CONSTRUCTION OF SEWERAGE SYSTEM IN HDH.NOLHIVARANFARU, K.THULUSHDOO AND K.HIMMAFUSHI, MALDIVES

TECHNICAL SPECIFICATION

PART 2: SEWERAGE SYSTEM WORKS- Revision 1

RIYAN PRIVATE LIMITED

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SECTION 1 - SCOPE OF WORKS

Section 1 - Scope of Works

1.0. Scope of Works

1.1. Summary of Scope of Works

The Scope of Works includes

1. **Sewer Reticulation System:** Construction of Sewer reticulation system including supply and installation of pipes, manholes, other fittings & specials.
2. **Pump Stations:** Supply / Construction & Installation of Pump stations and supply and installation of pipes, other fittings & specials between the Pump Stations and the Sewage Treatment Plant/sea outfall , based on flow detail given on drawings, BOQ & Technical Specification.
3. **Administration building.** Construction of administration building based on detailed design report, drawings, BOQ & technical specification, including Installation of Mechanical & Electrical Equipment.
4. **Sewage Treatment Plant:** Design & Construction of Sewage Treatment Plant with reference to the Employer's Requirement, including construction of Administration Building and Installation of Mechanical & Electrical Equipment.
5. **Sewer Outfall:** Supply & Installation of Sewer Outfall

1.2. Appendix to Scope of Works - Detailed Scope of Works

1.2.1. Sewer Reticulation System

The Scope of works includes;

- Supply & Installation of gravity reticulation sewers and property branch connections including inspection chamber as specified in the drawings, BOQ & Technical Specifications.
- Testing, commissioning of above works.

1.2.2. Pump Stations

The Scope of works includes;

1. Construction of Pump Stations, Valve chambers and Pressure main as specified in drawings, BOQ & Technical Specifications.
2. Supply & Installation of submersible components of pump stations; supply spares, control panels and monitoring instruments, based on the Flow Schedule given in drawings, BOQ & Technical Specifications.
3. Supply materials including valves and construct the external pipe work in the pump stations as shown in drawings.
4. Supply & Installation of Rising Mains as given in Drawings, BOQ Supply materials
5. Supply materials and install the security lighting in the pumping stations.
6. Confirm the profile of seabed based on the indicative profile provided, Supply i. materials and install Sea Outfall, based on the Drawings, BOQ &. Specification.

8. Testing & Commissioning including

   i. Specific training for the pump station system
   ii. Quality assurance for pump System Components

1.2.3. Administration building.

The scope of works includes:

1. Construction of the administrative office as per the drawings provided.
2. Buildings, roads, and hard standings required for open to air storage and parking, footpaths, Boundary Walls, landscaping and all ancillary works.

1.2.4. Sewage Treatment Plant

The scope of works includes:

1. Providing, constructing, testing, commissioning of Extended Aeration Activated Sludge (AS) treatment plant as specified in the drawings.
2. Marine outfall for discharge of treated effluent from the sea outfall pumping station to the sea,

3. The influent sewage will be coming to the treatment plant by means of pressure pipeline from the pump stations.
4. The scope of work for STP shall cover all preliminary treatment, sludge drying bed, treatment plant drainage, chambers, buildings, roads, hard standings required for open to air storage and parking, footpaths, Boundary Walls, landscaping and all ancillary works.
5. The scope of work shall also include all the pipe work, valves, penstocks, cabling and all other civil, architectural, mechanical and electrical, instrumentation, control and telemetry works necessary for the successful construction and safe and efficient operation of the treatment plant.

1.2.5. Sewer Out fall

The scope of works includes:

- Laying sewer out fall pipe in the land as shown in drawing.
- Laying sewer out fall pipe in the sea as shown in drawing.

1.3. Summary of Standards

A summary of standards referred to in various Sections of the Technical Specifications

2.2 Polyethylene Pipes and Fittings	
ASTM D2737-12a	Standard specification for Polyethelene (PE) Plastic Tubing
IGN 4-32-18	The choice of pressure ratings for polyethylene pipe Systems for water supply and sewerage duties
WIS 4-32-08	Fusion jointing of polyethylene pressure pipeline systems using PE80 and PE100 materials
WIS 4-32-11	Thermoplastic end load resistant mechanical fittings for polyethylene pipes of nominal size
BS EN 12201-1:2011	Plastics piping systems for water supply, and for drainage and sewerage under pressure. Polyethylene (PE). General
BS EN 12201-2:2011+A1:2013	Plastics piping systems for water supply, and for drainage and sewerage under pressure. Polyethylene (PE). Pipes
WIS 4-52-01	Polymeric anti-corrosion (Barrier) coatings
BS EN ISO 2081:200	Metallic and other inorganic coatings. Electroplated coatings of zinc with supplementary treatments on iron or steel
BS EN 1514-1:1997	Dimensions of non-metallic gaskets for relevant pressure
BS EN 681-2:2000	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Thermoplastic elastomers
BS EN 1514-1:1997	Flanges and their joints. Dimensions of gaskets for PN-designated flanges. Non-metallic flat gaskets with or without inserts
BS 4320: 1968 (98)	Specification for metal washers for general engineering
	purposes (metric series)
BS 2782-0:2004	Methods of Testing Plastics

BS EN 10088-2:2014	Stainless steel nuts, Screws, Washers & bolts

2.3 Valves, hydrants, surface boxes, manhole covers	
BS EN ISO 1461:2009	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
BS EN 1982:2008	Copper Alloy Ingots and Copper Alloy and High Conductivity Copper Castings
BS EN 1092-2:1997	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Cast iron flanges
BS EN 14399-1:2015	High-strength structural bolting assemblies for preloading. General requirements
BS 4346-1:1969	Joints and fittings for use with unplasticized PVC pressure pipes. Injection moulded unplasticized PVC fittings for solvent welding for use with pressure pipes, including potable water supply
BS EN ISO 1452-1:2009	Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure. Unplasticized poly(vinyl chloride) (PVC U). General
BS EN 1171:2015	Industrial valves. Cast iron gate valves
BS 5163-1:2004	Valves for waterworks purposes. Predominantly key-operated cast iron gate valves. Code of practice
BS EN 1401-1:2009	Plastic piping systems for non-pressure underground drainage and sewerage. Unplasticized poly(vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system
BS EN 681-1:1996	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Vulcanized rubber

Section 3 Pipe Laying	
BS EN 1610:2015	Construction and testing of drains and sewers
BS EN 752:2008	Drain and sewer systems outside buildings

Section 4 – Manholes	
ASTM D3350 - 14	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM D1505 - 10	Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D1238 - 00	Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D790 - 10	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D638 - 14	Standard Test Method for Tensile Properties of Plastics
ASTM F1473 - 13	Standard Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins
ASTM D2837 - 13e1	Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
ASTM F1759 - 97(2010	Standard Practice for Design of High-Density Polyethylene (HDPE) Manholes for Subsurface Applications
ASTM D2657 - 07(2015)	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings

ASTM C1147 - 14	Standard Practice for Determining the Short Term Tensile Weld Strength of Chemical-Resistant Thermoplastics
ASTM F1759 - 97(2010)	Standard Practice for Design of High-Density Polyethylene (HDPE) Manholes for Subsurface Applications
ASTM D2657 - 07(2015)	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
ASTM D2321 - 14e1	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

Section 5 –Sewerage System	
BS EN 12255-9:2002	Wastewater treatment plants. Odour control and ventilation

Section 6- Pumps for Sewage	
BS EN 1982:2008	Copper and copper alloys. Ingots and castings
BS EN 1561:2011	Founding. Grey cast irons
BS EN 13835:2012	Founding. Austenitic cast irons
BS EN 1092-2:1997	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Cast iron flanges
BS EN 1092-1:2007+A1:2013	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges

Section 7- Sewage Treatment Plant	
BS EN 12255-1:2002	Wastewater treatment plants- Part 1: General construction principles
BS EN 12255-3:2000	Wastewater treatment plants. Preliminary treatment
BS EN 12255-4:2002	Wastewater treatment plants. Primary settlement
BS EN 12255-6:2002	Wastewater treatment plants. Activated sludge processes
BS EN 12255-8:2001	Wastewater treatment plants. Sludge treatment and storage
BS EN 12255-10:2001	Wastewater treatment plants. Safety principles
BS EN 12255-13:2002	Wastewater treatment plants. Chemical treatment. Treatment of wastewater by precipitation/flocculation
BS EN 197-1:2011	Cement. Composition, specifications and conformity criteria for common cements
ASTM A775 / A775M	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
	steel fasteners. Bolts, screws and studs
BS ISO 1940-1:2003	Mechanical vibration. Balance quality requirements for rotors in a constant (rigid) state. Specification and verification of balance tolerances
BS 7671:2008+A3:2015	Requirements for Electrical Installations. IET Wiring Regulations

SECTION 2 - PIPES, FITTINGS & SPECIALS

Section 2 - Pipes, Fittings & Specials

2.0. Specifications for Pipes, Fittings & Specials

2.1. General

2.1.1. Ambient Conditions

All items of materials and equipment shall be in every aspect suitable for storage, installation, use and operation in the conditions of temperature and humidity prevailing in Republic of Maldives.

The temperature of the water flowing in the pipelines will be about 30 deg. C.

2.1.2. Inspection and Testing

The Contractor must provide Quality Assurance Certificates, established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent, for the supply items have been subjected to the tests performed as per applicable standards. The certificate shall be valid for a period covering the manufacture of the certified items. If the Contractor is not the manufacturer, the Contractor will provide the Quality Assurance Certificates of the original manufacturer. The materials shall be suitably marked to enable them to be identified from references on the certificates.

If Certificates are not provided or if the Engineer determines that testing is required, the Contractor shall arrange for inspection, testing and obtaining of such information as may be required to be carried out at the place of manufacture according to this Specification. If there are no facilities in Maldives for carrying out the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere at no extra cost. Any materials or workmanship which is shown by such tests not to be in accordance with the specifications shall be rejected not withstanding any previous certificates, which may have been provided. Notwithstanding the above, the Contractor will be required to rectify any deficiencies which are attributable to defects in the workmanship or quality during the Defects Liability Period specified in the contract.

2.1.3. Packing and Protection

All items shall be adequately crated or packaged to withstand damage and deterioration due to shipping, handling and storage. Protection shall be provided to prevent ingress of foreign matter. The methods of protection and shipping shall be to the approval of the Engineer.

Bolts of the same length and size (and their accompanying nuts and washers) shall be packed together in boxes not exceeding 100 kg. gross weight.

Joint rings and gaskets shall be packed in boxes and separate packages shall be provided for each size and description of ring or gasket. All fittings shall be packed in open sided crates.

The Supplier shall supply at his own cost all necessary materials and equipment for making good, where approved by the Engineer, any damage to pipes, fittings or valves suffered during delivery.

2.1.4. Protection of Ends

The Supplier shall provide protection to the approval of the Engineer for the ends of all pipes and fittings prior to the pipes and fittings leaving the place of manufacture in order to guard effectively against damage during transit and storage and the ingress of foreign matter inside the pipes and fittings. All details of the proposed method of providing such protection shall be submitted at the time of tendering. The cost of providing protection to the ends of pipes and fittings shall be included in the unit prices tendered in the Bill of Quantities.

2.1.5. Handling and Transportation

The Engineer will reject any pipes, fittings, or valves, which have been damaged. The Supplier shall comply with the following requirements:

a) Pipes, fittings, and valves shall not be dropped, or allowed to land on sharp or other objects, which will cause bends, or dents, or damage to the coating.

b) When lifting pipes and fittings special lifting hooks with curved saddles to fit the curvature of the pipes or fitting shall be used. Alternative types of lifting hooks, clamps, or slings may be used subject to the Engineer's approval.

c) Suitable pillow shall be used to protect pipes and fittings under securing chains or other lashings and **no unsupported over hangings of more than 1m will be allowed,** when pipes are being transported. When transporting, only 4 tiers high stacking in the lorry will be allowed.

d) uPVC pipes and fittings shall be protected from direct sunlight and shall not be shipped as deck cargo.

2.1.6. Storage

The storage of pipes and fittings shall be in accordance with the manufacturer's recommendation but the pipe stacking shall not exceed four tiers high unless otherwise approved by the Engineer. In case of outdoor storage, the pipes shall be kept fully covered by gauge 1000 black polythene sheeting in order to protect from direct sunlight.

The fittings shall be stored indoors with packing intact. Solvent cement shall be stored in a dark cool place (away from fire) with containers tightly closed.

2.1.7. Marking of Pipes, Fittings and Specials

Each pipe or fittings shall have the manufacturer’s name or identification mark embossed or engraved on it. Also each pipe, fittings and valves shall be legibly and indelibly marked with the following;

a) the manufacturer's name or identification marks

b) the dates of manufacture

c) the angle in degrees in the case of bend

In addition to what is specified in the Standards, all pipes, specials and fittings shall be legibly and indelibly marked with details as follows;

The Supplier shall label and clearly mark all pipes, fittings, crates and boxes in indelible paint as specified in the notes forming a part of this Specification. Valves shall have the weight printed on the surface.

2.2. Polyethylene Pipes and Fittings

2.2.1. Scope

This specification covers polyethylene pipes and assorted fittings and ferrules for the use of rising mains and sea out fall.

2.2.2. Reference Standards

ASTM D2737-12a	Standard specification for Polyethelene (PE) Plastic Tubing
IGN 4-32-18	The choice of pressure ratings for polyethylene pipe Systems for water supply and sewerage duties
WIS 4-32-08	Fusion jointing of polyethylene pressure pipeline systems using PE80 and PE100 materials
WIS 4-32-11	Thermoplastic end load resistant mechanical fittings for polyethylene pipes of nominal size
BS EN 12201-1:2011	Plastics piping systems for water supply, and for drainage and sewerage under pressure. Polyethylene (PE). General
BS EN 12201-2:2011+A1:2013	Plastics piping systems for water supply, and for drainage and sewerage under pressure. Polyethylene (PE). Pipes
WIS 4-52-01	Polymeric anti-corrosion (Barrier) coatings
BS EN ISO 2081:200	Metallic and other inorganic coatings. Electroplated coatings of zinc with supplementary treatments on iron or steel
BS EN 1514-1:1997	Dimensions of non-metallic gaskets for relevant pressure

BS EN 681-2:2000	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Thermoplastic elastomers
BS EN 1514-1:1997	Flanges and their joints. Dimensions of gaskets for PN-designated flanges. Non-metallic flat gaskets with or without inserts
BS 4320: 1968 (98)	Specification for metal washers for general engineering
	purposes (metric series)
BS 2782-0:2004	Methods of Testing Plastics
BS EN 10088-2:2014	Stainless steel nuts, Screws, Washers & bolts

2.2.3. Materials

2.2.3.1. Pipes

Polyethylene pipes shall be black in colour, flexible, PN 16 pressure rating and in coiled form, complying with ASTM D2737 or equivalent DIN or BS standards or IGN 4-32-18.

Pipes shall be manufactured by using polyethylene or any other material whose main component uses ethylene as main raw material. During the manufacturing process, the pipes shall be marked with pertinent product and process information at approximately 3m intervals along the pipe.

At least the following information should be included.

- Manufacturer's identification
- Standard number
- Nominal size and pressure rating
- SDR or SIDR or SODR number whichever is relevant
- The identification mark; in letter size 10mm.
- Third party certification

Pipes shall be produced by manufacturers who operate a quality assurance scheme to ISO 9002 series. The supplier shall submit a copy of quality assurance certificate.

In the event of supplying the pipes manufactured to other than ASTM – D2737-12a standards, DIN or BS, supplier shall provide all information related to

- Conformity of particular product to a specification mentioned above
- Relationship between the offered material specification and the ASTM-D2737-12a in the form of product catalogues and their comparison.
- Manufacturers' catalogues should be submitted with clear marking on corresponding comparisons to show the offered material is superior or equivalent to the specifications given.
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Polyethylene fusion joints and fittings shall comply with the relevant provisions of WIS No 4-32-11 or WIS 4-32-08. Mechanical joints and fittings for polyethylene pipes shall comply with WIS No 4-24-01, Type 1 end load performance, or WIS No 4-32-11.

Pipes shall be delivered to site and stored on timber or an appropriate alternative, with end caps fitted to prevent contamination of the pipes by debris or vermin. Pipes and fittings shall be adequately protected from contamination at all times. Large fittings shall be stored on pallets. Pipes and fittings shall be stored in a secure, clean area away from the Working Area, until they are required for installation.

2.2.3.2. Testing

Testing shall be carried out fully in accordance with the requirements of ASTM – D2737-12a or the equivalent JIS, DIN or BS standards. The manufacturer shall provide results of tests conducted in accordance with the relevant standard.

2.2.4. Mechanical Couplings, Repair Clamps and Flange Adaptors

All mechanical couplings, repair clamps and flange adaptors shall comply with ISO 9002 quality assurance system. Quality assurance certification should be from an organisation accredited to issue such certification. Documentary evidence regarding accredition together with the scope of certification should be provided.

Mechanical couplings and repair clamps shall comply with WIS 4-52-01 or equivalent and shall be PN 16 pressure rated unless otherwise stated. Internal surface shall be coated to class "A" standard and external surface to class "B" minimum.

All these fittings shall be protected against corrosion by the application of Rilsan nylon 11 coating or equivalent (both internal and external) with the coating thickness of not less than 250 microns. Engineer's approval shall be obtained for any other types of coating, prior to order.

The mechanical couplings and repair clamps shall be designed for a safe allowable angular deflection of 6° without leakage while it shall be 3° for flange adaptors.

All fastners of couplings, clamps and adaptors shall be electroplated to BS 1706: 1990(1996)grade zn 10 or equivalent followed by a suitable primer and then with a Rilsan Nylon 11 or equivalent coating to a thickness of 60 – 120 microns.

Gaskets and rubber rings shall be of EPDM and the physical properties shall comply with table 3 of BS 2494:1990. Gaskets shall be of the inside bolt circle type and the dimensions shall comply with BS EN 1514-1:1997. The dual hardness of rubber rings shall be in the range of 7 6-84 IRHD at the heal of the ring and 46-5 5 IRHD at the bulb of the ring while 76-84 IRHD shall be the hardness range for Gaskets.

Prior to the commencement of the manufacture the Contractor shall submit to the Engineer, for approval, detailed drawings of all mechanical couplings repair clamps and flange adapters.

Repair clamps shall be a two half or wrap around design. The body of the clamp shall deform to the circumference of the pipe. The clamp shall provide a seal, of minimum length 200mm over the entire surface area of the clamp. The clamping system shall be self-aligning and locking prior to the tightening of the retaining system. Bolts shall be removable.

Repair collars (split collars) shall be two half design with a service boss (up to 2" BSP) cast on the housing. Bolts shall be removable.

Repair fittings shall achieve a permanent watertight seal on all the required pipe materials and sizes.

Mechanical couplings shall be the same pressure rating as the pipe to which they are attached but in no case less than 10 bar.

2.3. Valves, hydrants, surface boxes, manhole covers

2.3.1. Scope

This section covers the requirements for the supply of valves, hydrants, surface boxes and manhole covers.

Accessories associated with the valves are also specified.

2.3.2. Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

2.3.3. Reference Standards

BS EN ISO 1461:2009	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
BS EN 1982:2008	Copper Alloy Ingots and Copper Alloy and High Conductivity Copper Castings
BS EN 1092-2:1997	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Cast iron flanges
BS EN 14399-1:2015	High-strength structural bolting assemblies for preloading. General requirements
BS 4346-1:1969	Joints and fittings for use with unplasticized PVC pressure pipes. Injection moulded unplasticized PVC fittings for solvent welding for use with pressure pipes, including potable water supply

BS EN ISO 1452-1:2009	Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure. Unplasticized poly(vinyl chloride) (PVC U). General
BS EN 1171:2015	Industrial valves. Cast iron gate valves
BS 5163-1:2004	Valves for waterworks purposes. Predominantly key-operated cast iron gate valves. Code of practice
BS EN 1401-1:2009	Plastic piping systems for non-pressure underground drainage and sewerage. Unplasticized poly(vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system
BS EN 681-1:1996	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Vulcanized rubber

2.3.4. Records and Drawings for Materials to be Supplied

The following records and drawings of all types of valves shall be made available by the supplier for inspection.

- Drawings showing overall dimensions, valve construction and settings
- Data related to pressure ratings, weights and materials of manufacture (each component)
- Test certificates of works tests

In addition to above the followings shall also be submitted.

- Performance data of air valves
- Seating designs and the seating materials of butterfly valves

2.3.5. Painting

The external and internal surfaces except mating surfaces of all valves shall be treated with a bitumen solution at the place of manufacture. Threaded and exposed machined surfaces liable to rusting shall be adequately protected in accordance with BS 5 163:2004.

2.3.6. Manhole Covers and Frames

Manhole covers and frames shall be of class D as per BS EN 124-2:2015 unless otherwise stated. They shall be made from Ductile Iron. The covers shall be non-ventilating double triangular, non-rock, black bitumen coated or epoxy coated. The keyways shall be closed and the couplings bolts, etc. shall be galvanized. All manhole tops must comply to load Group 4 – class D 400 – which is used for carriageways of roads including pedestrian streets, hard shoulders of roads and parking areas for all kinds of road vehicles. Manhole tops of class D 400 shall have a minimum frame height of 100 mm. The frame height can be reduced where the frame is provided with anchoring.

2.4. Key Features of Specifications

Some of the salient features of the specifications are summarized below to furnish a quick reference. The tenderers are under obligations to refer the whole of the specifications in their entirety prior to perfecting their tender documents, and will be deemed to have done so during the tendering stage.

Feature	**Description**	**Standard of Conformity**
The material for valve Body		
• **Diameters up to 150 mm**	Cast Iron	
• **Diameters above 150 mm**	Ductile Iron	BSEN 1563: 2011
Feature	**Description**	**Standard of Conformity**
Sluice Valves		

• **Up to 600 mm**		BS 5163:2004
• **Above 600 mm**	Ductile Iron	BS EN 1171:2015
Manhole covers and frames		
• **Material**		BS EN 124-2:2015
• **Class**	Ductile Iron	BS EN 124-2:2015

2.5. uPVC Pipes And Fittings

2.5.1. uPVC Pipes

Socket and Spigot uPVC pipes shall be of the type specified, complying with international standard. The pipes shall be supplied in lengths not exceeding 6 meters. Gravity sewers are to be rubber Ring jointed, Spigot / Socket uPVC pipe with a stiffness classification of not less than N4.

The Supplier shall be responsible for the compatibility of fittings with the uPVC pipes offered; and satisfy the hydrostatic pressure requirements as set out in BS EN ISO 1452-1:2009.

2.5.2. Manufacture of uPVC Pipes

The Supplier shall furnish copies of certificates of quality control tests carried out during manufacture of the pipes and fittings if required by the Engineer undertake such additional tests, as he considers necessary. The Supplier shall, when required, disclose to the Engineer particulars of all toxic substances present as the result of tests carried out.

2.5.3. Jointing of uPVC Pipes and Joint Rings, Sealing Rings and Gaskets

uPVC pipes of diameters 90 mm and above shall be joined by means of mechanical joints with joint rings, in accordance with BS EN ISO 1452-1:2009.

The ***joint rings***, sealing ring and gasket material shall be EPDM, with a hardness range of (70-80). All gaskets shall be of the inside bolt circle type.

Lubricant proposed for jointing mechanical joints of uPVC pipes shall not impart any taste, affect the quality of the water or be conducive to the growth of organisms.

Sealing Rings: The Supplier shall provide certificate to the effect that rubber joint rings, rubber sealing rings, rubber gaskets provided under this Contract have been designed and manufactured considering the following aspects so as not to render leaky joints at specified pressure when in use.

1. cross sectional dimensions
2. peripheral length
3. smooth surface finish without any blemishes, depressions, protrusions et.
4. gaskets shall be moulded type without any joints.

The Supplier shall provide written instructions on the method of forming the chamfer on cut end of pipe for jointing.

2.5.3.1. Gravity Sewer Pipes and Gravity pipelines from Pump Station to STP

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All gravity pipes shall be UPVC to BS EN 1401-1:2009. All gravity mains shall 8E 160mm DIA UPVC of wall thickness & stiffness rated to SN4 & SDR41. All gravity house laterals shall be 110mm diameter UPVC of wall thickness & stiffness rated to SN4 and SDR41. All gravity mains shall also have minimum 0.4% slope. Moreover all the gravity pipes shall be jointed using rubber ring push fit jointing method & rubber rings comply with BS EN 681-1:1996. Despite connection from the household to the inspection chamber not being included in the detailed drawings, provision shall be given in IC for multiple connections. The contractor must also ensure that all sewer pipes shall be buried under earth cover of minimum 0.6 meters.

2.5.4. Flanges, Nuts and Bolts and Washers

All flanges shall be in accordance with BS EN 1092-2:1997, Specification for Flanges and Bolting for pipes, Valves, and Fittings-metric-series. Flanges shall be raised faced. Dimensions of the flanges shall be in accordance with the standard as well. All nuts washers

and bolts to be supplied with flanges shall be of high tensile steel complying with BS EN 14399-1:2015.

The screw threads in all pipes and fittings shall comply with ISO metric screw threads. The bolt lengths shall be sufficient to ensure that nuts are full threaded when tightened in their final position with two threads showing. Washers shall be provided under head of the bolt and under the nut.

2.5.5. Sampling and Testing

The Contractor must provide Quality Assurance Certificates, established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent, for the supply items have been subjected to the tests performed as per applicable standards. The certificate shall be valid for a period covering the manufacture of the certified items. If the Contractor is not the manufacturer, the Contractor will provide the Quality Assurance Certificates of the original manufacturer. The materials shall be suitably marked to enable them to be identified from references on the certificates.

If Certificates are not provided or if the Engineer determines that testing is required, the Contractor shall arrange for inspection, testing and obtaining of such information as may be required to be carried out at the place of manufacture as specified below.

The number of samples to be tested for mechanical characteristics of uPVC pipes shall be selected at random in proportion to the total number of pipes and specials of each diameter in the delivery as follows:

- For deliveries of lots of 50 to 150 - 2%
- For deliveries of lots of 151 to 250 -1%
- For deliveries of lots of over 250- 0.5%

The Supplier shall, if required, undertake a reasonable number of tests on pipes or specials where the delivery is less than 50 in number.

Supplier, on the request of the Engineer, shall arrange the manufacturer to test samples from the production line in the presence of the Engineer or a nominated agency and ensure that the pipes and fittings produced are in conformity with the standards specified in BS 4346: Part 1: 1969 and BS EN ISO 1452-1:2009.

Hydrostatic test certificates in respect of pipes and fittings manufactured in accordance with, or to a standard not inferior to BS 4346: Part 1: 1969 and BS EN ISO 1452-1:2009 shall be supplied for pipe and fittings separately.

If there are no facilities in Maldives for carrying out the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere at no extra cost. Any materials or workmanship which is shown by such tests not to be in accordance with the specifications shall be rejected not withstanding any previous certificates, which may have been provided.

2.5.6. Acceptance or Rejection of Consignments

Any pipe or fitting which fails to satisfy the requirements of the Specification shall be rejected. However the pipe or fitting which fails to satisfy any of the tests specified in the relative clauses of this specification the test in question shall be repeated on two further samples. Such samples shall be selected from the same pipes lot or from a second selection by agreement between the Supplier and the Engineer and should either of these further samples fail any of the tests, the pipes or fittings represented shall be deemed not to comply with these tests in which the samples failed and whole lot of such pipes or fittings so represented shall be rejected.

One set of "Go/No Go" gauges shall be provided for checking the circularity of each size of uPVC pipe and specials on arrival at their destination.

SECTION 3 PIPE LAYING

Section 3 Pipe Laying

3.0. Scope

This section covers the requirements for the procedures for pipe laying and its components.

3.1. Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

3.2. Reference Standards

The following standards are referred to in this section;

BS EN 1610:2015	Construction and testing of drains and sewers
BS EN 752:2008	Drain and sewer systems outside buildings

3.3. Preparation of Trench Bottom:

Pipe shall be laid directly on a trench bottom containing coupling holes so as to provide a continuous contact with the pipe between coupling holes.

Coupling Holes: Prior to lowering pipe into the trench, a coupling hole shall be dug in the trench bottom having a length, width, and depth to allow assembly and to maintain a minimum clearance of two inches (2") between coupling and undisturbed trench bottom. Shaping Trench Bottom: Prior to lowering pipe into the trench, the trench bottom between coupling holes shall be made flat and cut true and even to grade so as to provide continuous contact of the trench bottom with the pipe.

3.4. Lowering Pipe and Accessories into Trench:

All pipe, fittings, valves, hydrants, and accessories shall be carefully lowered into the trench using suitable equipment in such a manner as to prevent damage to pipe and fittings. Under no circumstances shall pipe or accessories be dropped or dumped into the trench. The pipe and accessories shall be inspected for defects prior to lowering into trench. Any defective, damaged, or unsound material shall be repaired or replaced. All foreign matter

or dirt shall be removed from the interior of pipe before lowering into position in the trench. Pipe shall be kept clean.

3.5. Installation of Pipe:

In the case of PE pipes the pipes shall be jointed above ground by fusion welding and lowered into trench as one length between junctions. In case of uPVC pipes, After a length of pipe has been placed in the trench with the spigot end forced home in the bell of the adjacent pipe, it shall be brought to the correct line and grade, and secured in place by tamping an approved backfill material around it.

Whenever pipe laying is not in progress, the open ends of pipe shall be closed either with a watertight plug or by other approved. means. If there is water in a trench, this seal shall be left in place until the trench has been pumped completely dry.

The pipe shall be cut so that valves, fittings, or closure pieces can be inserted in a neat and workmanlike manner and without any damage to the pipe. The manufacturer's recommendation shall be followed concerning how to cut and machine the ends of the pipe in order to leave a smooth end at right angles to the pipe's axis.

Properly restrained bends shall be used for all major alignment changes. Joint deflections shall only be used for minor alignment changes necessary to avoid obstructions. Long radius curves by joint deflection shall only be used if approved by the Board. In any event, joint deflectors shall not exceed manufacturer's recommendations, or that necessary for the joint to be satisfactorily made.

No pipe shall be laid in water or when trench conditions are unsuitable. If crushed stone is used to improve trench conditions or as backfill for bedding the pipe, its use is considered incidental to the project, and no separate payment will be made for its use.

Where a water line crosses over a sanitary sewer, a full length of pipe shall be used with its joints straddling the sewer. Where a water line is to be parallel to a sanitary or storm sewer, it shall be laid at least 10' from the sewer. If it is not practical for the water and sewer lines to be separated as described above, the water line shall be laid at least 18" above the top of the sewer. All pipe shall be joined in the exact manner specified by the manufacturer of the pipe and jointing materials.

3.6. Pipe Laying

The bedding for pipes shall be constructed by spreading and properly compacting suitable granular bedding materials over the full width of the trench. For normal bedding the trench bottom shall be given a final trim and shape so that the pipe will be uniformly bedded on the required grade. Any stones or flints likely to damage the pipe or its coating shall be picked out of the pipe bed, and any hole so formed shall be filled with soft material and trimmed to the correct level.

Pipes and fittings shall be carefully examined for cracks and other defects immediately before installation. The interior of all pipes and fittings shall be thoroughly cleaned of foreign matters before being installed and shall be kept clean until the work has been installed. Before jointing, all joint contact surfaces shall be wire brushed if necessary, wiped clean, and kept clean until jointing is completed.

The pipe shall be laid directly on the trench bottom or bed prepared as above, in perfectly straight lines and true gradients in accordance with the plans and sections shown on the drawings or as otherwise directed by the engineer. Pipes shall be embedded properly by placing embedment materials and shall be protected from lateral displacement during embedment operations.

Bricks or other hard materials shall not be placed under the pipes for temporary support except where a concrete bed is to be provided. Precautions shall be taken to prevent foreign materials from entering the pipe during installation. Pipe laying shall begin at the lowest elevation with bell ends facing the direction of laying except when reverse laying is permitted by the Employer.

Whenever pipe laying is stopped, the open end of the pipe shall be closed to keep sand and earth out of the pipe. All necessary steps shall be taken to prevent the pipe from floating in the event of flooding of the trench.

Socket pipes shall be laid singly with the sockets uphill unless shown otherwise on the drawing and each spigot end shall be pushed into the next socket so that the space between the surfaces of the joint is one thirtieth of the internal diameter of the pipe or 10mm whichever is less. This space shall be established by marking the spigots or by other approved means.

Joint preparations and jointing operations shall comply with the instructions and recommendations of the pipe manufacturer. Immediately before joints are pushed together, all joint surfaces shall be coated with the lubricant furnished with the pipe. The position and condition of each rubber gasket (unbounded gaskets) shall be checked with a feeler after the joint is completed.

Connection between new work and existing pipes and junctions or manholes shall be made under conditions which will least interfere with service to users. Where pipe has to be connected to the existing manholes or junctions the opening, if required, for pipe connection shall be made as directed by the engineer. Approved leak proof cement shall be used for such installation or connection of pipes and shall be carried out as directed by the engineer.

Pipes and fittings passing through or into concrete shall be grip bonded in order to get a satisfactory bond with the concrete. This is achieved by painting the surface with solvent cement and whilst it is wet, sprinkling with dry course sand or grit. Once the surface is dry, it is ready to bond directly to concrete.

The pipe should be laid to the gradient shown in the drawing on a selected bedding material properly compacted to the satisfaction of the engineer. Up to 300 mm above the pipe, only selected soil without sharp stones should be placed in 150mm layers and compacted properly.

The contractor should installed “Y” branches / Tees where necessary and at the location given in the drawing or directed by engineer on to the pipe while laying the pipe. The Y connections shall be installed in the E pipe prior to lowering the pipe into the trench. The PE part of the pipe shall be stopped as shown in the drawing, 600mm below ground level.

Where a minimum cover above the crest of the pipe is less than required cover, concrete encasing of 300mm all around the pipe shall be provided. The concrete shall be Grade 20 mixed using mixing machine. In stretches where lateral pipes are to be provided, contractor should lay the laterals along with the laying of main sewer.

Where the lateral pipes are to be encased in concrete, it should be 300mm 1:2:4(20), right round properly compacted as directed. The pipe should be end capped. Where the drain water gutter boxes obstructs laying of the lateral, contractor should make an opening and place the pipe across those. And encase the pipe in concrete as directed by the engineer. A construction joint shall be provided at every pipe joint.

3.6.1. Pipe Jointing

3.6.1.1. Pipe Jointing for UPVC pipes

The following procedures must be followed for pipe jointing in UPVC pipes.

- Install gaskets in accordance with manufacturer's published instructions.
- Align pipe carefully before joining. Do not use excessive force to join pipe sections.
- Support pipes as required to assure concentricity until joint is properly completed. Keep pipe joints free from mud, silt, gravel or other foreign material.
- Avoid displacing gasket or contaminating with dirt, petroleum products, or other foreign material. Remove, clean, reinstall and lubricate gaskets so disturbed.
- Where deflection at joints is permitted, deflect only after joint is completed. Do not exceed maximum joint deflection recommended by manufacturer.
- Cut pipe as required for fittings or closure pieces, square to centerline, and as recommended by manufacturer.
- Make watertight connections to manholes and structures as recommended by manufacturer.
- At structures, ensure joint is correctly aligned or provide flexible joint not more than 300 mm from outside face of structure, or as otherwise indicated.
- For pressure mains provide thrust blocks for change in directions and pipe ends. Thrust block size calculations shall be approved by concerned engineer prior to installation. Thrust block concrete shall be with minimum 20MPa compressive strength.
- Ballast concrete shall be with a minimum compressive strength of 25MPa.

3.6.1.2. Pipe Jointing for HDPE pipes:

The following procedures must be followed for pipe jointing in HDPE pipes.

- Assemble and join outfall pipe sections into one continuous pipe length by the thermal butt fusion welding process as recommended by the pipe manufacturer. Perform jointing by qualified personnel in accordance with manufacturer's requirements using pipe jointing equipment approved by pipe manufacturer.
- Proper protection should be provided for the jointing equipment as required by the manufacturer to maintain suitable ambient conditions while jointing is in progress.

- Provide a joint certification for each joint made including recording the conditions under which jointing took place.
- Flanged joints: Allow pipe lengths to be joined to cool to ambient soil temperature before joining.
- Align pipes properly and install so one face is in compression against other.
- Do not use bolts to pull pipe ends to overcome gap or misalignment.
- Leave flanged joints exposed for minimum hours. Retighten bolts before pressure testing. Pipe passing through sleeve across reef is to be a single pipe length.

Whenever pipes are laid directly on the trench bottom or on a sand or granular bed, depressions shall be formed in the bedding at the pipe joints to ensure that the pipe is uniformly supported throughout the length of it's barrel. Whenever pipes are laid directly on the trench bottom, this shall be trimmed and levelled to provide uniformed support to the whole length of the barrel. All rocks and other material likely to cause damage to the pipes shall be removed from the trench bottom and the voids filled with granular material.

Pipes shall be laid on setting blocks only when a concrete bed is to be used.

Pipes shall be accurately laid to lines, levels and grades shown on the Contract Drawings.

Departures from these shall only be made by prior agreement with the Engineer. Measures shall be taken to prevent debris etc. from entering the pipes as installation proceeds, and to anchor each pipe to prevent flotation or other movement before the construction is completed. Open ends of pipes shall be sealed at the end of each day's operations.

3.7. Granular Bedding

Granular bedding for pipes shall be constructed by spreading and compacting the material over the full width of the pipe trench. After the pipes have been laid, a haunch may be formed by placing and compacting additional material either side of the pipe. Bedding shall be 150 mm thick and shall consist of a single size of less tan10mm.

3.8. Concrete Bedding

Concrete bedding for the pipes shall be constructed by first placing the pipes on setting blocks, the top face of which shall be covered with two layers of compressible packing. The concrete shall be placed to the required depth in one operation.

Where the pipes have flexible joints, the concrete bedding shall be continued over it's full cross-section, at intervals not exceeding 6 meters, by a shaped former of compressible filler. The interruption must coincide with the pipe joints.

3.9. Concrete Surrounding

Where full concrete protection of the pipes is required, further concrete shall be placed over the pipes after partial curing of the concrete bed. Shaped formers of compressible filler shall be used where the pipes have flexible joints, and these shall be placed coincident with those provided for the bedding such that the whole cross - section of the bed and surround is interrupted.

3.10. Disposal of Water

Water shall not be permitted to accumulate in any part of the works. Water arising from or draining into excavations shall be drained or pumped to approved disposal points. No existing foul sewer, or completed pipeline of the sewerage system under construction, shall be utilized for the drainage of excavations.

Where temporary drains are required, they shall be open jointed and laid in a narrow trench below the main trench bottom in an approved position.

Precautions shall be taken to prevent adverse effect on adjacent land due to loss of fines as a result of removing water from excavations.

3.11. Pressure Pipeline

3.11.1. Material

The material of all pressure pipelines in the project shall be Poly-ethylene.

3.11.2. Execution

A. Inspection of Materials: A careful field inspection shall be made of all material before installation, and any material found to be damaged in shipment or not meeting the requirements of the specifications will be rejected and replaced. B. Alignment and Grade:

1. All pipe shall be laid and maintained to the required lines and grades. Fittings, valves, and hydrants shall be at the required locations and with joints centered, spigots home, and all valves and hydrant stems plumb.

2. Temporary support and adequate protection and maintenance of all underground and surface utility structures, drains, sewers, and other obstructions encountered in the progress of the work shall be furnished by the contractor.

3. Where the grade or alignment of the pipe is obstructed by existing utility structures such as conduits, ducts, pipes, branch connections to main, or main drains, the obstruction shall be permanently supported, relocated, removed, or reconstructed by the contractor in cooperation with owners of such utility structures.

4. All pipe shall be laid to the depth shown on the contract drawings or as required by the Engineer in writing. The depth shall be measured from the established street grade or the surface of the permanent improvement to the top of the pipe barrel.

   This depth shall not be less than 300 mm.

3.12. Pipeline Pressure and Leakage Testing

3.12.1. Scope

This section covers the requirements for carrying out pressure testing and leakage testing for the pipeline system

3.12.2. Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

3.12.3. Testing Schedule and Procedure

The Contractor must submit in advance the schedule and procedure for testing the pipeline system. This must include the detailed procedure, methods, equipment, sequences and a tentative schedule for approval by the Consultant and Island Authorities.

3.12.4. Pressure Testing

All pipes and appurtenances must be hydrostatically tested while conforming to the relevant standards.

3.12.5. Leakage Testing

Leakage testing must be carried out in parallel with the pressure test to ensure that pipe joints are watertight

3.12.6. Pressure Testing (Pipe Lines) and Leakage Testing

All pipes shall be tested after laying and before backfilling by carefully filling the main with clean water, taking care that all air is expelled from the main. An accurate clearly readable pressure gauge shall then be connected to the main together with a pump and the pressure in the main shall be raised to required test pressure specified below. The Pump Shall be then disconnected for a period of at least two hours, after which the pump should be reconnected, its container filled with water to a specified mark and pumping carried out until the pressure rises again to the test pressure. Valves shall be tested by applying a pressure not less than working pressure to one side of the closed valve to prove that the valve is sealing properly.

The Amount of water used from the pump container must be measured and the test shall be considered unsatisfactory if the amount of water consumed is more than specified below.

An objective for apparent loss due to such factors is 2 litres per meter of nominal bore, per kilometre length, per meter head per 24 hours of test pressurisation.

$$Q = 2(litres)\ x\ diameter\ (m)\ x\ length\ (km)\ x\ head\ (m)\ per\ day.$$

Where Q equals to measured volume of make up water in litres.

Allowable loss in water line is as follows.

Nominal Dia. Of Pipe (mm)	Loss in litre/km length/head (in m)/day
100	0.2
150	0.3
200	0.4

If the test is unsatisfactory, the contractor shall examine the pipe joints and fittings and make good any defects and shall re-test the pipes in the same way until a satisfactory test, witnessed by the engineer, has been carried out. Any pipes, fittings or joints broken under pressure shall be taken out and replaced at the contractor's expense.

All exposed pipe, fittings, valves, hydrants and joints shall be examined carefully for visible leaks during the leakage test. The Contractor must provide for the testing and subsequent detection of leaks, if any, all necessary stoppers, caps, pumps, accurate gauges, supports, water and other necessary apparatus and materials which must be of a type approved by the consultant.

Before any test is carried out all changes of direction in the pipelines, junctions, stopped ends and the like shall be securely anchored so that no moment can take place under the test pressure.

Any Leak which is found to occur in a pipeline after backfilling and before the end of the maintenance period shall be located, rectified and all necessary reinstatement carried out at the contractor's expenses all to the satisfaction of the consultant.

Water shall not contain injuries amounts of harmful impurities which may adversely affect quality of work. Portable fresh water shall be used for pressure testing, leak test and cleaning purposes. Saline water shall not be allowed to use for the above purposes.

Contractor shall bear the cost of water.

All pipe lines that are not subjected to gravity flow including riser mains and sea outfalls shall be tested at 6.0 bar head or 1.5 times of working pressure whichever is the greater. Gravity Sewer (PE pipes) shall be tested at 2.0 bar head. The duration of each successful

pressure test shall be at least 2-3 hours. The specified test pressure (based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge) shall be applied with a pump connected to the pipe.

All exposed pipes, fittings, valves, and hydrants shall be carefully examined during the test. Any cracked or defective pipes, fittings, valves, or hydrants discovered in consequences of this pressure test shall be removed and replaced with sound material in the manner specified. Repeat the test until the results are satisfactory.

3.12.6.1. Leakage testing for gravity sewer pipes

3.12.6.1.1. Low Pressure Air Test

The low pressure air test must be conducted, by a pumping method approved by the Consultant, between two consecutive manholes in accordance with ASTM F 1417 for plastic pipe. Air must be pumped for about five minutes into the tested section at a pressure equal to 100 mm of water on the pressure gauge where the pressure should not fall below. All pipe outlets must be plugged in the section being tested with suitable test plugs.

3.12.6.1.2. Exfiltration test

The groundwater elevation should be determined and the sewers in the downstream manhole and incoming pipes in upstream manhole should be plugged. Riser pipe should be installed in the outgoing pipe of upstream manhole when highest point in service

lead is less than 0.7 m below the bottom of manhole cone. The sewer pipe and manhole or pipe riser should be filled with water to point 0.7-0.15 meters above highest point in sewer pipe, house lead, or ground water table, whichever is highest. The water should then be allowed to stabilize for 1-2 hours and a reading taken to determine drop of water surface, over a one-hour period, and calculate water loss or measure quantity of water required to keep water at same level. Loss shall not exceed 0.12 litres per hour per 100 meters of pipeline per millimetre of nominal internal diameter of the pipe.

3.12.6.1.3. Infiltration Test

The total infiltration, which may be measured by means of a weir located in the downstream manhole, must not exceed 6 litres per day per millimetre of nominal bore per kilometre of pipeline. This infiltration test may not be performed until the sewer line and manholes are completed and all known leaks are repaired.

3.12.7. Cleaning Pipelines

Interior cleaning: As required by the specification, the interior of all pipe and fittings shall be thoroughly cleaned of foreign matter before being installed. Precaution shall be taken to prevent foreign material from entering the pipe during installation. Debris, tools, clothing, or other material shall not be placed in or allowed to enter the pipe. Whenever pipe laying is stopped, the open end of the pipe shall be sealed with a watertight plug which will prevent trench water from entering the pipe. Contractor shall use suitable sterilization agent to clean the pipe before and after installation and such cost shall be bared by contractor.

Specifications: Immediately before pipelines and manholes and other works are taken over by the Employer the contractor shall, at his own expense, rod out and flush all sewers and manholes, and wash out all rising mains and other pipe work to ensure that there are no obstructions. The contractor shall make good any defects located to the satisfaction of the engineer. The contractor shall also, in presence of the Engineer's representative, pass a loose plug through the whole of the pipelines in order to ensure that they are entirely clear of obstruction and that the invert is smooth. The loose plug shall be in the form of a cylinder, made of timber not less than 25 mm thick or any other material approved by the consultant, and the outside diameter shall be 25 mm less than the pipe diameter or one tenth of pipe diameter whichever is the lesser and its length shall not be less than its diameter. The whole cost of providing the plugs and carrying out this work shall be borne by the contractor.

Cleaning of pipelines: All pipelines conveying water or wastewater installed under this contract, including all valves and fittings installed therein, shall be flushed or cleaned to

the satisfaction of the engineer. Flushing shall precede disinfection for potable water piping and valves. Potable water shall be used on the potable water system only. No crossConnection condition shall be allowed on the potable water system at any time. Small pipelines shall be flushed with water at the maximum velocity which can be practically developed. The flushing velocity shall be at least one meter per second, unless otherwise permitted by the engineer. Booster pump shall be used if required to obtain the necessary volume or velocity of water.

3.12.8. Reaction Anchorage and Blocking

All exposed piping with mechanical couplings, push-on-or mechanical joints, or similar joints subject to internal pressure shall be blocked, anchored, or harnessed to preclude separation of joints. All un-lugged bell and spigot or all bell tees, Y - branches, bends deflecting 11¼ degree or more, and plugs or caps, which are installed in buried piping subjected to high internal hydrostatic head, shall be provided with suitable reaction blocking, anchors joint harness, or other acceptable means for preventing movement of the pipe caused by internal pressure.

Reaction blocking shall extend from the fitting to solid undisturbed earth and shall be installed so that all joints are accessible for repair.

3.12.8.1. Pipe Flexibility

Unless noted otherwise on the drawings pipes passing out of or into manholes, and under or from under structures, shall have their first flexible joint at a position not greater than one pipe diameter from the manhole or vertical line through the face of the overlying structure.

3.12.8.2. Junction and drain Connections

All junctions are to be oblique and unless the connection is to be laid at the time the junction is laid, are to be fitted with suitable stoppers obtained from the manufacturer of the pipe.

No saddles shall be used except with the prior approval of the engineer, which will only be given exceptional circumstances. If the contractor omits to lay a junction as directed, then the engineer may require the necessary pipe or pipes to be taken out and replaced with the proper junction all at the Contractor’s expenses.

3.12.8.3. Protection of Steel Couplings

Viking Johnson Couplings, Viking Johnson Flange Adaptor and Vicking Johnson Stepped Couplings shall be protected by the Denso plast Strip System or other equal and approved. The metal Surfaces to be protected shall be kept clean and dry during all subsequent operations. The entire joint shall be primed with Denso Priming Solution, including a minimum overlap of 100 mm onto any existing pipe coating.

Denso Mastic Plast or equivalent (Strips) measuring 915 mm x 250 mm x 10 mm shall then be applied to the joint with the scrim carrier to the outside, after first having discarded the plastic film interleaving. Each strip shall be firmly moulded to the contours of the joint so that on completion the entire joint is firmly encased in mastic. On pipes of 219mm and above where more than one strip is required to go around the joint, the overlap between successive strip should be 25 mm; the overlap being in downward direction. On the pipes of 165 mm and above, where two strips are required across the joint, the overlap between adjacent strips should be not less than 25 mm. After application of the mastic two separate turns of Denso Tape shall be circumferentially wrapped around the joint, care being taken to form the tape into the angle between the flanges and the pipe and to smooth down any underlying air pockets or folds. The tape shall commence and finish on top of the joints and shall overlap onto the pipe barrel by a minimum distance of 25 mm on either side of the joint.

3.12.8.4. Grip bonding of pipes & fittings

All pipes and fittings passing through or into concrete shall be grip bonded in order to get a satisfactory bond with the concrete. This is achieved by painting the surface with solvent cement and whilst it is still wet, sprinkling with dry coarse sand or grit. Once the surface has dried, it is ready to bond directly to concrete.

3.12.8.5. Testing

After laying the pipes and before back filling the contractor shall carry out the following, as directed by Employer.

a) Pressure testing in pipe lines (leak test)

b) Alignment

c) Gradient / Levels

d) Conditions and stability of bed.

If the test is unsatisfactory, the contractor shall make good any defects and shall retest the pipes until a satisfactory test has been carried out. The contractor shall provide water, apparatus and materials for testing and subsequent detection of leaks. The water used for testing shall not be saline.

On completion of laying of pipes and construction of consecutive two manholes, contractor should test the pipes and manhole for leaks. The ends of the pipes should be plugged with packer with a transparent tube connected to it placed at the upstream end will be used to monitor the leaks. The pipe shall be filled until the water level in the tube is 1 .5m above the invert of the pipe and monitored for 30 minutes after waiting for two hours to stabilize. The drop in level shall not be more than 4.5mm per meter length tested. Water for testing shall be provided by contractor and water used for testing should not be saline.

The Sewer mains shall be tested to a test pressure of 2.0 bar. Prior to testing of sewers, the internal surfaces of pipes and inspection chambers shall be thoroughly cleansed. Previously cleansed and tested sewers, shall not be used to drain water and matter from sewers being cleansed.

Each section shall be tested progressively by the Contractor during construction, each time two pipes are laid. No backfilling of trenches shall be carried out until a successful test has been completed on the pipes to be backfilled.

After backfilling, branch gravity networks mains should be tested under the inspection of the Engineer. Pressure testing shall be carried out from Inspection Chamber to Inspection Chamber or Cleanout to Inspection chamber.

All open ends and connecting branches in gravity sewers shall be stopped with suitable plugs or caps, before testing commences.

3.12.9. Field Quality Control

3.12.9.1. Acceptance tests

Each reach of sewer shall meet the requirements of the following acceptance tests. All defects shall be repaired to the satisfactions of the engineer.

3.12.9.2. Lamping

Unless otherwise indicated on the drawings, each section of sewer line between manholes shall be straight and uniformly grades. Each such section will be lamped by the contractor in the presence of engineer representatives.

3.12.9.3. Exfiltration

After completing the installation of a sewer line or section of the line, and before backfilling of the line, an exfiltration test shall be carried out on each reach of sewer between manholes. Individual or multiple reaches may be tested at one time as approved by the engineer.

Exfiltration and shall be conducted by blocking off all manhole and Y branch openings, except those connecting with the reach being tested, filling the line, and measuring the water required to maintain a constant level in the manholes. Each manholes shall be subjected to at least one exfiltration test.

During the exfiltration test, the average water depth above the pipe invert shall be 2000 mm or the full depth of the upper manhole. The total exfiltration shall not exceed 30 litres per mm of nominal diameter per km of pipe per day for each reach tested. For purposes of determining maximum allowable leakage, manholes shall be considered sections of 1200 mm pipe. The exfiltration tests shall be maintained on each reach for at least 2 hours and as much longer as necessary, in the opinion of the Engineer to locate all leaks.

The Contractor shall provide, at his own expense, all necessary piping between the reach to be tested and the source of water supply, together with equipment and materials required for the tests. The methods used and the time of conducting exfiltration tests shall be acceptable to the Engineer. All water required for cleaning and for flushing and disinfection shall be furnished by the contractor at his own expenses.

3.13. Sea outfall pipe line

i. This section deals with the particular requirements of sea outfalls to be constructed from pumping station on land to the deep sea beyond the reef. The outfall shall

conform to the general requirements for pipelines valves and earthwork specified in the specification.

ii. This contract includes the construction of sea outfall pumping main from pumping station along the sea bed up to the deep sea beyond the reef as shown in the Drawings and as instructed by Engineer.

iii. iii. The tender drawing provides an indicative seabed profile. The contractor shall confirm this profile deploying divers.

iv. The sea outfall main shall be of High Density Polyethylene pipe.

v. The outfall main shall be prevented from floatation using ballast block.

vi. The outfall shall be laid to a depth of 1m below the ground until it reaches the sea and then continue along the sea bed in the direction as shown on the Drawings. The exact location of the outfall shall be approved by the Engineer before commencement of any construction.

vii. The outfall shall be laid on the sea bed with depths below sea level as shown in the drawing. The pipes shall be weighted down by pre-cast concrete anchors as shown in the detailed drawing. The pipes shall rest on the anchor blocks. The pipe shall be placed in the natural rock bed grove as shown in the drawings. The contractor shall ensure that suitable methods, equipment and materials are employed and shall allow for such items in his pricing.

viii. The contractor shall obtain all information regarding variation of tide levels, currents, winds and other relevant information from the appropriate authorities prior to finalizing his proposals. The contractor shall submit his detailed proposals for construction of the outfall for approval of the Engineer before commencement of constructions.

SECTION 4 – MANHOLES

Section 4 – Manholes

HIGH DENSITY POLYETHYLENE MANHOLES

4.0. Scope

This section covers the requirements for carrying out pressure testing and leakage testing for the pipeline system

4.1. Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

4.2. Reference Standards

The following standards are referred to in this section and the drawings relevant to this section;

ASTM D3350 - 14	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM D1505 - 10	Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D1238 - 00	Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D790 - 10	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D638 - 14	Standard Test Method for Tensile Properties of Plastics
ASTM F1473 - 13	Standard Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins

ASTM D2837 - 13e1	Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
ASTM F1759 - 97(2010	Standard Practice for Design of High-Density Polyethylene (HDPE) Manholes for Subsurface Applications
ASTM D2657 - 07(2015)	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
ASTM C1147 - 14	Standard Practice for Determining the Short Term Tensile Weld Strength of Chemical-Resistant Thermoplastics
ASTM D2321 - 14e1	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

4.3. Materials

The pipe for the manholes shall be made from high-density polyethylene (HDPE) resins meeting the following requirements:

4.3.1. HDPE Material

The HDPE material supplied under this specification shall be high density, high molecular weight. The HDPE material shall conform to ASTM D-3350-14 with minimum cell classification values of 345464 C.

4.3.2. Physical Properties of HDPE Compound

i. Density- the density shall be not less than 0.95 5 gms/ccm as referenced in ASTM 1505.

ii. Melt Index- the melt index shall be no greater than 0.15 gms/10 minutes when tested in accordance with ASTM 1238.

iii. Flex Modulus-flexural modulus shall be 110,000 to less than 160,000 psi as referenced in ASTM D 790.

iv. iv. Tensile Strength at Yield – tensile strength shall be 3,200 to less than 3500 psi in accordance with ASTM D 638.

v. Slow Crack Growth Resistance shall be per ASTM F 1473 (PENT Test). The results shall be greater than 100 hours.

vi. Hydrostatic Design Basis shall be 1,600 psi at 23 degrees C when tested in accordance with ASTM D 2837.

4.4. Submittals and Quality Assurance QA/QC Certification

The Contractor must provide Quality Assurance Certificates, established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent, for the supply items have been subjected to the tests performed as per applicable standards. The certificate shall be valid for a period covering the manufacture of the certified items. If the Contractor is not the manufacturer, the Contractor will provide the Quality Assurance Certificates of the original manufacturer. The materials shall be suitably marked to enable them to be identified from references on the certificates.

The manhole supplier shall submit certification that the HDPE material meets the specifications.

The fabricator of the manholes shall submit drawings showing the position of the inlets, outlets and the overall dimensions along with any other special features such as man ways, ladders, etc.

The fabricator shall submit data indicating that the manholes meet the requirements of ASTM F 1759, “Design of High Density Polyethylene (HDPE) Manholes for Subsurface Applications”.

The manhole should be proven to have acceptable design for the following areas:
a) Ring Compressive Strain

b) Combined Ring Compressive and Ring Bending Strain

c) Ring Buckling

d) Axial Strain

e) Axial Buckling

f) Thickness of the bottom based on depth and groundwater. Thickness should be based on acceptable stress and deflection amounts.

- Calculations supporting these requirements will be part of the submittal package.
- The fabrication technician shall perform work in accordance to butt fusion of high-density polyethylene per ASTM D2657 and for extrusion and hot air welding per ASTM C 1147. The fabricator shall submit the written quality assurance program used during fabrication of the manholes. The fabricator may be required to submit their overall QA/QC program for fabricating thermoplastic structures, the welding certification program for the fabrication technician per ASTM C 1147 and the facility safety program.
- The manholes and pipe shall be tested with water or air. The structure shall be determined to be leak free before shipping. A written certification shall be sent to the engineer certifying the manholes are leak free. The test results shall become part of the submittals. An identification plate indicating, the job number, testing data, and when built and by whom, shall be attached to the manhole.

If Certificates are not provided or if the Engineer determines that testing is required, the Contractor shall arrange for inspection, testing and obtaining of such information as may be required to be carried out at the place of manufacture according to this Specification. If there are no facilities in Maldives for carrying out the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere at no extra cost. Any materials or workmanship which is shown by such tests not to be in accordance with the specifications shall be rejected not withstanding any previous certificates, which may have been provided.

4.4.1. Approval or Rejection

- Written approval or rejection of substitution given by the ENGINEER.
- ENGINEER reserves the right to require proposed product to comply with color and pattern of specified product.
- In the event substitution results in a change of Contract Price or time, provisions in the Agreement will be applied for adjustment.
- Substitutions will be rejected if:

1. Submittal is not through the CONTRACTOR with his stamp or approval.
2. Requests are not made in accordance with this Section.
3. In the ENGINEERS opinion, acceptance will require substantial revision of the original design.
4. In the ENGINEERS opinion, substitution is not equal to original product specified or will not perform adequately the function for which it is intended.

4.4.2. Third Party Testing

The Contractor must provide Quality Assurance Certificates, established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent, for the supply items have been subjected to the tests performed as per applicable standards. The certificate shall be valid for a period covering the manufacture of the certified items. If the Contractor is not the manufacturer, the Contractor will provide the Quality Assurance Certificates of the original manufacturer. The materials shall be suitably marked to enable them to be identified from references on the certificates.

If Certificates are not provided or if the Engineer determines that testing is required, the Contractor shall arrange for inspection, testing and obtaining of such information as may be required to be carried out at the place of manufacture according to this Specification. If there are no facilities in Maldives for carrying out the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere at no extra cost. Any materials or workmanship which is shown by such tests not to be in accordance with the specifications shall be rejected not withstanding any previous certificates, which may have been provided. Notwithstanding the above, the Contractor will be required to rectify any deficiencies which are attributable

to defects in the workmanship or quality during the Defects Liability Period specified in the contract.

4.4.3. Deviations- Procedure for requesting substitute Consider after award of Contract.

A letter defining the deviation and justification must be sent to the engineer. The letter must identify:

1. The Product
2. Manufacturer's Name
3. Representative Contact Name and Telephone Number
4. Specification Section or drawing reference of originally specified product
5. Discrete name or tag number assigned to original product in the Contract Document.

Manufacturer's literature clearly marked to show compliance of proposed product with Contract Document. Itemize comparison of original and proposed product addressing product characteristics including but not necessarily limited to:

1. Size
2. Composition or material of construction
3. Weight
4. Electrical or mechanical requirements
5. Product Experience:
    a. Location of past projects utilizing product
    b. Name and telephone numbers of persons associated with referenced projects knowledgeable concerning proposed product.
    c. Available field data and reports associated with proposed products 6. Data relating to changes in construction schedule
7. Data relating to changes in cost.

8. Samples: At request of the Engineer, a full size sample may be required. This sample maybe held by the Engineer until completion of the project.

4.4.4. Rejection

The high-density polyethylene manholes may be rejected for failure to meet any of the requirements of this specification.

4.5. HDPE Manhole Construction

The HDPE manholes shall be constructed of HDPE pipe with a nominal OD as specified. For sizes above 1.5 metres , a profile wall pipe can be used. The service conditions will determine the class of pipe. Calculations must be provided to verify the wall thickness to be used.

The bottom thickness of the manholes will be determined in accordance with ASTM F 1759. Calculations must be provided to justify the thickness of the bottom.

The inlets and outlets shall be extrusion welded on the inside and outside of the structure using good welding practice. Gussets shall be attached at 90 degrees, 180 degrees, 270 degrees, and 360 degrees around the inlets and outlets unless impractical.

All manhole connections larger than 110mm OD pipe shall be butt fusion welded, electrofusion welded, or flanged connections. For 110mm OD pipe and smaller threaded transition fittings can also be used as well as the acceptable connections listed.

Manholes shall be factory tested with water or with air. The hydrostatic test shall be conducted by filling the structure with water and checking for leaks. Minimum test duration will be one hour. If air is used, 2 to 5 psi shall be used for 30 minutes. Data showing the

structure to be leak-free will be supplied. The owner or his representative may request to observe the test.

The ladders in the manholes, if specified, shall conform to standard. Top of the manhole shall be built to the requirements of the drawings. If air testing is required, flanged tops or man ways will be required. Reinforced concrete pads spanning the HDPE manhole will be required when HDPE manholes are used in traffic areas. A traffic rated frame and cover will be required. A professional engineer shall approve the design of the concrete pad.

Those calculations must be included in the submittal.

Where large changes in temperature are expected, restraints shall be designed as an integral part of the manhole by the fabricator/manufacturer to prevent strain at the inlets or outlets. These restraints shall be cast into a concrete collar around the pipe. Antiflotation and/or anti-settling anchor collars, if required, shall be designed as an integral part of the manhole by the fabricator/manufacturer of the manhole. Shop drawings, approved by the specifying engineer, shall be required for restraints, anchors, collars, etc. that are designed by the manhole fabricator/manufacturer prior to acceptance of the HDPE structures.

4.6. Construction Practices

Handling of Manholes. HDPE manholes shall be stored on clean, level, and dry ground to prevent undue scratching or gouging of the pipe. The handling of HDPE manholes shall be done in such a manner that there is no damage. Nylon slings are often used.

Flanged Connections. Flange adapters (where shown in the drawings) shall be attached to HDPE manhole inlets and outlet stubs during fabrication by butt fusion welding per ASTM D 2657. A ductile iron back up ring will be used with each flanged connection. The rings will use a standard ANSI 1 50# bolt pattern. Check the drawings for materials required for corrosive conditions.

1. Bolts shall be tightened in a "star pattern" to recommended torque values.
2. Bolts must be tightened a second time after 24 hours to insure a positive seal.
3. Gaskets are not required on HDPE to HDPE connections.

Pipe Joining. HDPE pipe shall be joined using butt fusion. All butt fusion welds shall be made as described in ASTM D 2657. Electrofusion welding can be used for making pipe welds. Hot air and extrusion welding are not permitted for pipe joining. All pipe and fittings welds shall be made using a Manufacturing Data Logger. The contractor shall maintain records of the temperature, pressure, and graph of the fusion cycle.

Handling of Fused Pipe- Fused segments of pipe shall be handled so as to avoid damage to the pipe. Limit bending of the pipe welded to fittings or manholes. Nylon slings are preferred.

Equipment Mounting- Special provisions must be made when mounting pumps in an HDPE manhole. Bolting directly to the wall of the HDPE structure is never recommended.

4.7. Direct Burial Installation

Trench Construction- The trench and trench bottom shall be constructed in accordance with ASTM D-2321, Section 6, Trench Excavation, and Section 7, Installation. The HDPE manhole shall be installed on a stable base consisting of 12" of Class I materials compacted to 95% proctor density per ASTM F 1759, Section 4.2. All required safety precautions for manhole installation are responsibility of the contractor.

4.8. Backfilling Around the Manholes:

The backfilling of earth around the PVC Inspection chambers / Catch pits or HDP manholes shall be in 150mm thick layers properly compacted with a mechanical vibrator.

All PVC catch pits/ Inspection chambers and HDPE Manholes shall be protected and supported by 150 mm concrete layer right round and water proofing compound shall be applied for such concrete surfaces.

Contractor shall make necessary drilling and making holes in Manholes and Inspection chambers to connect sewer pipe line.

SECTION 5- PUMPS

Section 5- Pumps

5.0. Scope

This part specifies the requirements for pumps in all the Pump stations, Central control room, all buildings, STP and roads inside the administration building premises.

Following clauses specify the general requirements and standard of workmanship for the equipment and installations.

5.1. Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

5.2. Reference Standards

The following standards are referred to in this section and the drawings relevant to this section. Submersible sewage pumps shall, but not necessarily be limited to, conforming to the following standards:

BS EN 1982:2008	Copper and copper alloys. Ingots and castings
BS EN 1561:2011	Founding. Grey cast irons
BS EN 13835:2012	Founding. Austenitic cast irons
BS EN 1092-2:1997	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Cast iron flanges
BS EN 1092-1:2007+A1:2013	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges
BS EN 1092-3:2003	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Copper alloy flanges

BS ISO 10816-1:1995+A1:2009, ISO 10816-1:1995	Mechanical vibration. Evaluation of machine vibration by measurements on non-rotating parts. General guidelines
BS EN 60034-1:2010	Rotating electrical machines. Rating and performance
BS EN ISO 9906:2012	Rotodynamic pumps. Hydraulic performance acceptance tests. Grades 1, 2 and 3
BS EN 60079-14:2014	Explosive atmospheres. Electrical installations design, selection and erection
BS 5512:1991, ISO 281:1990	Method of calculating dynamic load ratings and rating life of rolling bearings
BS EN 50525-1:2011	Electric cables. Low voltage energy cables of rated voltages up to and including 450/750 V (U0/U). General requirements
BS EN ISO 3506-1:2009	Mechanical properties of corrosion-resistant stainless steel fasteners. Bolts, screws and studs
BS ISO 1940-1:2003	Mechanical vibration. Balance quality requirements for rotors in a constant (rigid) state. Specification and verification of balance tolerances
BS 7671:2008+A3:2015	Requirements for Electrical Installations. IET Wiring Regulations

5.3. General Pump Requirements

Sewage pumps shall be mono-block, non-clog type and suitable for pumping raw un-screened sewage containing sludge, storm water, fibrous material, plastic pieces, and other floating material/debris commonly found in sewage. Pumps shall be capable of admitting soft solids of minimum 100 mm dia and capable of dealing with the sewage/sludge with specific gravity of 1.05. Motor operating speed shall not exceed 1450 rpm and in cases of

pumps with high discharge, pumps with motor rated at 960 rpm may be considered for submission.

Impellers shall be of single/double vane non-clog design. Additionally, a special contrablock cutting and tearing system should also be incorporated on the suction side of the pump for disposing of soft material, which would otherwise clog the pump.

Maintenance free anti-friction, permanently grease filled ball bearing shall be provided and this shall withstand all axial and radial forces at any point of operation. The weights of the revolving parts of the pumps including the unbalanced hydraulic thrusts of the impellers shall be carried by thrust bearings provided in each pump assembly.

The pump installation design shall be such as facilities automatic installation and removal of the pump without having to enter into the sewage pit. Profile gasket shall be provided in automatic coupling system so to avoid metal to metal contact between the pump and delivery bend to ensure leak-proof joint.

A reverse rotation prevention system shall be incorporated in the pump design to ensure that the pump does not start rotating in the reverse direction due to wrong electrical connection.

5.4. Contractor Submittals

In addition to the other requirements of the Specification, Contractor shall provide data and information described in the following paragraphs prior to manufacture of the specified pumps for sewage service.

The Contractor shall provide manufacturer's published pump curves, system curves and necessary hydraulic calculations to justify the pump model and configuration selected and proposed for supply and installation. A shop drawing shall be submitted by the Contractor clearly outlining the following information.

Technical Data Sheet on the pump(s) specifying the following:

- Pump Configuration

- Performance Curve from a factory test on a pump of similar configuration and application
- Plan, Elevation and Sectional drawing of the pump clearly indicating footprint, internal dimensions, allowed tolerances
- Velocity of liquid in pump suction at duty point
- Velocity of liquid in pump delivery at duty point
- Velocity of liquid in the pump casing or impeller eye at duty point
- Materials of construction shall be specified in detail and itemized against the sectional drawing of the pump proposed
- Material Certification sheets showing the material composition, strength and related properties such as hardness and related parameters
- The following technical information on pump and associated electrical equipment shall be completed, duly signed, stamped and enclosed with the Technical Bid by the Contractor at the time of submission of bids for this Contract.
- Submersible Pumps
- Motor for Submersible Pump-set
- Starter(s)

O&M Manuals and Instructions, which shall include all the documentation provided as above and as required in the Specification.

5.5. Pump Requirements

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the Specification without surging, cavitation, or excessive vibration to the limits specified. All pumps and drives shall be from approved manufacturers.

The pumps shall meet maximum allowable shut-off head (minimum 150% of the head at operating point, and if dry-mounted submersibles, the maximum allowable required net positive suction head (NPSH) designated in the Specification.

The pumps shall not overload the motors for any point on the maximum pump speed performance characteristic curve and the pump operating range, within the limits of stable pump operation, as recommended by the manufacturer, to prevent surging, cavitation, and vibration.

To ensure vibration-free operation, all rotating components of each pumping unit shall be statically and dynamically balanced to BS ISO 1940-1:2003 and the following requirements shall be met:

- The mass of the unit and its distribution shall be such that resonance at normal operating speeds is within acceptable limits
- In any case, the amplitude of vibration as measured- at any point on the pumping unit shall not exceed the below limits
- At any operating speed, the ratio of rotative speed to the -critical speed of a unit, or components thereof, shall be less than 0.8 or more than 1.3.

Vibration levels shall not exceed the levels given in BS ISO 10816-1:1995+A1:2009, ISO 10816-1:1995 for typical values of zone A and B. The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and oil or water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty.

The Contractor shall be responsible for proper operation of the complete pumping system, which includes the pump, motor, variable speed drive unit (if designated), and associated controls furnished with the pump. The Contractor shall ensure that the controls and starting

equipment are suitable for use with the pump motor, taking into account all requirements including starting currents and number of starts per hour.

For the performance curve of the selected pump impeller, the head shall continuously rise as flow decreases throughout the entire curve from run out to shutoff head. The Contractor shall ensure that drive motors, variable speed drive systems (if specified) and pumps shall be supplied and tested together by the pump manufacturer, who shall supply full certification for the proper function of the entire pumping system.

If variable speed drive systems are specified, motor and drive system shall be fully compatible, and shall be of sufficient power and torque, and be capable of sufficient heat transfer for starting, accelerating and continuously operating over the entire range of head/capacity conditions, from minimum to maximum pump operating speed, as designated. The motor shall be derated to take into consideration the reduced cooling effect when running at the lowest speed with the variable speed drive.

5.5.1. Design Conditions

Pumps shall be designed and manufactured to satisfactorily operate and perform within the designated design conditions and requirements specified herein. They shall be designed for a minimum service life of 100,000 hours with service intervals at 20,000 hours.

Castings, fabrications, machined parts and drives shall conform to industry standards for strength and durability and shall be rated for continuous duty over the entire operating range.

Bearings shall be of the anti-friction type designed for an L10 life of at least 50,000 hours in accordance with BS 5512. Pump maximum operating speed shall not exceed 1450 rpm. Pumps shall be of non-clog design, capable of passing solids of a minimum 1 00mm diameter sphere unless otherwise specified. Pumps shall be suitable for use in the conditions specified. Renewable impeller wear rings shall be fitted, to the impeller and case, except where not available on a standard production unit. Impellers shall be single / double vane non-clog design.

Submersible pumps shall have the duck foot bends flanged to NP16, BS EN 1092 or equivalent IS. In the case of dry mounted pump the outlet and inlet shall be flanged to NP16 BS EN 1092.

The pump, motor and associated electrical equipment shall be rated for a minimum 6 starts per hour, unless otherwise specified and shall also be capable of running non-stop for a minimum duration of 12 hours and maximum duration of 23 hours without exceeding the nominally allowable temperature and performance conditions. Contractor shall ensure that the pump manufacturer provides certification, which guarantees the following:

- Flow rate
- Total head
- Power input
- Pump and Motor Efficiency

5.5.2. Materials

Pumps shall be manufactured of the following materials as a minimum:

- Volute Casing and Impellers shall be stainless steel (CF8M) Impeller shall be of single/double vane non-clog design with a block cutting and tearing system incorporated on the suction side
- Casing wear rings and impeller wear rings shall be Stainless steel (CF 8 M)
- Bends shall be cast iron, BS: 1452 Grade 250
- Motor casings shall be cast iron, BS: 1452 grade 250
- Shafts shall be stainless steel according to BS EN 10250-4:2000
- Fasteners shall be stainless steel, BS EN ISO 3506-1, BS EN ISO 3506-2 and EN 1.4301. The lifting system shall be manufactured of the following materials:
- The guide rail system shall be stainless steel; BS EN 10088 Type 1.4401
- Lifting chains and cables shall be stainless steel; BS EN 10088 Type 1.4401.

5.5.3. Fabrication

Pumps shall be fabricated in accordance with the following requirements:

- Pumps shall be capable of handling raw, unscreened sewage
- In the case of submersible installations no portion of the pump shall bear directly on the floor of the wet well.
- Wet well pumps shall incorporate the following features:

- Pumps shall utilize a guide system to permit easy removal and reinstallation without dewatering the pump sump
- Discharge connections shall be made automatically with a simple downward motion without rotation when the pump is lowered into operating position. The pump shall be capable of being removed without disconnecting any fasteners
- An appropriate length of chain shall be connected to the motor eyebolts to permit raising and lowering of the pump
- Impellers shall be fabricated according to the rated motor size as follows:
- Non-clog type statically and dynamically balanced, keyed to the shaft
- Provided with pump-out vanes to prevent material from getting behind the impeller and into mechanical seal area
- Provided with wear ring as necessary to assure efficient sealing between volute and impeller
- Impellers shall not be trimmed unless approved by the engineer
- Single /multi vane or vortex type, with a cutter impeller in the case of small flows.

Discharge Connection and Guide Rails shall be fabricated as follows:

- Sliding guide bracket and discharge connections shall be provided which, when bolted to the floor of the sump and to the discharge line, will receive the pump discharge connecting flange without need of adjustment, fasteners, clamp, or similar devices.
- The guide rails shall not support any portion of the weight of the pump. The pump discharge connections shall incorporate a sealing face and connection yoke to allow for automatic coupling to fixed discharge connection pipe work.

Pump Shafts shall be fabricated as follows:

- Pump shafts shall be of such diameter that they will not deflect more than 0.05 mm measured at the mechanical seal, whilst operating at full driver output
- The shaft shall be turned, round and polished
- The shaft shall be key-seated for securing the impeller.

- Shaft Seals shall be fabricated as follows:
- The drive motor and pump/motor bearings shall be sealed along the shaft with tandem mechanical seals operating in an oil filled chamber. The seals shall require neither routine maintenance nor adjustment, but shall be capable of being easily inspected and replaced.
- Two back to back mechanical seals shall seal the motor off from the pump.
- The upper seal shall be oil lubricated with a carbon rotating component and fixed tungsten carbide component.
- The lower seal shall have both parts in tungsten carbide.
- A detector shall indicate when moisture is leaking past the first seal.

Bearings shall be fabricated as follows:

- Bearings shall be capable of taking the static weight of the rotating parts and any thrust generated by the operation of the pump
- The upper bearing(s) shall be of the grease lubricated sealed for life type; the lower bearing (s) shall be lubricated by the internal oil supply
- The bottom bearing(s) shall be of the angular contact ball bearing type in combinations with roller bearing(s)
- If required in the project specification, remote indication shall be provided for bearing high temperature using a thermistor at the lower bearing, to provide a signal at 95◦C.

Motors shall be fabricated as follows:

- Motors shall be 415 V/3 , 50 Hz, rated at 10 % above the maximum power requirement • Motors shall be squirrel cage, induction, air filled, totally sealed to IP 68, suitable for the maximum immersion depth to be encountered, rated for zone 2 use with group 1 gases, to BS EN 60079-14.
- Motor insulation shall be Class F, limited to a Class B temperature rise

- Motor temperature shall be monitored using a thermistor, in each phase of the winding, set to stop the motor when the monitored absolute temperature reaches 130 ◦C
- A watertight cable junction box sealed from the motor shall be provided for the motor power and signalling cables shall be EPR insulated, sheathed flexible 450/750 volts grade, oil and grease resistant, with tinned annealed copper conductors in accordance with BS EN 50525-1. The cable shall be brought directly out of the submersible motor without joints, and shall be of sufficient length, minimum 20 m to be terminated in an IP67 junction box outside adjacent to the wet well. They shall be sized in accordance with the electricity utility regulations and BS: 7671
- Cables shall be supported using a proprietary 'sock' arrangement at the top.
- Where required in the Special Specification pumps shall be provided with proprietary monitoring and control units for inclusion in the motor controls.

Analogue inputs shall include the following:

- Winding temperature
- Bearing temperature
- Cooling oil temperature

Digital inputs shall include the following:

- High winding temperature
- High bearing temperature
- Loss of coolant oil/seal failure
- Over temperature
- Moisture ingress

Motors shall be capable of start-up and operation in the event of a completely flooded wet well. Motors shall be selected to meet the maximum power required for the selected

impeller at all operating conditions. Motor cooling shall either be oil cooled and fins shall be mounted on the external frame to dissipate heat to the surrounding service fluid (sewage). The use of external cooling water is not acceptable. Coatings and Protection shall be provided as follows:

• Cathodic protection with replaceable sacrificial zinc anodes shall be provided if required in the Special Specification.

• All parts of the pump and motor shall be 100% holiday free fusion bonded epoxy coated to a minimum thickness of 300 microns.

5.5.4. Accessories

The following accessories shall be provided for each pump:

• Pressure gauges. The discharge pipe work of each pump shall be provided with a 19 mm diameter tapped opening and stainless or brass isolating valves and diaphragm pressure gauges. In the case of dry-mounted submersibles a similar tapping valve and gauge shall also be provided on the suction pipe work of each pump

• Air bleed offs. In the case of submersible pumps automatic brass air bleed ball valves shall be provided on the reflux valves, venting via a 40 mm diameter stainless steel pipe to the wet well. In the case of dry mounted submersible pumps these valves shall be provided on the highest point of the volute casing

• Labels. Each pump shall have a stainless steel label permanently fixed to the pump and an identical label fixed to the pump starter compartment.

5.5.5. Factory Inspection and Testing

The Contractor shall secure from the pump manufacturer certification that the following inspections and tests have been conducted on each pump at the factory, and submit to the Engineer prior to shipment:

- The pump casing has been tested hydrostatically to 1.5 times the maximum closed valve pressure

- Impeller, motor rating and electrical connections checked for compliance with the specifications
- Motor and cable insulation tested for moisture content or insulation defects
- Prior to submergence, the pump has been run dry to establish correct rotation and mechanical integrity
- The pump has been run for 30 minutes submerged under a minimum of 2 m water after the operational test (e) above, the insulation tests (b) above has been performed again, and after the performance test (2) below
- NPSH (dry well mounted pumps only)

Each pump shall tested at the factory for performance according to BS EN ISO 9906, including:

- Flow
- Inlet pressure
- Outlet pressure
- Motor power
- Torque
- Efficiency

The Contractor shall secure from the pump manufacturer the following certification and submit to the Engineer prior to shipment:

• Certified copies of the pump characteristic curves and reports generated by the tests described above and as required by BS EN ISO 9906

• Foundry composition certificates for all major castings (pump case, impeller, motor housing) showing exact material composition and tests conducted to ensure compliance with the pump manufacturer's material specifications.

The Contractor must also provide Quality Assurance Certificates, established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent,

for the supply items have been subjected to the tests performed as per applicable standards. The certificate shall be valid for a period covering the manufacture of the certified items. If the Contractor is not the manufacturer, the Contractor will provide the Quality Assurance Certificates of the original manufacturer. The materials shall be suitably marked to enable them to be identified from references on the certificates.

If Certificates are not provided or if the Engineer determines that testing is required, the Contractor shall arrange for inspection, testing and obtaining of such information as may be required to be carried out at the place of manufacture as specified below.

Each pump shall be tested for the full operating range of the pump to BS EN ISO 9906 Test shall be carried out at rated speed with minimum NPSH available at site. Pump performance shall be within the tolerance limits specified in the above said BS. The contractor shall furnish the guaranteed values of discharge and efficiency for the total head at duty point for each pump.

The following tests shall be performed on the motor-pump combination unit: Motor

- Hi-Pot Test
- Bearing Temperature Test

The said motor shall be run dry for a period of six to eight hours and temperature measurements on the inner and outer raceway of the bearing (outboard and inboard) be made starting at the six hour mark and ending at the eight hour mark. Temperatures shall be recorded over 15 minute intervals and shall not exceed 120 deg. F (outer raceway) and 180 deg. F (inner raceway).

- Insulation Breakdown Test
- Pump
- Pump Performance Test
- Vibration Test

If the said pump or pumps fails the witness shop test, a re-test shall be performed at NO additional cost to the Client. Required modifications to the equipment, revised schedule and work plan shall be provided in a new submittal by the Contractor for review.

Pursuant to successful completion of the shop test, the Contractor shall submit a shop drawing containing the test procedure, witness shop test results including system drawing, performance curve, detailed calculations and data collected (readings). System Efficiency calculated during the witness shop test shall meet or exceed the manufacturers guaranteed efficiency for the said pump. Contract shall also certify that the efficiency guaranteed by the manufacturer shall be equal or greater than the efficiency guaranteed by other manufacturers (minimum 3 nos.) for commercially available pumps of the said configuration. System Efficiency shall be calculated by obtaining the BHP of the motor by use of a Torque Dynamometer or approval equivalent measuring instrument. Nominal efficiency of the motor shall not be used in calculation of motor output (pump input).

Characteristic and system curves for the pumps shall be supplied to a reasonably large scale, which shall show the capacity of the pumps under single and multi-pump operation at the duty point.

When tested through their complete range of workable heads at the maker's works, all the pumps shall give results which conform to the curves submitted with the Tender. Curves showing pump efficiency and kW loading shall also be included.

5.5.6. Commissioning Tests

The commissioning tests shall be performance and reliability trials to ensure that the pumps have been correctly assembled and installed and that their performance matches that obtained during the manufacturer’s factory and shop tests. In the event of an unwarranted change in the pump performance characteristics or power consumption, all necessary steps

shall be taken as soon as possible to establish the cause and remove the fault at no additional cost to the Client. Similar action shall be taken for an undue increase in bearing or gland temperature, increased gland leak rates, unsatisfactory vibration levels or any other fault or defect in the operation of the pumps. The site reliability trials shall include the following:

- A record of bearing and coupling clearance and alignments shall be tabulated to show the "as-built" condition of each pump
- A record of all overload, timing relay and oil pressure relays shall be tabulated to show the "as-built" condition of each motor starter
- All cables shall be ‘megger’ tested to confirm the integrity of the insulation. A tabulated record of results shall be made
- The control panel shall be statically tested with motors disconnected to confirm the correct sequence of operation
- Each pump shall be operated individually over the range from closed valve to maximum emergency top water level, on a recirculation basis, using fresh water, and for a minimum of four hours continuously. During this test the following parameters will be recorded:
- Motor phase currents
- Pump output
- Ambient and test water temperatures
- Motor/pump casing temperature (dry well submersible only)
- Power consumed - Power factor
- Vibration (dry well submersible only)

The commissioning trials shall extend until each pump unit has run 'continuously' for at least 3 days under all operating conditions. The term 'continuously' shall include running at various speeds or on a start/stop basis as determined by the control system.

If there are no facilities in Maldives for carrying out the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere at no extra cost. Any materials or

workmanship which is shown by such tests not to be in accordance with the specifications shall be rejected not withstanding any previous certificates, which may have been provided. Notwithstanding the above, the Contractor will be required to rectify any deficiencies which are attributable to defects in the workmanship or quality during the Defects Liability Period specified in the contract.

5.5.7. Spare Parts and Tools

The Contractor shall ensure that the pump manufacturer provides all spares and special tools required during the commissioning and maintenance periods and as required below. In addition to the spare parts required in the Specification the following spare parts for each pump shall be furnished to the Client:

- Three sets of complete upper and lower bearings
- Three sets of wear rings
- Three sets of gaskets and three sets of 'o' rings complete
- Three sets of upper and lower mechanical seals
- Additional spare parts as recommended by pump manufacturer and/or recommended by the Engineer-in-charge to cover two years of operation following the maintenance period. The cost of the above mentioned spare parts shall be included in the rate quoted for the pumps.

SECTION 6- SEWAGE TREATMENT PLANT

Section 6- Sewage Treatment Plant

6.0 Scope

The scope of work for STP shall cover all preliminary treatment, sludge drying beds, odour control, treatment plant drainage, standby power generation, and chambers..

Following clauses specify the general requirements and standard of workmanship for the equipment and installations.

6.0. Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

6.1. Reference Standards

The following standards are referred to in this section and the drawings relevant to this section. Submersible sewage pumps shall, but not necessarily be limited to, conforming to the following standards:

BS EN 12255-1:2002	Wastewater treatment plants- Part 1: General construction principles
BS EN 12255-3:2000	Wastewater treatment plants. Preliminary treatment
BS EN 12255-4:2002	Wastewater treatment plants. Primary settlement
BS EN 12255-6:2002	Wastewater treatment plants. Activated sludge processes
BS EN 12255-8:2001	Wastewater treatment plants. Sludge treatment and storage
BS EN 12255-10:2001	Wastewater treatment plants. Safety principles
BS EN 12255-12:2003	Wastewater treatment plants. Control and automation

BS EN 12255-13:2002	Wastewater treatment plants. Chemical treatment. Treatment of wastewater by precipitation/flocculation
BS EN 197-1:2011	Cement. Composition, specifications and conformity criteria for common cements
ASTM A775 / A775M	Standard Specification for Epoxy-Coated Steel Reinforcing Bars

6.2. Design requirements

All components subject to occasional failure shall be installed with sufficient standby capacity to achieve full treatment capacity and efficiency with one assembly out of service. In the case where stand-by assemblies cannot be practically installed, provisions shall be made to replace rapidly by another one kept in stock

Lean concrete shall be GRADE C15 and all structural concrete shall be GRADE C35A while Cement for all structural works shall be Sulphate resistant Portland cement to BS4027:1996 unless specified otherwise. Structural dimensional tolerances must agree with those specified in BS EN 12255-1.

All structural reinforcement steel shall be epoxy coated reinforcement to ASTM A775 / A775M while the required soil bearing pressure for the foundation is 150kn/m². The contractor shall carryout geotechnical testing to ensure that this is achieved and necessary ground improvements shall be done if required

All internal concrete surfaces shall be protected with epoxy coating of thickness 500 microns and Bituminous coating shall be provided to all external surfaces of concrete works below ground so that the components are resistant against chemical and biological attack from wastewater, sludge, air and gas components and against temperatures and temperature changes as appropriate. All GI / steel members shall be protected with universal primer and 2 coats of anti-corrosive paint

Wastewater treatment plants shall have emergency power generation or an equivalent facility to provide a sufficient power supply during power failure of the network, e.g. a terminal for easy connection with a readily available mobile power generator. Connected to the

emergency power supply shall as a minimum include the measuring and control system, the pumps for wastewater and return sludge and any aeration equipment (at a designed minimum capacity).

The Contractor shall provide safe access in the form of paths and stages to allow easy supervision, operating, servicing, cleaning and maintenance. Openings should be provided which allow easy replacement of equipment. The location of operating and maintenance points shall allow for adverse weather conditions and other hazards (e.g. handling of gases, vapours, sludge, oil and grease).

6.3. Extended Aeration Activated Sludge Treatment Plant

6.3.1. Bar Screen and Grit Channel

The 12 mm thick stainless steel Bar screen aperture size should be 6-10 mm for the requirements of sludge disposal and discharge permit conditions for the final effluent. The design service life of the equipment for screening installations shall correspond to service life class 3, as specified in prEN 12255-1.

The grit shall be disposed of in accordance with the health and safety requirements specified in prEN 12255-10:2000. Grit chambers should be constructed to operate in multiple channels. In the case of single channel installations, a bypass or alternative facility should be provided. Design features shall ensure that each channel may be taken out of service individually.

6.3.2. Oil and Grease Trap

Grease and oil removed from the wastewater shall be disposed of in accordance with the health and safety requirements of prEN 12255-10. The grease separator shall facilitate the safe and efficient removal of separable solids, grease and oil.

6.4. Equalization tanks

The sewage treatment plant shall be equipped with Equalisation tanks. Flow should be controlled by level sensor and outflow should be measured using flow meters at the outlet of the equalisation tanks.

6.3.3. Aeration Tanks

Aeration devices should have the capacity to provide sufficient agitation to thoroughly mix the biomass, the pollutants and the dissolved oxygen. The Contractor should verify that the power input of the aeration device, derived from aeration requirements, is not lower than the power required to ensure adequate mixing conditions at all times

Air diffusers shall be installed to ensure a uniform depth of immersion. The aeration system shall have the capacity to supply sufficient oxygen to ensure carbonaceous oxidation, endogenous respiration and oxidation of nitrogen compounds (if these are required) under all operating conditions.

The aeration system shall be designed to operate under the most severe on-site conditions (e.g. extreme temperatures, inclement weather and corrosive atmosphere). As stated in BS EN 12255-6 the following performance data shall be provided for aeration equipment.

- the characteristics and dimensions of the test aeration tank with the aeration system built in;
- the test procedure used;
- the test protocol;
- the nominal oxygen transfer capacity;
- the nominal oxygen transfer efficiency

6.3.4. Clarifier Tanks

The clarifiers shall achieve the required separation of the activated sludge solids from the effluent and provide a concentration zone for withdrawal of sludge for re-circulation. General construction principles and the design service life of equipment within clarifiers shall conform to EN 12255-1.

6.3.5. Sludge Drying Beds

Sludge drying beds will consist of cells with porous filter media and drain pipes. The filter beds are usually built of multiple sand and gravel layers where the particle size increases from the top to the bottom. The finest upper layer is gradually removed together with the dried sludge and shall be renewed after several removal cycles. The upper sand layer shall have a depth of 50 mm to 100 mm and the lower gravel layer shall have a depth of 300 mm to 400 mm. The drainage pipes in the gravel layer shall have a minimum DN 80.

The removal of the sludge is carried out manually or with mechanical scrapers. Adequate access must be provided for vehicles to carry out sludge removal.

6.5. Control Panel

Controlling and Monitoring system for the sewerage system should be provided including all necessary cabling and wiring according to BS EN12255-12 Wastewater treatment plants.(Control and automation) The monitoring system will be required to control the pumps through a control panel. Control and automation systems will be used to support the operators in maintaining process quality and cost efficiency of the wastewater treatment plants. In addition they serve for documentation of the process, especially to monitor and record the effluent quality parameters and as a tool for organising the maintenance of the plant itself.

Section 7- Sewer Jetting Machine

7.0. Scope

The scope of work covers supply of jetting machine.

7.1. Requirements

A trailer mounted sewer jetting machine, make of international repute shall be supplied. The sewer jetting equipment shall include the following: (i) high pressure hoses with hydraulically assisted hose reel and jetting nozzel designed to provide optimum performance on 100mm, 150mm and 200mm nominal diameter pipes where distances between access points may be up to minimum 60meters, (ii) suitable for cleaning out house connections with inspection chamber located on private land with little access or working space between the boundary wall and the superstructure, and (iii) should be provided with its own power source and water storage facilities and mounted on its own trailer for transporting the equipment within a nominal operating radius of 5km over both surfaced and un-surfaced roads. Tank shell will be electrically welded construction.

Where applicable a truck chassis mounted unit with pump drive for the high pressure-jetting pump tapped from a new generation total power take off (split shaft P.T.O.). The total power take off shall be fitted with one independent output drive shaft. The tank will be mounted on an auxiliary frame and will be adequately strengthened to render its torque. The auxiliary frame will be manufactured to the size of vehicle's chassis and will be of an electrically welded construction.

7.2. Tank: Technical data

Capacity	: 1500 Litre
Construction	: Cylindrical, Shell with torrispherical dished end
Material	: 5 mm thick non corrosive shell, dished end and internal, epoxy coated inside and outside
Vacuum capacity	:minimum 85%
Maximum operating pressure range	:-0.90 to 1 bar gauge tank pressure.
Test Pressure	:1.5 bar gauge

7.3. High Pressure Jetting System

System	: Triplex plunger Pump
Make	: International Reputed
Stroke	:40 mm
Motor / Power unit	:Diesel engine with electric start
Water Pump Delivery Capacity	: nominal 60 LPM (Range 30-60 LPM)
Pressure	:nominal 100 Bar (Range 60-120 Bar)
High Pressure Hose Reel	:60m
Material	:Rubber
Make	:Reputed
Hydraulically drive hose reel	: minimum 50m length
Working Pressure	: 215 bar

The high pressure jetting system will be adequately protected by incorporating a suction filter, relief valve. The trailer will be supplied by the supplier and delivered with a factory fitted side Power Taking off (PTO).