a way are connected by means of flanges between which a rubber gasket is inserted. At the end the bolts' nuts are tightened, in turns, to the prescribed strength. Water-supply armatures are connected to PE pipes in the same way.

Pipes connection by means of flange tube of PE and free flange is executed in larger profiles. First the flange has to be fitted on the end of the pipe.

The end of the pipe and the flange tube have to be fixed to the welding device. The ends to be welded are then treated in a special way, warmed up and welded together by pressing. Between the two prepared ends of the pipe a rubber basket is inserted and the flanges are tightened by means of bolts with nuts. Armatures with flanges may be connected to PE pipes in the same way.

Connecting PE pipes by welding in an inseparable connection is applied in canals that are influenced by groundwater or sea water. The mutual connecting of such sections is performed by separable connection by free flange and PE flange tube. The connection of the pipes is carried out in the excavated ditch itself.

The connections' welding is performed by means of hot air, similar to metal burner-welding or by means of a special device. The second way is much safer and more precise. Generally light portable devices are used on the spot. The welding process itself consists of stages, levelling of the surfaces to be connected to the same height before warming up, warming-up by means of a warming-up element with Teflon surface, quick removal of the warming element and connecting of the warmed surfaces by pressing (15 N/mm^2 force).

The pressing lasts until the welded spot cools down normally. Warming and cooling times are prescribed depending on the pipe profile. Warming up of connection surfaces is performed at a temperature of about 200°C , while welding may be carried out at external temperatures ranging from 3° to 30°C . The pipe ends must be protected from direct sun heating for a length of about 2 m, in order to achieve a uniform temperature throughout the pipe's circumference.

PE shaped pieces may be welded to polyethylene pipes, while connecting of cast-iron pieces and armature is carried out by means of free flange and tube. After connecting, the pipeline section is laid down in the excavated canal. PE pipes have a relatively high dilatation coefficient at temperature changes, so that in longer sections it is necessary to lay the connected pipeline in the canal in a winding manner, if the temperature is expected to fall after covering up. After the pipeline is laid on the lower part of the bed the medium and upper part of the bed is executed and the remaining part of the canal is covered up.

Covering up must be performed in layers with the required compaction. The connected pipes that are covered up in a land canal must have uncovered connections until the entire pipeline's water tightness pressure testing is successfully performed.

The PE pipes' flexibility enables the laying of the pipeline in a mildly winding fashion in canals excavated in difficult rocky areas, when there are problems to excavate the designed canal. The minimal allowed pipeline bending radii depend on the pipe's selected diameter and pipe walls' thickness (foreseen working pressure for the pipeline):

- pipeline for work pressure of 6.0 bars, $R > 20 \cdot D$,
- pipeline for work pressure of 10.0 bars, $R > 20 \cdot D$.

In the course of works execution in the canal, the open end of the pipe must be protected by a special stopper to prevent the entry of earthen material or anything else. In case of pipe laying in a canal filled with groundwater each laid pipe must be additionally protected against the up-lift force.

Pipes connections to the HDPE manhole may be executed on the spot envisaged for that purpose at the bottom of the manhole or by execution of an additional connection. Details of this execution and of additional connections are given in the drawings. Connecting to the HDPE manhole must be executed by fitting of a gasket and pipe connection to openings envisaged for that purpose.

Pipe connections to the manholes depend on the way in which the manholes are configured. Connection to manholes with plastic inserts must be carried out by sticking the pipe directly into the plastic insert. Connecting to the concrete manhole must be achieved by building a special HDPE insert in the manhole wall. This insert has a HDPE ring welded which enables a better connection with the concrete wall and ensures its impermeability.

All route interruptions where arched formative parts, pipeline endings and branching are built-in, must be specially anchored by concrete anchoring blocks for the absorption of longitudinal forces.

Impermeability testing of the pressure sewage system formed by sewage HDPE pipes and manholes is performed according to Serbian standards adjusted to soil conditions.

The test section length depends on the topographic features, i.e. the length is defined by the difference in height between the lowest and the highest point of the tested pipeline.

4.17.10 Flanged adaptors

Flanged Adaptors shall be polyethylene except when specified and can be safely electrofused with electrofusion couplers. The length of the adaptors shall therefore be sufficient to allow proper fusion widths.

Relevant clauses of the Specifications for Polyethylene fittings shall also apply.

The flange adaptors shall be compatible with the steel flange complying with Serbian standards.

4.17.11 Mechanical joints for HDPE pipes

Notwithstanding Clause above, mechanical joints may also be used for converting HDPE pipes of larger diameter (i.e. as from 160mm diameter). The Contractor shall in this respect follow the instruction of the Engineer.

The fitting itself shall be designed and manufactured for the aforesaid nominal pressure. These joints shall be manufactured in accordance with ISO S8.

4.17.12 Flanges and bolting for pipes, valves and fittings

Flanges and bolting for pipes, valves and fittings shall all be to Serbian Standards or to any other standard specified in the design, provided that they are each compatible with the other for the purposes of jointing like-sized components and are such that corrosion by galvanic action shall be avoided. Unless otherwise specified the rating and test pressure of the flanges shall not be less than the rating and test pressure of the pipeline.

4.17.11 Bolts, nuts and washers

Black hexagonal bolts and nuts and flat washers shall be according to Serbian Standards or other standard approved by the Engineer.

4.17.13 Gaskets and joints rings

Gaskets and Joints rings shall be manufactured from natural or approved synthetic rubber conforming to Serbian Standards.

Flanged joint gaskets shall be the inside bolt circle type, unless specified otherwise, and shall comply with Serbian Standards.

4.17.14 Flexible couplings and flange adaptors

Flexible couplings for steel and cast iron pipes and flange adaptors at Valves suitable for use with water at a maximum temperature of 40°C and for the appropriate pipes test pressure.

Flexible couplings and flange adaptors exposed in chambers shall be protected internally and externally with an approved nylon or epoxy coating to minimum thickness 250 microns. Bolts and nuts shall have similar coating or be in stainless steel to Serbian Standards. Buried couplings shall be protected by approved molten bitumen moulding or paste and tape wrappings.

4.18 Valves

4.18.1 Assembly of equipment and protection

Except where otherwise specified all valves and generally all pipeline equipment shall be completely assembled at the manufacturer's workshop as no item shall be imported as unassembled components. They shall have also received their complete protective coatings before despatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection against corrosion and accidental damage.

Except as otherwise specified or approved, valves shall be of double-flange cast iron construction and shall be designed and tested to the declared Standard Specification and as a minimum shall comply with the relevant provisions of the appropriate Standards detailed below,

Table 1. Valve standards

Type of valve	ISO	DIN	BS
Cast iron gate valves	5752	3202	5150
Cast iron gate (parallel slide) valves			5151
Cast iron check valves		3202	5153
Butterfly valves	5752	3202	5155
Diaphragm valves			5156

4.18.2 Installation, operation and maintenance manuals

The Contractor shall supply the Engineer for all materials, plant or equipment, all the manuals and drawings describing the recommended procedures for their assembling, dismantling, installation and operation. These documents shall give their dimensions, weight and space required for operation and maintenance of the said plant and equipment. The operation and maintenance manual shall also be submitted by the Contractor to the Engineer.

A draft of these documents shall first of all be submitted for approval by the Engineer one month prior to installation on Site. After approval by the Engineer, the Contractor shall submit within two weeks three copies of the approved documents suitably bound under hard cover to the Contracting Authority and two further copies to the Engineer.

Gear operations shall be provided in the following sizes or larger, unless otherwise specified:

Table 2. Gear operations

Class	Gate valve	Globe valve	Ball valve	Butterfly valve
PN6	350 mm	300 mm	200 mm	200 mm
PN16	300 mm	250 mm	200 mm	200 mm
PN64	250 mm	200 mm	-	150 mm

Where gearing is required for operation the gears shall be machine cut and shall be fully enclosed with external greasing points.

4.18.3 Gate or section valves

Unless otherwise specified by the Engineer, gate valves shall be double flanged and manufactured in accordance with Serbian or other equivalent approved standard and shall be of the wedge type. All valves shall have a drain plug, and easing screws shall be fitted on all sizes above 200 mm nominal diameter.

The valves shall have inside screw spindles and shall close clockwise. The spindle shall be shouldered to allow repacking of the gland whilst the pipeline remains in service.

The spindle shall be made of stainless steel at least equivalent to X20 C13. The wedge gate shall be solid and the wedge facing rings and body seats shall be made of stainless steel or alternatively of bronze or gun-metal.

The valves which are to be installed in the ground shall be of the double flanged type with fully enclosed gearing and operating mechanism and shall be so designed that no bolts, nuts, etc, are exposed to the soil and shall be in stainless steel in accordance with Serbian or other norm specified in the design.

The valves which are to be directly installed in the soil shall be provided with surface boxes which can withstand a 10 tonne load and shall be supplied complete with protection tube, extension spindles and accessories at no extra charge. The extension spindles and protection sheath shall be of such a design that, if necessary, cutting to the true total length is possible. The surface boxes, protection sheaths and extension spindles shall be protected from corrosion by a 150 micron coating of bitumen epoxy.

The extension spindles shall be equipped with square headed key handles with dimensions of 19 mm x 19 mm for all sizes of valves.

The valves to be installed in chambers shall be supplied with either a cast iron or malleable iron hand wheel.

The valves to be installed directly in the ground shall be supplied with cast iron caps and one solid forged valve tee key for every five valves to be installed.

The flanged valves shall be supplied with flange adaptors and connecting bolts and nuts at no extra charge where specified or required.

The Contractor shall submit to the Engineer the manufacturer's certificate which shall show that the valves and their components comply with the above specified requirements.

The minimum nominal pressure rating shall be PN 16 or higher as specified by the manufacturer and flanges and drilling shall be to Serbian Standards.

4.18.4 Air valves

Air valves for automatically exhausting or admitting air from and into pressure pipelines are specified on the Drawings. The orifice of these valves shall allow large volume of air to be released during pipe filling and admit large volumes of air into the pipeline during emptying.

The orifice of the air valves shall be designed to prevent premature closure whilst air is being released from the pipeline. The floats shall be made of rubber-coated carbon steel.

The valves shall be fitted with a gauged outlet orifice designed to prevent water hammer resulting from the sudden filling of the drained air pocket by the flow of water.

The valves must allow the evacuation of small volumes of air that can accumulate at the highest points of the pipeline during normal operation.

All the air valves shall be fitted with an isolating valve to allow safe dismantling during operation.

The Contractor shall indicate in writing to the Engineer the manufacturer's recommended diameter of the pipes on which each size of air valve can be mounted. The dimensions given on the drawings are indicative of the recommended sizes and do not prejudice the manufacturer's recommendations which shall prevail.

4.18.5 Non-return valves

The non-return valves shall be double-flanged and made of a corrosion resistant material. They must be designed and manufactured to prevent the return of fluid in a direction opposite to the normal flow direction.

The non-return valves shall be watertight when closed and, when open the fluid shall flow through the valve without turbulence. The operation shall be silent. If flat type valves are supplied, special care shall be taken to check the closure time and the head loss of the valves.

The non-return valves shall be fitted to the pipeline by means of dismantling joints which shall be supplied free of charge with the valves.

4.19 Electromagnetic flow meters

Electromagnetic flow meters shall comply with the requirements of Serbian Standards. They shall operate on electromagnetic induction principles and give an output signal directly proportional to the liquid rate of flow. Each meter shall have a stainless steel metering tube (detector head) and a non conductive liner suitable for potable water. The detector head shall be complete with corrosion resistant earth rings.

The primary flow head shall be suitable for continuous submersion up to a water head of 3m to Serbian Standards and be IP 68 or better. The primary flow head shall have removable electrodes for cleaning without stopping the flow.

The signal converters shall have enclosures to IEC 529; IP 65 or better. The measuring range shall be continuously adjustable from 1 – 9.99 m/s with an option to change to 0.5 – 5 m/s for high accuracy measurement of low flows.

At any time, flow rate in cubic meters / hour and total volume in cubic meters shall be displayed. The total volume and mean flow rate shall be logged and stored on an hourly basis for a period of up to 3 months and the data shall be downloaded to a Personal desktop or laptop computer through a handheld battery powered data logger. All software and equipment associated shall be delivered on commissioning of the system. Power requirements shall be specified at tendering stage by the tenderers.

The accuracy of flow measurement for any flow rate within the range specified shall be +/- 0.5% for water at a temperature up to 35°C.

4.20 Pressure and Vacuum Gauges

Gauges shall be provided for all pumps on the pressure side and on blowers on the suction and pressure side or as shown on the Drawings and for all other equipment where necessary.

Pressure and compound gauges of approved manufacture with an accuracy of $\pm 2\%$ shall be provided and fixed directly to and at the same level as the delivery and suction branches of each dry well pump. The gauges shall be fitted with diaphragm type isolating valves and with siphon pipes. Gauges shall not be connected to air release or auxiliary suction pipes.

All gauges shall have concentric dials of 150 mm in diameter, pressure gauges being graduated in metres head, and compound gauges in cm of mercury and metres head. Gauge graduations shall be such that the gauge is never used continuously beyond 60 per cent of the maximum graduation. The face of the dial shall have a warning label marked in red attached thereto reading in the project country language: "IMPORTANT: TURN OFF WHEN NOT IN USE".

The gauge mechanism shall be of the Bourdon tube type, having stainless steel movements and shall comply with RS standards or other international recognized standards. It shall be sealed from the liquid being measured by means of a diaphragm or capsule and be filled with silicon oil.

All gauges shall be fitted with a pressure snubber to dampen pressure pulsations.

Before the gauges are delivered to site, each gauge shall be tested in accordance with BS 1780 or other international recognized standards and a test certificate for each gauge, confirming that they are of the required accuracy, shall be sent to the Engineer. Further copies of the test certificates shall be incorporated in the operating and maintenance manuals.

4.21 Flexible Shaft Couplings

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

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

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

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

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

All couplings shall be fully checked for alignment and all necessary equipment for checking alignment shall be supplied by the Contractor.

Particular attention shall be paid to achieving accurate alignment of solidly bolted couplings and the Contractor's proposed alignment procedure shall be to the approval of the Engineer. In particular, alignment procedures which involve rotating only one half coupling will not be accepted. The coupling alignment procedure shall include a final check in the "bolted-up" condition for "cranking".

Where flexible couplings are used, the Contractor shall fully describe the arrangements proposed for ensuring that the desired freedom of relative movement between the shafts is obtained, when transmitting a torque corresponding to the continuous maximum rating.

Final alignment shall be checked by the Contractor in the presence of the Engineer.

4.22 Lifting Equipment

4.22.1 General

Lifting gear and associated equipment shall comply in general with RS standards or other international recognized standards, and the equipment and the installation shall be approved by the National Inspection for Lifting Devices.

The assemblies shall be suitable for lifting the heaviest single item of equipment within the working area. The load hook, incorporating a ball swivel joint, shall extend to within 1.0 m of the lowest working level, whilst sufficient headroom shall be allowed below the crane hook to enable the tallest item of machinery to clear the motor floor level by 1.0 m.

4.22.2 Travelling Cranes

Cranes shall be designed with a lifting capacity of not less than 20% more capacity than the heaviest single part of the plant and a lifting height of approximately 4m above working floor level. The ultimate lifting capacity and height shall be determined during the design liaison in compliance with equipment to be delivered and the civil works.

Separate drives for lengthwise and lateral motion of the lifting gear and for the lifting movement shall be incorporated.

The local switch box/control unit for the crane is also part of this item. Drives and all electrical equipment with overload protection and end limit switch.

Travelling cranes shall be manually or electrically operated and include travelling bridge, crab and hoist, electrical motor gears and plant where applicable, operation and maintenance instructions and all other necessary items like bolts, buffers, fixings, etc. Cranes, if electrically operated, shall be supplied complete with flat cables on roller suspensions, controls and motorgears giving speeds in both horizontal directions of 15/5 m/min. The hoisting speed shall be approximately 2 m/min with crawling speed of 0.2 m/min.

Safety devices such as fuses, relays for overloads and limit switches, alarm bells, etc. as well as the main switch for the crane shall be located in a separate cabinet. This cabinet shall also house the transformers for the control circuits and the fuses.

The maximum load of the crane shall be marked on the crane with painted figures in Serbian language easily readable from the floor.

All cranes' details will be subject of the Main Design, site organization design and H&S report, properly installed, tested and checked.

Before handing over to the Beneficiary, the crane shall be tested with a load of 125% of the maximum marked load in accordance with the applicable standard.

4.23 Pumping Equipment

4.23.1 General

The whole of the pumping works, machinery and apparatus shall be new and of first class manufacture. For the purpose of the Contract, the following definitions shall apply:

- a) "Design point of performance" - means the total head developed between the pump unit inlet and outlet connections.
- b) "Static head" - means the difference between the free water surface level on the suction side of the pump and the delivery level.
- c) "External works friction head" - means the head required to overcome friction external to the pumping station and velocity head at the outlet of the pumping main.
- d) "External works losses" - means the friction and turbulence losses in all pipework and valves included in the pumping station beyond the pump delivery flange.
- e) "Internal works turbulence losses" - means the friction and losses in the pump and suction pipework up to the pump delivery flange.
- f) "Total head" - means the sum of (b), (c), (d), and (e).
- g) "Net effective lift" - means the sum of (b) and (c).

Characteristic and system curves for the pump against the various static heads to a reasonably large scale, shall be supplied with the tender and when tested through their complete range of workable heads at the manufacturer's works, the pumps shall give results which conform to the said curves. The curves shall also show pump efficiency and kW loading. Pump testing to be carried out according to regulations as set out by the German Hydraulic Institute (or equal).

Where pumps are working in parallel curves for solo operation all the various possible parallel combinations shall be submitted. It should be noted that under solo operation the pump output will increase owing to the pump and system characteristics and the pump shall operate satisfactorily for long periods under these conditions without motor overloading.

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:

- a. When the pipework is new and in good condition;
- b. When the pipework is older;
- c. The full range of static heads occurring in the works;
- d. The various possible combinations of parallel pump operation.

Where possible the pumps shall be positioned so that a positive suction condition is obtained within the full curve of operation. The net positive suction head required (NPSHR) curve for the full range of operation shall be submitted which shall be compatible with that available to enable the pump to operate, without cavitations over the full range of flows at all liquid levels.

The design speed of any pump shall not exceed 1,500 rpm. The pump unit assembly design and the method of supporting rotating assemblies shall ensure that no unit or shaft operates at a speed within 25 % of any critical speed.

The rotating parts of each pump shall be supported by substantial bearings. The design shall be such that no thrust is transferred from the pump to the motor shaft where these do not form an integral unit. The combined thrust and journal bearings shall be capable of reverse rotation at 150 % of full forward speed.

Dry installed pumps shall be equipped with double acting mechanical seals with sealing water /sealing liquid connection and shaft sleeve. Submersible pumps shall be equipped with double acting mechanical seals with leak detection sensor in the oil chamber between the two seals. All mechanical seals shall be of material SiC/SiC. Where shafts are susceptible to wear at bearings and glands, renewable sleeves shall be fitted. Wear rings and bushes shall be fitted to the casing and impeller at the points of running clearance. Where sealing and lubricating water is supplied to bearings and glands, it shall be free from suspended solids and the associated pipework shall be fitted with air release cocks and flow indicators.

Each pump shall be complete with all necessary ancillary equipment and fittings to render the unit complete and immediately ready for service. This shall include isolating valves, non-return valves, cooling water discharge pipework, gland leakage pipework, air release pipework, pressure gauges, gauge pipework, holding down bolts, access platforms and other items as appropriate. Where practicable, pressure gauges shall be wall mounted.

Apertures in pump head stools shall be guarded and, if outdoors, the guards shall be of solid polycarbonate or acrylic plastic to offer protection from wind and airborne particles.

All studs, bolts and nuts used in the construction of the pumps shall be of stainless steel.

All intermediate shafting between pumps and motors shall be provided complete with adequate guards.

All pumps, where possible, shall be of the same manufacture and design to simplify spares requirements and maintenance.

4.23.2 Pump Motor

The Contractor must ensure that the pump motors provided shall be of sufficient power, without overloading, to drive the pumps when operating at the worst static head conditions and when operating against worst pressure condition on Site at an ambient temperature of 40°C. The motors shall comply with the requirements of the Electrical Specifications.

The Contractor shall in his offer give details of motor power requirements; pump configuration and pump-motor set assembly dimensions.

All pump motors shall be equipped with thermal switches in the motor windings as a safeguard against overheating.

4.23.3 Pump Bearings and Seals

The rotating element shall be carried on ball and/or roller bearings generously rated to ensure satisfactory and stable running without vibration under all conditions of operation. Bearings shall be suitable for an ISO B10 life of 60,000 hours at the pump speed. Seals shall be provided to protect the bearings from ingress of moisture, dust, sand and the particular climatic conditions prevalent at the Site.

1. All bearings shall be according to DIN standard, SI unit dimensions where practicable.

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2. Pump bearings shall be external to the pump casing and be removable with the rotating element.
3. Pump bearings shall be adequately rated ball or roller type and shall be arranged to take all radial and axial loads during start-up and running conditions.
4. Pump bearings shall be mounted in dust-proof housing and provided with accessible lubricating points for grease gun greasing.

4.23.4 Connecting Flange

Connecting flanges of horizontal and vertical split casing pumps, single end suction pumps and centrifugal sludge pumps shall be pressure rated to PN10 to DIN 2462 and shall incorporate two adjacent tapping plugged unless otherwise specified. Flanges shall be machined on the face and edge and spot faced at the back.

4.23.5 Pressure Gauge

The gauge mechanism shall be of the bourbon tube type on 100 mm diameter having stainless steel movements and shall comply and be tested in accordance with DIN 16064 (or internationally acceptable standards).

1. Gauge graduations shall be such that the gauge is never used continuously beyond 60 % the max. graduations. Pressure gauges shall be graduated in bars or milli-bars.
2. The face of the dial shall have a warning label marked in red attached thereto, reading "IMPORTANT TURN OFF WHEN NOT IN USE".
3. All gauges shall be provided with glycerine filling to dampen pressure pulsation.

As far as possible, all pressure gauges shall be mounted either on walls, pump supports or brackets that do not have any vibration. Direct mounting at the pressure gauges on the pump casings or pipes must be avoided. They must also be mounted at a height suitable for ease of reading.

4.23.6 Centrifugal Pump

Centrifugal pumps characteristics shall be stable with the delivery pressure falling continuously from a maximum at the closed delivery valve condition. Characteristics shall be non-overloading and unless otherwise specified all pumps shall be suitable for parallel operation with other pumps delivering to the same system. Except for axial flow pumps, all pumps shall be capable of being started and run for short periods with their delivery valves closed.

Pumps shall be designed to handle sewage, sewage effluents and sludge and shall run unattended for long periods. They shall be capable of passing solids up to a maximum sphere size of 100 mm or 3 mm less than the smallest branch size; they shall pass stringy matter, rags, paper and plastics without choking.

The peripheral speed of the impeller blades shall not exceed 25 m/sec at the specified duty.

The critical speed of the pumps shall occur at not less than 150 % of the maximum rated speed.

The shut off head shall be as low as possible preferably around 160 % of duty head.

Net positive suction head (NPSH) required for the pumps when pumping singly or in any combination as specified shall satisfy the NPSH available. The calculations are to be submitted with the Contract. Any deviation in NPSH of pumps shall be corrected on Contractors responsibility and expense.

Centrifugal pumps shall comply with the following:

1. Rotating parts of pumps shall be statically balanced during manufacturing and dynamically balanced after assembly.
2. Casings shall be so designed that the withdrawal of the impeller and drive end cover assembly can be affected without disturbing the pump casings.

3. Hand holes shall be provided, close to the eye of the impeller and near the delivery branch on the volute to facilitate inspection and the clearance of blockages. The covers to the hand holes are to be bolted and shaped internally to match the internal contours of the casing and to minimise disturbances to the flow.
4. Renewable internal "wear plates" shall be fitted or the casing shall be arranged for replaceable suction and gland plates.
5. Casings shall have sufficient metal thickness in the volute where not protected by wearing plates to compensate for corrosive and abrasive action of the sewage.
6. Casings shall have accesses manufactured for top and bottom wearing rings shaped in a way that after fitting the rings a smooth internal profile is obtained and the casing is continuously protected by renewable parts from the inlet to the impeller vane tips.
7. Impellers shall be designed in order to reduce the specific power demand to a minimum on the highest efficiency, i.e. "N-Series" type impellers shall be applied.
8. Impellers shall be constructed of best nickel cast iron; they shall be smooth, well finished, and free from blowholes and imperfections, statically and dynamically balanced.
9. The impellers must be of the self-cleaning unshakeable type and whenever possible of the non-shrouded type. Impeller shrouds shall have rudimentary vanes designed to keep grit, solids and foreign matter away from the eye and neck bush.
10. The impellers shall be securely fitted to pump spindles in such manner that they do not loosen or become detached when the pump is in operation, or when the impeller is rotated in the wrong direction by reversed flow or reversed motor connections.
11. The impellers shall be provided with means to prevent abrasive matter getting to the glands and, in fully shrouded impellers, to prevent the collecting of matter between the outer shroud and the pump casing.
12. Pump spindles shall be of stainless steel or high tensile steel and fitted with renewable stainless steel, nickel chrome or bronze sleeves to protect the spindles against wear over the distance it passes through the stuffing box.
13. Casing wearing rings shall be of best quality close-grained cast iron or nickel iron in a full circle and fully concealed and machined.
14. Casing wearing rings shall be deep and of adequate section to prevent sag and distortion when not in the seating and when stored.
15. Casing wearing rings shall be a light drive fit in the casing and be located in suitable recesses machined in the casing.
16. Casing wearing rings shall form a continuous and smooth surface without gaps or steps with the adjoining surfaces of the pump casing.
17. Intermediate shafting between vertical spindle pumps and motors shall, whenever possible be by "Hardy Spicer" transmission shafting with a splined slip joint above the pump and universal flexible couplings with needle roller bearings.
18. When the transmission requirement is too great for 'Hardy Spicer' shafting, solid transmission shafting may be offered with rigid flange type couplings utilising fitted bolts.
19. Every length of transmission shaft complete with couplings shall be dynamically balanced.
20. The weight of transmission shafts shall be carried by trust bearings in the motor mountings.
21. Where intermediate bearings are required to steady the shafting, independent bearing supports must be provided.
22. All intermediate bearings must be provided with facilities for greasing and those in inaccessible locations must be piped to a common greasing manifold.

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23. A 20 mm bore drainage pipe shall be provided for vertical spindle pump from the invert of the sill on the top cover and leading down into the floor drainage channel to allow drainage of gland seepage water.
24. Each centrifugal pump shall be provided with air release valve and pipe.
 - a. Air/gas release pipe mounted at the top of the pump delivery branch of not less than 25 mm diameter. The pipework shall be arranged with crosses and tees and plugs at each section to permit rotating of each leg of the pipework.
 - b. An automatic air release valve shall be fitted into the air/gas release pipework at a position convenient for maintenance.
25. The suction arrangement leading to the eye of the impeller shall:
 - a. Be of best quality close-grained cast iron Grade 14 and of adequate thickness to provide for the abrasive and corrosive action to sewage.
 - b. Be tested to the same pressure as the pump casing.
 - c. Be fixed to the pump casing and horizontal suction pipe with bolts and nuts.
26. The suction arrangements shall avoid perforation in the suction pipework and present a good flow pattern at the entrance to the impeller. The suction pipework shall not be less in diameter than the eye of the impeller.
27. If "water hammer" is possible, the necessary precautions shall be installed. In such cases the preventive measures shall be described.

4.23.7 Submersible Pump

The pumps shall be designed for handling of Waste, activated return sludge and for surplus sludge, and shall be capable of passing solids up to a sphere size of 80 mm. They shall pass stringy matter, rags, paper and plastics without clogging.

Submersible pumps shall comply with the following

1. The pump casings shall be of cast iron, and shall be provided with a renewable suction end, wear plate, a discharge cover and a support foot.
2. The impellers shall be designed to give non-overloading characteristics over the complete working range of the pump and shall be capable of conveying liquids, which will evolve gas.
3. Impellers shall be designed in order to reduce the specific power demand to a minimum on the highest efficiency, i.e. "N-Series" type impellers shall be applied.
4. The design of the pump units shall be such that there will be no tendency to unlock any part due to a possible reversal of rotation and shall not pass through or approach the critical speed.
5. The pumps shall be capable of working for long periods without cleaning or attention and special precautions shall be taken to avoid wear on working surfaces due to grit.
6. Slide ring sealing, sealed for life shall be provided between motor and pump.
7. The unit shall be supplied with an adequate length of suitably sheathed flexible cable and pass through a watertight gland on the entry of the motor body.
8. The pumps shall be installed as a permanent wet sump installation and each unit shall be complete in all respects with guide rails complete with upper and lower fixing brackets, lifting chain, automatic pump discharge branch connection, cable guides and holders to allow pumps to be raised or lowered without entering the sump.
9. Glands shall be fitted with mechanical seals (Material: SiC/SiC) with automatic seal supervision in the oil chamber.

10. The shafts of pumps shall be made wear resistant with protection sleeve where they pass through the mechanical seal.
11. The pumps shall be suitable for operation on a 400 volt, three phase, 50 Hz supply.
12. The pump motor shall be of squirrel cage induction type, with protection class IP 68, ex-rated and be continuously rated for use in sewage at ambient temperature.
13. The motor shall allow 15 starts per hour and be protected from overheating by the use of PTC thermistors.
14. The motor shall be protected with a moisture resistant Class "F" insulation capable of resisting temperature of up to 155°C. For monitoring moisture intrusion into the motor cavity, the pump shall be supplied with an additional and independent moisture sensor in the motor cavity..
15. The pressure pipework shall be provided with reflux and gate valves in vertical position and shall be of stainless steel and flanged. The reflux valve shall be fitted in the delivery pipe immediately below the gate valve. Fittings and valves shall be secured to the wall by stainless steel brackets.
16. Each pump shall be fitted with a removable lifting handle and supplied with a connected stainless steel lifting chain to facilitate removal. The upper end of the chain shall be conveniently anchored in an approved manner and location. Chain ends shall be fitted with stainless steel shackles and pins.

4.23.8 Submersible Sump Pump

Each sump pump shall be installed as a fixed unit and shall be complete with all necessary pipework, level controls, motor starter and cabling. Submersible sump pumps shall comply with the following:

1. Sump pump shall be of the submersible type with pump units suitable for operation on 400 volts three phase, 50 Hz supply. It shall be capable of handling floor drainage from the various pump chambers and floor ducts.
2. The sump pump shall be of heavy construction with impellers made of high-grade abrasive resistant material having non-overloading characteristics.
3. Discharge pipework and valves shall be provided with reflex valve and gate valve and shall discharge into an adjacent chamber channel or pipe.
4. Discharge pipework shall be 50 mm minimum nominal bore and the pump shall be capable of passing sphere of up to 18 mm diameter.
5. Each pump shall be fitted with a removable lifting handle and supplied with a connected stainless steel lifting chain to facilitate removal. The upper end of the chain shall be conveniently anchored in an approved manner and location. Chain ends shall be fitted with stainless steel shackles and pins.

4.23.9 Portable Site Drainage Pump

Portable site drainage pumps shall be provided complete with all necessary hoses, cables, starter and support rope suitable for transportation to and use at any location on the works.

Portable site drainage pumps shall comply with the following-

1. The pumps shall be of submersible type suitable for operation on a 400 volt, three phase, 50 Hz supply.
2. Each pump shall be capable of handling sludge, liquids containing grit, and solids as found in pump suction sump drainage, tanks and general site drainage duties.
3. The pumps shall be of heavy construction with open type impellers of high abrasive material having non-overload characteristics and shall be generously rated for prolonged operation. The pump shall be suitable for operation in liquids that have been subject to direct sun and the

rating has to be continuous when operated at any point on the characteristic curve between closed valve and zero head.

4. The pumps delivered shall be suitable for the connection of flexible hoses utilising a quick release type coupling.
5. Discharge hoses 15 m long of 50 mm diameter rubber with fabric or cord reinforcement shall be provided for each small pump, each length fitted with quick release type metal coupling to suit the pump.
6. Large pumps shall be rated to deliver 15 - 20 litres per second against heads up to 16 meters. The pump shall be capable of passing solids up to 75 mm diameter sphere.
7. Small pumps shall be rated to deliver 5 - 7.5 litres per second against heads up to 10 m. The pump shall be capable of passing solids up to 18 mm diameter sphere.
8. Manual control shall only be provided for the portable pumps. The motor-overheating protection by thermal switch in the windings shall be included in the control circuit.

4.23.10 Horizontal Centrifugal Pump

Horizontal single stage casing pumps in modular construction with single vane impeller not self priming. Casing shall have an interchangeable wear ring, axial inlet nozzles and radial top discharge nozzles.

Horizontal centrifugal pumps shall comply with the following

1. Fitting and removal of the rotor shall be possible axially without having to remove the pump from the pipeline or the foundation.
2. Shaft bearings are sealed for life anti-friction bearings. The bearings are to be sized to guarantee a service life of 50,000 hours.
3. Shaft Sealing; at the drive end: mechanical seal independent of direction of rotation SiC/SiC material combination at the rubbing surfaces.
4. Shaft Sealing; at the pump end: mechanical seal independent of direction of rotation SiC/SiC material combination at the rubbing faces.
5. Common, permanent liquid quench consisting of paraffin oil.
6. Assembly parts: Belt drive, inclusive baseplate, belt pulleys, belts, belt guard, masonry bolts dowels.
7. Materials specification:
 - a. Casing parts in contact with media: grey cast iron 25
 - b. Impeller: grey cast iron 25
 - c. Discharge Cover grey: cast iron 25
 - d. Wear ring: grey cast iron 25
 - e. Shaft: 1.4021.05
 - f. Bearing Bracket: grey cast iron 25

Each pump shall be complete with all necessary ancillary equipment and fittings to render the unit complete and immediately ready for service, as required in the pump-sections before.

4.23.11 Positive Displacement Pump

Positive displacement pumps (eccentric pumps), whether rotary or reciprocating, shall be self-priming and of the horizontal helical rotor and fixed stator type. They shall be driven by electric motors and mounted together with their motors on a combined base plate or frame. Rotors shall be long enough to provide more than 360 degrees of helical passage.

Positive displacement pumps shall comply with the following:

1. Stators shall be of synthetic rubber moulded into a rigid outer barrel. Suction and delivery connections shall be flanged.
2. Pumps shall be provided with dry running protection (DSP) of the rotor by conductivity sensor or thermal stator protection.
3. Max. relative velocity between stator and rotor to be 1 m/s.
4. Pumps shall be provided with pressure relief valves to prevent generation of excessive pressures and, unless specified otherwise, means to minimise pressure fluctuations. Pressure relief valves may be integral parts of the pumps or fitted externally. Liquid bled off from pressure relief valves shall be returned to the suction side of the pump or to the suction sump.
5. Positive displacement pumps, which are belt driven, shall incorporate means to prevent overstressing the belt drive by using a torque-limiting clutch.
6. Positive displacement pumps shall comprise, but not be limited to:
 - a. Horizontal dry-mounted pump
 - b. Common base plate for pump and motor
 - c. Three phase motor
 - d. Progressive cavity type complete with hand-wheel controlled variable speed drive
 - e. Pressure switch for overpressure protection and temperature control element for stator protection
 - f. Suction switch for low pressure protection and temperature sensing element for stator protection
7. Materials specification:
 - a. Casing parts in contact with media: grey cast iron 25
 - b. Shaft: Cr-Steel 1.4021
 - c. Coupling rod: Cr-Steel 1.4021
 - d. Rotor: hardened tool steel 1.2436
 - e. Stator: Perburan SB
 - f. Shaft sealing: gland packing or equal

4.24 Fixed Speed Centrifugal Air Blowers

4.24.1 General Requirements

Blowers and motor units shall be designed for an operating life of 10 years without major overhauls.

Furthermore, blowers shall not need normal maintenance procedures requiring replacement of parts within the first 18,000 hours of operation except for lubricants and filters.

The blower and its driving motor shall be separate machines, close coupled, using a flexible coupling to form an integral unit mounted on a suitable common bedplate. Each component shall be dowelled to facilitate re-assembly.

Components likely to become worn in the course of normal operation shall be capable of replacement, making use of readily exchangeable components.

The blower shall be installed in a manner that eliminates vibration occurring to the plant or being transmitted into the building structure.

The blowers and motors shall be suitably protected against the ingress of dust and water.

The noise level within the buildings is specified below in the Sub-section "Suppression of Noises". If each blower cannot obtain the specified noise level, it shall be equipped with the necessary noise reducing enclosure made of galvanized steel sheets with insulation material. The enclosure shall be easily demountable with snap locks.

Where forced ventilation is necessary in conjunction with acoustic enclosures and oil cooling, the rating of the fan motors used for this purpose shall be included in the Tender.

The additional loading represented by forced ventilation fans will be taken into account when calculating the overall system operating efficiency.

4.24.2 Capacity Requirement

The tenderer shall offer blowers from within a standard range to meet the total head requirements of the complete system and provide the range of flows specified. They shall have a non overloading power characteristic and be sized with allowance for the variations in atmospheric pressure, temperature and relative humidity stated below:

Standard conditions	
Air temperature	15°C
Relative humidity	75%
Atmospheric pressure	1013 mbar

Standard operating range	Minimum	Maximum
Air temperature	0°C	40°C
Relative humidity	25%	100%
Atmospheric pressure	950mbar	1,050mbar

The blowers shall be sized to give maximum operating efficiency at the standard conditions. The blowers shall be capable of operating over the stated operating range. Blower efficiencies are to be quoted for the minimum, standard and maximum operating conditions.

Blowers shall have a steep performance scale to enable satisfactory flow division between blowers in parallel operation. This shall be achieved by load sharing or cascade control to provide the most efficient means of operation. Blowers shall achieve a wide dynamic volumetric operating range with each blower demonstrating a minimum of 45% turndown.

A minimum of 3.5% shall be available above the maximum design adiabatic head before surge conditions will be encountered.

4.24.3 Mechanical Construction

The blowers shall be the single stage centrifugal type with inlet guide vanes control or outlet diffuser vanes as appropriate. Blowers using variable discharge diffusers in combination with inlet guide vanes shall be provided where improved efficiency can be demonstrated or where they are necessary to achieve blower turndown requirements.

Pinion and input shafts shall be of high grade alloy steel. The first critical speed shall not exceed 80% of running speed. The starting mechanism shall ensure that the blower does not dwell at the first critical speed by providing rapid acceleration through it. The second critical speed shall exceed 120% of running speed.

Pinion shaft bearings shall be of the sleeve or tilting pad type adequately sized for the imposed loads and include thrust bearings.

The input shaft shall be on ball, roller or sleeve bearings and include a thrust bearing.

The blower shall have an integral horizontally split gearbox of cast iron construction.

Impellers shall be of the radial flow backward curved vane type for high efficiency and a wide volumetric operating range.

The internal sealing rings and shaft seals shall be of the labyrinth type suitable for the duty imposed, minimising the rate of leakage and being readily replaceable during maintenance.

Blower casings shall be of high grade cast iron with a diffuser design for high efficiency conversion of velocity pressure to static pressure.

4.24.4 Lubrication

The lubrication system shall comprise the following:

- i) Integral oil reservoir
- ii) Mechanically operated main oil pump
- iii) Electrically operated auxiliary oil pump
- iv) Oil cooler, including radiator and forced air blast cooling
- v) Oil filter.

Lubrication of the gearbox shall be by a pressure system. The main oil pump shall be of the positive displacement type and be mechanically driven from either the gearbox or the main drive motor. The pump shall have sufficient capacity to ensure that effective lubrication of the blower continues as the blower runs down following a power failure.

The auxiliary oil pump shall be electrically driven and suitably rated for priming the blower before start up and during run down. The auxiliary pump shall also act as the main pump if required.

The oil cooler radiator shall have a minimum specification of copper tubes with aluminium fins.

The oil cooling system shall include a thermostatic oil temperature control valve.

Oil filtration shall be 10 micron absolute or better, using a replaceable, cartridge type paper element filter.

The oil settling reservoir shall provide at least a 5 minute retention time.

All relief check and pressure control valves shall be included.

Pipework and fittings shall be of corrosion resistant metallic material with compression fittings.

A heater shall be installed in the oil reservoir to ensure satisfactory starting of the blower in cold weather.

4.24.5 Air Flow Controls

Inlet guide vane control shall be used to provide the required flexibility of duty with a constant speed squirrel cage motor.

The guide vanes shall provide pre-rotation to the air as it enters the impeller to lower the power requirements as turn-down occurs. The guide vanes shall be operated simultaneously from a single spindle. The spindle shall be electrically actuated.

Variable discharge diffusers, arranged to adjust the throat area of the blower, shall be arranged radially around the periphery of the impeller. The discharge diffusers shall be operated simultaneously from a single spindle. The spindle shall be electrically actuated.

4.24.6 Connections

The delivery of each blower shall be fitted with a flexible bellows units, which shall be protected by tie rods to prevent distortion of the bellows whilst in service.

The suction inlet of each blower shall have a means of attachment to the filter/silencer unit, which maintains mechanical alignment and does not stress the compressor casing.

4.24.7 Air Filter and Silencer

The air filter shall utilise self supporting disposable modular filter pocket units installed with air tight seals within a rigid frame. Air shall be filtered to the requirements of ISO EN or other international recognized standards

Additional filtering shall be provided if required to guarantee the long term operation of the blowers, air pipework and diffusers.

The air filter unit design shall be rated for 120% of the maximum air flow rate of the blower. Head losses through the silencer and filter unit shall be kept to an absolute minimum.

A permanently installed manometer shall be installed with each blower filter unit arranged to indicate normal and high (filter blocked) differential headloss across the air filter unit. An electronic signal and alarm shall be included for high headloss.

4.24.8 Anti-Surge System

A complete system to prevent surge occurring shall be installed to each blower to ensure that an airflow requirement below the optimum turndown of the blower will not lead to surge conditions. Where this is achieved with a blow-off valve, suitable silencing shall be provided.

Alternatively, the supplier shall include a surge detection system which closes the blower system down and raises an appropriate alarm.

4.24.9 Controls

All necessary sensor systems for oil, temperature and pressure shall be included to provide control and alarm functions.

Blowers shall be controlled by a pressure transducer in the main air pipe.

4.25 Weighbridge

4.25.1 General

Each weighbridge shall consist of the steel bearing part and reinforced concrete platform. Approximate length of the weighbridge shall be 18.00 m, and its approximate width is 3.00 m. The weighbridge shall be above the ground level (surface assembly) with elevated sides. Bearing capacity of the weighbridge shall be >15 t / axis.

Foundation panels of the weighbridge shall be concreted according to the weighbridge manufacturer's instructions.

Height of placement of the foundation boards in the foundations of the weighbridge according to the laws shall be such that after the installation of the supports, the weighbridge shall be elevated above the foundations a minimum 10 cm, while distance between the weighbridge and the foundation board may not exceed 5 cm.

Upon the installation of both weighbridges and their connection to electrical equipment, the scales shall be calibrated, adjusted and then certified by a licensed institution.

Upon the testing and certification of scales, they shall be released for trial operation under control.

4.25.2 Weighbridge supports – measurement converters

Total bearing capacity of measurement converters shall be at least twice as high as total bearing capacity of the weighbridge. The bearing capacity of selected converters shall be about 25 t per converter.

Converters shall be watertight, made of stainless steel. They shall be fully prepared with sleeve joints for simple assembly, preventing torsion and rotation of the converters. Lighting protection shall also be installed. Connecting power cable (standard length 25 m) shall be protected with a polyurethane coating from mechanical and chemical damages.

4.25.3 Weighbridge control program

The Contractor shall obtain and install a weighbridge control program. The program shall be in Serbian language, adjusted to the principles of work at waste disposal sites (simple use and speed of operation), with protection from unauthorized use.

The program shall provide 2 basic principles of operation:

- operation with two weighing sessions (entry – exit weighing) and
- work with memorized tare.

The program shall make possible to issue:

- weighing sheet;
- retail invoice and
- "R1" VAT invoice.

The program shall have the option of entry of information on the following, at a minimum: vehicle registration plates, partner, type of goods, driver, weighing authority and remark.

Documents (weighing sheet and invoices) shall include, at a minimum, information on document number, date and time of weighing, information on partner, information on goods, information on driver and weighing authority, information on tare, gross and net weighted goods.

The program shall also possess the following options:

- summary of information on all weighing events (date, time, vehicle registration, partner, type of goods, etc.);
- drafting of total and aggregate reports by all categories;
- presentation and print-out of reports in graphic form;
- summary of information from other separate points;
- exchange of information with other information systems;
- cancelling of documents;
- subsequent print-out of documents;
- installation of some of advance Structured Query Language (SQL) databases;
- back-up solution;
- connection with peripheral equipment and
- operation on several weighbridges (network operation).

4.25.4 Foundations

Reinforced concrete foundations of the weighbridge shall be made with transversal and longitudinal beams with installed basic grounding and PVC pipes for cables insertion (led from the weighing station) to the bridge supports – measurement converters. Preparation of the foundations for the module shall include the laying of a plastic foil on the weighbridge foundations, as well as spreading and compacting of a levelling sand layer.

For the foundations of the weighbridge, weighing station and overhang, concrete of minimum compressive strength C 25/30 shall be used and reinforcement steel according to Main Design.

4.25.5 Wastewater

Rainwater shall be drained from the roof by means of galvanised gutters into the shaft for rainwater sewage placed in the vicinity of the facility. Rainwater shall also be drained from the bottom of the weighbridge pits into the rainwater collection system and taken for further treatment.

4.25.6 Fire safety

Hydrants shall be placed in the nearby area of the weighing station making part of the integral fire protection system. Inside of the station, fire extinguishers shall be placed according to the Design.

4.26 Electrical Equipment

The electrical equipment to be provided for power supply and operation control, incl. measuring instruments shall comply with the requirements set out in these TS of the Tender Document.

4.27 Suppression of Noises

All plant offered should be quiet in operation. The noise level within the buildings shall not be more than 85 decibels (+5 per cent on this over the audible frequency spectrum measured at mid band) "A" scale when measured along a contour 3 metres from any single item of plant during starting, running and stopping. The noise level outside the Site shall not be more than 60 decibels (+5 per cent on this over the audible frequency spectrum measured at mid band) "A" scale when measured along a contour 3 metres from the external boundary fence. Noise test measurements shall be made on completion of the installation of the plant and equipment at Site to verify that it complies with this Clause. Plant which fails to comply with the noise level limits when tested will render it liable for rejection unless it is satisfactorily modified at the Contractor's expense by the programmed commissioning date.

4.28 Testing, Inspection and Pre-commissioning

See paragraph 5 of Vol. 3, Section 5.

