OMAN WASTEWATER SERVICES COMPANY S.A.O.C

الشركة العمانية لخدمات الصرف الصحي ش.م.ع.م

OMAN WASTEWATER SERVICES COMPANY

TECHNICAL STANDARD SPECIFICATION

CIVIL WORKS

SECTION 04 SEWERAGE

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Section # 04 Sewerage

1. General

1.1 Scope

This Section Includes Specifications for the Construction and Installation of Sewerage System Pipelines.

1.2 Reference Standards and Documents

BS EN 752-4:1998, Sewerage
BS EN 14161:2003, Pipelines
BS 410-2:2000, Test sieves
BS EN 12620:2002, Aggregates from natural sources for concrete
BS 1924, Stabilized materials for civil engineering purposes
BS 6031, Code of practice for earthworks
BS EN ISO 12958:1999, Methods of tests for geotextile
BS EN 1452:2000, Joints and fittings for use with unplasticised PVC pressure pipe
BS EN 13598-1:2003, Unplasticised polyvinyl chloride (PVC-U) pipes and plastics fittings
BS EN 1796:2006, BS EN 14364;2006 Glass reinforced plastic (GRP) pipes and fittings for use for water supply or sewerage
BS EN 1401-1:1998, Unplasticised PVC pipe and fittings for gravity sewers
BS 6076, Tubular polyethylene film for use as a protective sleeving for buried iron pipes and fittings.
BS EN 1993-1-5:2006, The use of structural steel in building
BS 4592:2006, Industrial type metal flooring, walkways and stair treads.
BS 5395-1:2000, Stairs, ladders and walkways
BS EN 12944-1to8, BS EN 14713 Code of practice for protective coating of iron and steel structures against Corrosion.
BS 3532, Method for specifying unsaturated polyester resin systems
BS 3749, E glass fibre woven roving fabrics for the reinforcement of polyester and epoxy resin systems.

1.3 Material Inspection

Pipes and fittings including inside linings and outside coatings, shall be inspected by the Contractor immediately before and after installation, and damage or other imperfection shall be repaired by the Contractor as directed by the Engineer before installation.

Material required for the repair of pipe, linings and coatings shall be obtained by the Contractor and shall be used in accordance with the Manufacturer's recommendations.

Without relieving the Contractor of any of his obligations, the Engineer may inspect and test the pipe and fittings by any appropriate means.

The Contractor shall remove from Site any pipe or fittings which in the opinion of the Engineer is not complying with the required standard.

The Contractor may replace damaged pipes and fittings to the approval of the Engineer.

The Contractor shall submit to the Engineer notice of work requiring inspection Through the approved form not less than 24 hours before requiring inspection of those works or otherwise in accordance with the project Quality Plan.

The Employer may employ the services of a specialist firm to assist the Engineer as he may require in any matter connected with pipes, and fitting including the inspection of materials and workmanship and the witnessing of tests at any stage during the execution and maintenance of the Works.

Such independent tests may be carried out at any stage during the execution and maintenance of the Works, but they shall not relieve the Contractor of his obligations under the Contract. To the extent ordered by the Engineer, the Contractor shall provide labor, plant, tools and materials (but not special testing equipment) for direct assistance to the specialist firm in their inspection and independent testing and for any further work, investigations, and repairs which the Engineer considers necessary as a result of such inspection or testing.

The provision of labor, plant and materials as aforesaid shall be an obligation of the Contractor where in the Engineer's opinion the inspection test or further investigation shows that materials and workmanship provided by the Contractor do not comply with the designated requirements.

2 Concrete Pipes and Fittings

2.1 Material

Concrete pipes and fittings shall conform to the requirements of BS 5911 Part 100 and BS 5911 Part 103 and BS EN 1917:2002.

The strength requirement and other features of particular application shall be as specified in the contract specific documentation.

Cement used for manufacturing pipes and fittings shall be Ordinary Portland cement conforming to BS 12. Aggregate shall conform to BS 882, 1202 Part 2. Reinforcement shall conform to BS 4449 or BS 4483 as appropriate.

2.2 Protection

Where designated concrete pipes shall be lined with polyvinyl chloride plastic PVC liner sheets. The PVC liner sheets shall be securely fixed to the formwork before pouring concrete.

Welding of the PVC liner sheets shall be carried out by skilled labor using the methods specified by the manufacturer.

The installation of PVC liner sheets in concrete pipes or structures, and the sealing and welding of joints, shall be carried out in strict compliance with all applicable specifications, instructions and recommendations of the plastic liner sheets manufacturer. All welding of liner plate shall be carried out by properly trained and approved workmen.

Once cast into the pipe, the liner shall be permanently and physically attached to the concrete by the locking mechanism and shall not rely on an adhesive bond unless otherwise approved by the Engineer..

Damaged liner plate shall be repaired in accordance with the manufacturer's recommendation and to the approval of the Engineer.

All exterior surfaces of concrete pipes shall be coated in accordance with the pipe Manufacturer's recommendations.

2.3 Inspection and Testing

Inspection procedures and tests shall be carried out at the place of manufacture. Pipes and joints shall be hydrostatically tested in accordance with BS 5911 Part 100 and BS EN 1917:2002.

The performance of pipes shall be verified by the testing of random sample pipes in accordance with the type of inspection and batch size mentioned. The pipes shall be subject to rejection on account of non-compliance with the following:

- Failure to pass hydrostatic test
- Failure of the longitudinal concrete surfaces of joints to meet dimensional tolerances
- Fractures or cracks
- Defects that indicate defective mixing
- Surface defects indicating honeycomb or open texture
- Insufficient cover to the reinforcement.

3 Glass Reinforced Plastic (GRP) Pipes and Fittings

3.1 Product manufacture, testing and installation shall comply with the following references, unless otherwise stated in the specifications or unless otherwise approved by the Engineer.

BS5480 Specification for glass reinforced plastics (GRP) pipes joints and fittings for use for water supply or sewerage.

BS 8010 Section 2.5 Pipe lines on land: design, construction and installation.

BS 2494 Materials for Elastomeric seals for Joints in pipe work and pipelines

BS 3396 Woven glass fibre fabrics for plastics reinforcement

BS 3496 ‘E’ glass fibre chopped strand mat for the reinforcement of polyester and other liquid laminating system.

BS 2782 Method of specifying unsaturated polyester resin systems.

BS 3532 Method of specifying unsaturated polyester resin systems.

BS 3691 'E' glass fibre rovings for the reinforcement of polyester and epoxy resin systems.

BS 3749 'E' glass fibre woven roving fabrics for the reinforcement of polyester and epoxy resins systems.

ASTM C581 Standard practice for determining chemical resistance of thermosetting resins used in glass fibre reinforced structures intended for liquid service.

ASTM D2584 Test for ignition loss of cured reinforced resins.

ASTM D2924 Standard test method for external pressure resistance of reinforced thermosetting resin pipe.

ASTM D2992 Standard method for obtaining hydrostatic or pressure design basis for reinforced thermosetting resin pipe and fittings.

ASTM D3262 Standard specification for fiberglass (glass fiber reinforced thermosetting Resin) sewer pipe.

ASTM D3681 Test method for chemical resistance of reinforce thermosetting resin pipe in a deflection condition.

ASTM D2563 Practice of classifying visual defects in glass-reinforced plastic laminate parts.

ASTM D2583 Test method for indentation hardness of rigid plastics by means of a Barcol impresser.

ASTM D4024 Specification for machine made "fiberglass" flanges.

ASTM D4161 Specification for "fiberglass" pipe joints using flexible elastomeric seals.

ASTM D570 Test methods for water absorption of plastics.

ASTM D2290 Test method for apparent tensile strength of ring or tubular plastics and reinforced plastics by split disk method.

ASTM D2343 Standard test method for tensile properties of glass fiber strands, yards and roving, used in reinforced plastics.

ASTM D3567 Standard practice for determining dimensions of fiber glass (Glass fibre reinforced thermosetting resin) pipe and fittings.

ASTM D3839 Under ground installation of fiber glass (glass fiber reinforced thermosetting resin)

ASTM D2412 Standard test method for external loading properties of plastic pipe by parallel plate loading.

ASTM D3517 Standard specification for fiber glass (glass fiber reinforced thermosetting resin) pressure pipe.

ASTM D3754 Standard specification for fiberglass (glass fiber reinforced thermosetting resin) sewer and industrial pressure pipe.

ASTM D3840 Standard specification for "Fiber glass" pipe fittings for non pressure applications.

ASTM D2471 Standard test method for get time and peak exothermic temperature of reacting thermosetting resins.

ASTM D1599 Standard test method for short time hydraulic failure pressure of plastic pipe, tubing and fitting.

Pipes, joints and fittings shall comply with the following requirements, unless otherwise approved by the Engineer.

a. All GRP components shall be designed and fabricated by one manufacturer.

b. Pipe size shall be as shown on the drawings, unless noted otherwise. Sizes indicated refer to nominal interior diameters.

c. For pressure pipes, minimum pressure rating shall be 10 bar, unless noted otherwise.

d. Minimum pipe stiffness shall be as follows, unless noted otherwise.

1. All pressure pipes: 10,000 N/m^2
2. Pipes buried less than 5 meters: 5,000 N/m^2
3. Pipes buried 5 meters and deeper: 10,000 N/m^2
4. All exposed pipes and fittings: 10,000 N/m^2

e. All GRP pipe shall be buried in granular surround, unless noted otherwise.

f. Maximum pipe length in granular surround: 12 meters.

g. Any GRP pipe placed in concrete surround shall be limited to a maximum pipe length of 3 meters.

All buried joints shall be unrestrained, flexible types (spigot and socket or external coupling) utilizing elastometric sealing rings, unless otherwise noted or unless otherwise approved by the Engineer.

All elastomeric sealing rings shall be obtained from the pipe

manufacturer.

All joints shall be capable of withstanding an external pressure of 100 Kpa without infiltration in both the straight and misaligned positions.

Restrained or locking joints may be accepted in lieu of thrust blocks with the Engineers approval.

All joints for exposed piping shall be flanged fittings or mechanical couplers, unless noted otherwise.

a. All flanged fittings shall be designed for class 16 service.

b. All bolts shall be stainless steel type A316.

All bends and fittings shall be obtained from the pipe manufacturer, unless otherwise approved by the Engineer.

All bends shall be “long-radius”, unless otherwise approved by the Engineer.

Additional testing for bends and fittings may be directed by the Engineer at the Contractor's expense.

Each pipe or fitting shall be clearly marked at the place of manufacture with the following information.

a. The name or distinctive mark of the manufacturer.
b. The date of manufacture.
c. The pressure rating (if applicable)
d. The nominal diameter
e. The manufacturing standard to which the product has been produced
f. For flexible pipes – stiffness in N/m^2
g. The angle of bends or branches
h. Where appropriate, the name of the Client and contract number
i. Where appropriate, individual reference number
j. Number and mark of independent testing agency (if applicable)

Pipe and fittings shall be submitted for all proposed sizes, stiffnesses and pressure ratings for the Engineer's approval prior to manufacture.

The submittal shall clearly indicate the following:

a. Pipe manufacturer's name.
b. Proposed pipe diameters
c. Proposed pipe pressure rating
d. Proposed pipe stiffness
e. Proposed manufactured lengths
f. Proposed joint type
g. Proposed sealing ring material and manufacturer's name
h. Maximum depth of cover
i. Minimum depth of cover

j. Maximum internal operating pressure (if applicable)

k. Maximum internal test pressure

l. Maximum allowable external pressure

m. Type and manufacturer of proposed resins

n. Type and manufacturer of proposed glasses

o. Type and manufacturer of proposed sand aggregates

p. Maximum proposed content of sand aggregate

q. Calculations showing adequate design

r. Shop drawings for fittings, showing all dimensions.

s. Installation drawings showings all necessary supports, gasket details, bolt torque and sequence for flanged fittings.

Samples shall be supplied according to the Engineers request

The GRP material supplier shall demonstrate to the Engineer, that he has the capability of manufacturing the required GRP pipelines of the sizes in accordance with the contract. The company shall have an internationally recognized quality management system in place and shall be accredited to ISO 9002 or equivalent.

Pipes, fittings and specials shall be delivered, handled and stored according to the manufacturer's recommendations along with the following provisions:

Transportation, handling and storage shall at all times be performed in a manner to avoid product damage.

Only nylon slings shall be allowed for lifting pipes and fittings. Steel chains, clamps or cables shall not be allowed for lifting purposes.

Steel chains or cables may be allowed for securing pipes during transport or storage provided protective padding or timber blocking is utilized.

Any pipes damaged during delivery, storage or installation shall be marked and set aside.

Proposals for repair of any damaged pipes shall be submitted in writing to the Engineer for approval.

No repairs to damaged pipes shall be attempted without the Engineer's approval.

Any damaged pipes deemed unsuitable for repair by the Engineer shall be removed form site and replaced at the Contractors expense.

Elastomeric sealing rings, (if they are not a fixed part of the coupling) shall be stored in closed containers or out of direct sunlight until needed.

Method statements shall be submitted for any repairs or hand lamination works.

Resins shall comply with the relevant provisions of BS3532 Type B unless otherwise approved by the Engineer.

Glass shall comply with the relevant provisions of the following standards, unless otherwise approved by the Engineer.

BS 3691 for rovings

BS 3496 for chopped strand mat.

BS 3396 or BS3749 for woven fabric.

Surface tissues shall comply with one of the above Standards.

Sand aggregate shall be a clean, graded silica sand compiling with BS 5480 requirements, unless otherwise approved by the Engineer.

The use of additives such as fire retardant, UV inhibitors, or coloured pigments or dyes shall be subject to the approval of the Engineer.

All pipes and joints shall be designed for a service life of 60 years, with up to 5% deflection in their installed condition.

The manufacturer, shall provide sufficient "type" test results to prove the proposed pipe design will meet the desired service life under the following conditions:-

a. Pipes shall be suitable for operating temperatures of up to 40^0C.

b. Sewerage pipes shall be suitable for resisting corrosive conditions (H_2S gas and condensates) encountered in the local sewage network.

c. All pipes shall be suitable for immersion in corrosive ground water.

All pipes shall have a resin rich vinylester internal liner with the following requirements.

a. Minimum thickness shall be 1.5mm.

b. The resin rich liner shall be reinforced with “C” glass surface tissue.

c. Resins shall be cured to achieve 90% of the manufacturer’s recommended Barcol hardness value.

The structural wall shall be made with isophthalic resins. Resins shall be cured to achieve 90% of the manufacturer’s recommended Barcol hardness value.

Glass in the structural wall shall be as follows:

a. For sewage service use corrosion resistant glass.

b. For storm water service “E” glass may be used.

Sand Aggregate shall be supplied with the following requirements:

a. No sand aggregate shall be utilized in pressure pipes, except on exterior surface.

b. For non-pressure pipes, sand aggregates may be allowed provided the manufacturer has sufficient type test results to prove the pipe design will meet the desired service life.

c. Fillers as defined in BS 5480 shall not be used.

Pipe sockets must be moulded with a resin rich liner similar to the pipe construction.

GRP pipes and fittings utilized for exposed service inside pumping facilities or valve/junction chambers shall be designed to resist all bending stresses, thrust forces surge pressures, negative pressures (vacuum) and vibratory forces.

A complete static and dynamic analysis shall be provided by an approved Engineering firm specializing in fluid dynamics for all exposed piping systems and shall include at least the following, unless otherwise directed by the Engineer.

a. Bending stress analysis and support design.

b. Surge/water hammer analysis.

c. Thrust force analysis.

d. Vibration analysis.

e. Stress and flexibility analysis.

f. Other as per Engineer's direction.

Exposed pipe and fittings shall be manufactured in the same manner and with the same materials as buried pipe, along with the following requirements, unless otherwise approved by the Engineer.

a. Resin in the structural wall shall be vinylester.

b. No sand aggregate shall be utilized in exposed pipe or fittings.

c. Minimum wall thickness shall be 10 mm.

d. Minimum stiffness shall be 10,000 N/m^2

Additional exterior stiffeners may be required to maintain circularity on large dia. pipes and shall be installed as directed by the Engineer.

An exterior resin rich layer 1.0 mm thick pigmented with UV inhibitor shall be provided on all exposed pipes and fittings.

Flanges shall be filament wound with epoxy or vinylester resins.

a. Drilled flanges shall conform to class PN 16 Standards.

b. Flanges manufactured by hand-layup methods shall not be accepted.

Exposed pipes shall resist a negative pressure of 0.8bar.

Minimum operating temperature: 50^0C.

Minimum surge pressure: 40% above working pressure.

Elastomeric sealing rings for buried pipe shall be manufactured with the following material in compliance with the following Standards, unless otherwise approved by the Engineer.

EPDM material conforming to BS 2494 Type "D" requirements.

Gaskets for flanged fittings shall be EPDM flat rings.

4. HDPE Non Pressure Pipe

High density polyethylene (HDPE) pipe shall be manufactured to conform to the requirements of CP 312 Part 1 and 3, and BS EN 123244- 1,2,5:2002. Where pipes are used for renovation work, pipes shall be of short lengths conforming to the requirements of the method selected and the available working space in the manholes or drive shafts. Longer lengths may be used for new installation where conventional open trench methods of construction are employed.

The base polymer shall be polyethylene with a derived density greater than 930 kg/m3 when determined in accordance with the method required by BS 3412. The base polymer shall be blended with additives that are necessary for the manufacture, storage and use of HDPE pipes for sewer lines, including antioxidants, carbon black and UV stabilizers.

The material in pipe form shall have a thermal stability of at least 15 minutes when tested in accordance with the isothermal method for differential thermal analysis. The ends of the pipe shall be cut, cleanly and squarely.

The jointing system for polyethylene pipes and fittings shall be in accordance with the pipe manufacturer's recommendations subject to approval by the Engineer.

The polyethylene pipe shall be Type 50 i.e. shall be designed to sustain a maximum working stress of 50 bar at 20°C. The wall thickness shall be based on a nominal pressure rating (PN) of l0 bar.

HDPE non-pressure pipes are used for gravity sewers having internal diameter larger than 250 mm. uPVC pipes are used for gravity sewers having diameter 250 mm or less.

The list of main standards to refer to is as follows, For undated references the latest edition of the published referred to applies.

CEN (Draft prEN 13476-1) “Thermoplastics piping systems for non-pressure underground drainage and sewerage – Structured-wall piping systems of Polyethylene”.

DIN 16961 “Thermoplastic pipes and fittings with profiled outer and smooth inner surfaces”.

ISO 9969 “Determination of Ring Stiffness of Plastic pipe by parallel plate loading”.

DVS 2209 Part 1 "Welding of polyethylene pipes by extrusion welding technique".

RIL – 77: 190 "Plastic pipes laid in ground and water. Laying instruction".

ASTM D 2321 "Underground Installation of Flexible Thermoplastic Sewer Pipe".

Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply. Compliance with other equivalent, pertinent or comparable standards (e.g. ISO, DIN, BS, EN) may be acceptable provided that the Contactor submits certification and complete documentation (including English-language versions of such other standards), to the satisfaction of the Engineer, proving that such other standards meet or exceed the specific requirements of the comparable Standards.

The raw material shall consist of black PE-HD with properties listed in Table 4.1. The raw material may only be added such additives that are needed to facilitate the manufacture of sound, durable pipe of good surface finish and mechanical strength conforming to these specifications, for intended end use, including weldability. A raw material with unknown properties must not be used. As fittings are fabricated from pipes, the same material properties and requirements apply to fittings.

The raw material shall be pre-pigmented, UV-stabilised and anti-oxidanted. The on line addition of pigment and/or stabiliser during pipe extrusion is strictly prohibited.

All HDPE resins shall be pipe grade, single compound. Mixing of different resin compounds is not permitted. Different batches of the same compound can be used.

The use of recycled resin permitted if the origins and grade are approved by the Engineer

The material used for extrusion welding shall be the same grade as the pipe material.

Each consignment of raw material shall be accompanied by the manufacturer's/suppliers test certificate.

Pipes used in the works shall be manufactured at plants that meet the requirements of and are accredited to ISO 9001 or 9002. Pipes produces in the Sultanate of Oman, subject to their compliance shall be preferred over imported ones.

The twin wall construction of the pipe shall be structurally designed to withstand external loads i.e. combination of dead load & imposed live load. The pipes are categorized in stiffness class 2, 4 & 8 kN/M^2.The stiffness class of the pipe shall be dependent on the load and installation condition of the pipe.

The physical properties of the raw material shall be in accordance with those listed below.

Table 4.1

Physical Properties	Value	Unit	Test method
Density: Base resin Compound	938 948	Kg/m^3 Kg/m^3	ISO 1183D/ISO 1872/2
Melt index: 2.16 kg	0.2	g/10 min	ISO 1133
Melt index: 5 kg	0.6	g/10 min	ISO 1133
Carbon black content	≥ 2	%	ASTM D 1603
Tensile strength at yield point	18	N/mm^2	ISO 6259
Elongation at yield point	9	%	ISO 6259
Ultimate elongation	>600	%	ISO 6259
E-modulus, tangent	550	N/mm^2	ISO 6259
Hardness	58	ShoreD	ISO 868
Charpy impact strength	No failure	Kj/m^2	ISO 179 (unnotched)
Vicat softening temperature	118	^oC	ISO 306 A-50
Brittleness temperature	<-70	^oC	ASTM D 746
Linear Expansion Coeff. (Average value over temp. range 20-90°C)	0.25	mm/m ^oC	ASTM D 696
Specific heat, Cp	2.0	Kj/kg.K	at 20°C, DSC
Specific heat, Cp	2.7	Kj/kg.K	at 200°C, DSC
Thermal conductivity	0.33	W/m.K	DIN 52612 (20°C)
Thermal stability Induction time	≥ 30	min	Al can, isothermal in oxygen, 210°C
Crystalline melting range	123-127	^oC	DSC
ESCR, F_{50}	>10,000	h	ASTM D 1693

The HDPE material supplier shall demonstrate to the Engineer, that he has the capability of manufacturing the required HDPE pipes of the sizes in accordance with the contract. The company shall have an internationally recognized quality management system in place and shall be accredited to ISO 9002 or equivalent.

The following markings shall be printed on the pipe:

a) Name or trademark of the pipe manufacturer

b) Nominal pipe size, in mm

c) Pipe stiffness class in KN/M².

d) Manufacturing standard.

e) A production code from which the date and place of manufacture can be determined

Handling of pipe & fittings shall be in accordance with the manufacturer's instruction and as specified below:

Care shall be taken in loading, transporting and unloading of pipes, to prevent any cuts/gauges/scratches, Nylon Belts/ropes or rubber-protected slings/straps shall only be used for handling the pipes. Use of steel chains, steel wire ropes and steel hooks inserted into pipe ends shall not be permitted.

Pipes shall be stored on clean, dry, level ground, free of sharp protrusions. Stacking of pipes shall be limited to a height that will not cause excessive deformation of the bottom layer of pipes. Where necessary, due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitably, as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

Pipes and fittings shall be examined before installation and any damage to pipes/fittings shall be repaired as directed by the Engineer. Pipes/fittings, discovered after installation to be damaged, shall be removed and replaced by new and undamaged pipes/fittings at the Contractor's expense.

5. High Density Polyethylene (HDPE) Pressure Pipe and Fittings

5.1. Product manufacture, testing and installation shall comply with the latest edition of the following references, unless otherwise stated in the specification or unless otherwise approved by the Engineer.

1. ISO 161/1 Thermoplastics pipes for the transport of fluids – Nominal outside diameters and nominal pressures – Part 1 : Metric Series.

2. ISO 1167 Plastic pipes for the transport of fluid – Determination of resistant to internal pressure.

3. ISO 1133 Plastics Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics.

4. ISO 1167 Plastic pipes for the transport of fluids – Determination of the resistance to internal pressure.

5. ISO 2505-1 Thermoplastics pipes – Longitudinal reversion – Part 1 Determination methods.

6. ISO 2505-2 Thermoplastics pipes – Longitudinal reversion – Part 2 Determination parameters.

7. ISO 3126 Plastic Pipes – Measurement of dimensions.

8. ISO 3607 PE-HD Pipe Tolerences.

9. ISO 4065 Thermoplastic pipes – Universal wall thickness table.

10. ISO 4427 Polyethylene (PE) pipes for Water Supply.

11. ISO 4437 Buried Polyethylene (PE) pipes for the supply of gaseous fuels.

12. ISO 4607 Plastics – Methods of exposure to natural weathering.

13. ISO 6964 Polyolefin pipes and fittings – Determination of carbon black content by calcinations and pyrolysis – Test method and basic specification.

14. ISO 12162 Thermoplastics materials for pipes and fittings for pressure applications pipes – Classification and designation – overall service (design coefficient).

15. ISO Data 8 Chemical Resistance of PE pipe.

16. ISO/TR 9080 Thermoplastics pipes for the transport of fluids – Standard extrapolation method for the long term resistance to constant internal pressure.

17. ISO/TR 10837 Determination of the thermal stability of polyethylene (PE) for use in gas pipes and fittings.

18. ISO/DIS 6259-1 Thermoplastics pipes – Tensile properties – Determination and basic specifications – Part 1: General test method.

19.ISO/DIS 6259-3 Thermoplastics pipes – Tensile properties – Determination and basic specifications – Part 3: Polyolefin pipes.

20.ISO/DIS 11420 Method of test for carbon black dispersion in polyethylene pipes and fittings.

21.ISO/DIS 11922 Thermoplastics pipes for the transport of fluids – Dimensions and tolerances. Metric series.

22.ISO/DIS 13761 Plastics pipes and fittings – Pressure reduction factors for polyethylene pipeline systems for use at temperatures above 20^0C.

23.ISO/DIS 13949 Methods for the assessment of the degree of pigment dispersion in polyolefin pipes, fittings and compounds.

24.WRC WIS 4-32-08 Specification for site fusion jointing of PE 80 and PE 100 pipe and fittings.

25.WRC WIS 4-32-14Specification for PE 80 and PE 100 Electro- Fusion fittings.

26.WRC WIS 4-32-15Specification for PE 80 and PE 100 spigot fittings.

27.DVS 2207 Welding of Thermoplastic HDPE pipe & pipeline components.

The following definitions shall pertain to words or phrases as utilised in this section.

5.2 Pipe and standard joints shall be submitted for all proposed sizes and pressure classes for the Engineer's approval.

The submittal shall clearly indicate or include the following:

a. Pipe manufacturer's name.

b. Proposed pipe diameters.

c. Proposed standard dimensional ratio (SDR).

d. Proposed pressure class or rating.

e. Maximum internal operating pressure at 40^0C.

f. Proposed manufactured lengths.

g. Proposed joint type.

h. Proposed Electro-Fusion fittings (if applicable).

I. Proposed sub-contractor for joint welding.

j. Maximum depth of cover (depending on soil)

k. Minimum depth of cover.

l. Maximum internal test pressure.

m. Maximum allowable external pressure.

n. Recent type test results according to the relevant standard of manufacture to prove the adequacy of the pipe.

5.3. Fittings, bends and special couplings for all proposed sizes and pressure classes shall also be submitted for the Engineer's approval.

a. Samples shall be supplied according to the Engineer's request.

5.4. All joint welding equipment, materials and procedures shall be submitted for the Engineer's approval.

5.5. The HDPE material supplier shall demonstrate to the Engineer, that he has the capability of manufacturing the required HDPE pressure pipelines of the sizes in accordance with the contract. The company shall have an internationally recognized quality management system in place and shall be accredited to ISO 9002 or equivalent.

5.6. Handling of pipe & fittings shall be in accordance with the manufacturer's instruction and as specified below:

Care shall be taken in loading, transporting and unloading of pipes, to prevent any cuts/gauges/scratches, Nylon Belts/ropes or rubber-protected slings/straps shall only be used for handling the pipes. Use of steel chains, steel wire ropes and steel hooks inserted into pipe ends shall not be permitted.

Pipes shall be stored on clean, dry, level ground, free of sharp protrusions. Stacking of pipes shall be limited to a height that will not cause excessive deformation of the bottom layer of pipes. Where necessary, due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitably, as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

Pipes and fittings shall be examined before installation and any damage to pipes/fittings shall be repaired as directed by the Engineer. Pipes/fittings,

discovered after installation to be damaged, shall be removed and replaced by new and undamaged pipes/fittings at the Contractor's expense.

5.7. PE Pipes & Fittings shall comply with the following general requirements, unless otherwise approved by the Engineer.

a. All pressure pipe and fittings 75mm OD & larger shall be manufactured with PE-100 material and a minimum SDR of 11.

b. Pressure pipes & fittings 63mm OD & smaller may be made with PE80 or PE100 material.

c. All pipes and fittings shall be suitable for sustained operating temperatures `of up to 40°C for a service life of 50 years. Contractor must provide suitable calculations to confirm the above performance for approval of the Engineer.

d. All PE pipes shall be manufactured in standard metric sizes according to relevant ISO Standards. The designated sizes on the drawings refer to nominal internal diameters.

e. All pipes shall be black in colour.

5.8. Raw PE material shall comply with the following requirements, unless otherwise approved by the Engineer.

a. All PE pipes and fittings shall be manufactured from virgin material. Recycled PE shall not be used.

b. All PE material shall be pre-pigmented and stabilized. The on-line addition of pigment and/or stabilizer during pipe extrusion or fitting manufacture is prohibited.

c. All PE material shall be a single compound. There shall be no mixing of different pipe compounds, however different batches of the same compound may be used.

d. The Contractor shall use PE resins that have outstanding SCG resistance. The resins used shall exhibit no "knee" in stress rupture curves at 80^0C for up to 1 year.

e. PE pipes made from the very high molecular weight resins shall not be used.

f. PE material shall conform to the following properties:

Table 4.2

Physical Properties	Unit	PE100	PE80
Density	kg/m^3	>950	>940
Melt flow index (190^0C@2.16kg)	g/10 min.	0.4-0.7	0.4-0.7
Mechanical Properties			
Tensile Strength	N/mm^2	>20	>18
Elongation at break	%	>600	>500
Flexural creep modulus	N/mm^2	>1000	>700
Shore hardness	-	60-65	58-62
Environmental stress crack resistance	H	>200	>200
Notched impact strength	mJ/mm^2	15	15
Thermal Properties			
Vicat softening point	^0C	>124	>116
Average coefficient of thermal expansion ($20^0C – 90^0C$)	mm/m^0C	0.15-0.2	0.15-.02
Thermal conductivity	W/m^0K	0.3-0.4	0.3-0.4
Normal operating temperatures	^0C	-30-+50	-30 - +50
Oxidation Induction Time	Minutes	>20	>20

5.9. Joints for PE pressure pipes shall comply with the following requirements, unless otherwise approved by the Engineer.

5.10. All joints between PE pipes and/or fittings for sizes 75mm OD & larger shall be welded by butt fusion or Electro Fusion methods.

5.11. Any pipes delivered in coils shall be fusion welded with special electro-fusion fittings and fully/semi automated equipment.

5.12. Pipes delivered in straight lengths may welded with electro-fusion couplers or butt-welded with fully/semi automated equipment.

5.13. The Contractor must employ an approved sub-contractor with certified staff to perform all welding operations. All sub-contractors and staff must be approved by the pipe manufacturer and the Engineer.

5.14. PE pipes 63mm OD & smaller may be joined with butt fusion welding or approved compression fittings.

5.15. PE pipes may be jointed to other piping systems by the following methods:

a. Special flanged fittings.

b. Special compression fittings suitable for PE pipe.

c. Other methods as approved by the Engineer.

5.16. Bends and Special Fittings shall comply with the following requirements, unless otherwise approved by the Engineer.

5.17. All bends and special fittings, even if manufactured elsewhere, shall be obtained from the pipe manufacturer.

5.18. All bends shall be “long-radius”, unless noted otherwise.

5.19. Additional testing for bends and special fittings may be directed by the Engineer at the Contractor’s expense

5.20. Each pipe, fitting or coupling shall be clearly marked at the place of manufacture with the following information, or as per ISO 4427.

a. The name or distinctive mark of the manufacturer.

b. The date of manufacture.

c. The standard dimensional ratio (SDR).

d. The pressure rating (if applicable).

e. The nominal diameter (O.D.).

f. The manufacturing standard to which the product has been produced.

g. The angle of bends or branches.

h. Where appropriate, the name of the Client and contract number.

i. Where appropriate, individual reference number.

j. Number and mark of independent testing agency (if applicable).

5.21. Elastomeric sealing rings for flanged fittings shall be manufactured with the following material in compliance with the following standards, unless otherwise approved by the Engineer.

5.22. EPDM material conforming to BS 2494 Type “D” requirements.

5.23. Routine sampling and testing shall be according to the following schedule, (Table 4.3, 4.4, 4.5) unless otherwise approved by the Engineer.

Table 4.3

1	Density	Once per raw material batch	ISO 1183
2	Melt flow index (190^0C@2.16kg)	Once per raw material batch	ISO 1133
3	Oxidation Induction Time	Once per raw material batch	ISO 10837

Table 4.4

1	Outside diameter	Every hour/Pipe	ISO	ISO 4427
2	Wall Thickness	Every hour/Pipe	ISO	ISO 4427
3	Length	Every hour/Pipe	ISO	12 Mtr. or as agreed
4	Ovality	Every hour/Pipe	ISO	ISO 4427
5	Marking	Every hour/Pipe	ISO	As per tender requirements of
6	Visual Inspection	Every hour/Pipe	ISO	ISO 4427
7	End Finishing	Every hour/Pipe	ISO	ISO 4427

Table 4.5

1	Heat Reversion Test	3 Samples per run/batch	ISO 2505-1	< 3%
2	Hydrostatic Pressure Test @ 20 deg. 100 hrs.	1 Sample / project	ISO 1167	ISO 4427 @ 12.4 MPa Wall Stress
3	Hydrostatic Pressure Test @ 80 deg. 165 hrs.	1 Sample / project	ISO 1167	ISO 4427 @ 5.0 MPa Wall Stress
4	Hydrostatic Pressure Test @ 80 deg. 1000 hrs.	1 Sample / project	ISO 1167	ISO 4427 @ 5.5 MPa Wall Stress
5	Tensile Strength at yield*	Every run/batch	ISO 6259/ ASTM D638	See Table 1

Note 1: Hydrostatic testing shall be carried out in accordance with the procedures in ISO 1167 and the pipes shall not fail in brittle mode.

Note 2: Tensile samples taken from the wall of PE pipes shall exhibit only a ductile mode of failure. These tests shall be undertaken at 23°C

1 using a sample shape defined in ASTM D638 and testing according to ISO 6259.

Pipes shall be sampled and tested under the Engineer's supervision.

5.24. For pipes with a nominal wall thickness of 20mm and above, a sample of polymer shall be taken from the pipe, using a sliver of material 0.5mm thick. The oxidation induction time of this material must meet the requirements listed in Table 1. This test should be on all pipes with a wall thickness at or above 20mm.

5.25. JOINTING

Polyethylene pipe or fittings are joined to each other by heat fusion or with mechanical fittings. Polyethylene may be joined to other materials by means of compression fittings, flanges, or other qualified types of fittings.

a) Butt Fusion

The most widely used method for joining individual lengths of polyethylene pipe and pipe to polyethylene fittings is by heat fusion of the pipe butt ends. This technique produces a permanent, economical and flow-efficient connection. Quality butt fusion joints are produced by using trained operators and quality butt fusion machines in good condition.

The steps involved in making a butt fusion joint are:

1. Clamp and align the pipes to be joined
2. Face the pipe ends to establish clean, parallel surfaces
3. Align the pipe profile
4. Melt the pipe interfaces
5. Join the two profiles together by applying the proper fusion force
6. Hold under pressure until the joint is cool

b) Electrofusion

The main difference between conventional heat fusion and electro-fusion is the method by which the heat is applied. In conventional heat fusion joining, a heating tool is used to heat the pipe and fitting surfaces. The electro-fusion joint is heated internally, either by a conductor at the interface of the joint or, as in one design, by a conductive polymer. Heat is created as an electric current is applied to the conductive material.

The steps to be followed when performing electro-fusion joining are:

1. Prepare the pipe (scrape, clean)
2. Mark the pipe
3. Align and restrain pipe and fitting per manufacturer's recommendations
4. Apply the electric current
5. Cool and remove the clamps
6. Document the fusion procedures

6. uPVC Pipe and Fittings

6.1 General

uPVC pipes are used for gravity sewers having diameter 250 mm or less.

. Product manufacture, testing and installation shall comply with the following references, unless otherwise stated in the specification or unless otherwise approved by the Engineer.

a. ISO 161/1Thermoplastics pipes for the transport of fluids Nominal outside diameters and nominal pressures – Part 1 : Metric Series.

b. ISO 1167 Plastic pipes for the transport of fluid – Determination of resistant to internal pressure.

c. ISO 2045 Single sockets for unplasticised polyvinyl chloride (uPVC) pressure pipes with elastic sealing ring type joints – Minimum depths of engagement.

d. ISO 2048 Double sockets for unplasticised polyvinyl chloride (uPVC) pressure pipes with elastic sealing ring type joints – Minimum depths of engagement.

e. ISO 2505 Unplasticised polyvinyl choride (uPVC) pipes – Longitudinal reversion – Test methods and Specification. Method B – Oven test.

f. ISO 2507 Unplasticised polyvinyl chloride (uPVC) pipes and fittings – Vicat softening temperature – Test methods and Specification.

g. SO 3126 Plastic Pipes – Measurement of dimensions.

h. ISO 3127 Unplasticised polyvinyl chloride (uPVC) pipes for the transport of fluids – Determination and specification of resistance to external blows.

i. ISO 3472 Unplasticised polyvinyl chloride (uPVC) pipes – Specification and determination of resistance of acetone.

j. ISO 3473Unplasticised polyvinyl chloride (uPVC) pipes – Effect of sulphuric acid – Requirement and test method.

k. ISO 3606Unplasticised polyvinyl chloride (uPVC) pipes – tolerances on outside diameters and wall thicknesses.

l. BS EN 1401-1: 1998 u-PVC gravity sewer pipes

Pipe sizes shall be as shown on the drawings, unless otherwise approved by the Engineer. The designated sizes on the drawings refer to nominal internal diameters.

Pipe class shall be as follows, unless otherwise noted or unless otherwise approved by the Engineer.

a. Pressure pipes: Class 16

b. Non-pressure pipes:

The pipe shall have the nominal dimensions shown on the Drawings. Non Pressure Pipes shall have a ring stiffness of 4,000 N/m^2 between manholes where the depth of cover over the crown of the pipe is less than 3.5 m in any part of that section between manholes. Non-Pressure Pipes shall have the ring stiffness of 8,000 N/m^2 between manholes where the depth of the cover over the crown of the pipe is equal to or greater than 3.5m in any part of that section between manholes.

Where pressure pipe is designated for non-pressure applications, manufacturing shall conform to the designated pressure class, unless otherwise approved by the Engineer.

Pipes shall be suitable for sustained operating temperatures of up to 45°C.

Pipe lengths shall be as follows, unless otherwise approved by the Engineer.

a. For 225mm outside Dia. and above, standard pipe length shall be 6 metres.

b. For 200mm outside Dia. and below, standard pipe length shall be 3 metres.

Maximum buried depth for uPVC pipes shall be 6 meters, unless approved otherwise by the Engineer.

All joints shall be spigot and socket type with flexible elastomeric sealing rings, unless approved otherwise by the Engineer.

a. Double sockets or slip on sockets may be used adjacent structures or special fittings.

b. Solvent welded joints may be used for buried fittings if assembled in the manufacturer's workshop under the Engineer's supervision. Solvent shall be as per the pipe manufacturer's recommendations.

c. Solvent welded fittings may be used for exposed piping, if approved by the Engineer.

All elastomeric joint seals (rubber gaskets) shall be obtained from the pipe manufacturer.

All joints shall be capable of withstanding an external pressure of 100 Kpa without infiltration in both the straight and misaligned positions.

All bends and special fittings, even if manufactured elsewhere, shall be obtained from the pipe manufacturer, unless approved otherwise by the Engineer.

All bends shall be "long-radius" unless otherwise approved by the Engineer.

Additional testing for bends and special fittings may be directed by the Engineer at the Contractor's expense.

Each pipe, special or fitting shall be clearly marked at the place of manufacture with the following information.

a. The name or distinctive mark of the manufacturer.

b. The date of manufacture.

c. The pressure rating (if applicable)

d. The nominal diameter

e. The manufacturing standard to which the product has been produced

f. The angle of bends or branches

g. Where appropriate, the name of the Client and contract number

h. Where appropriate, individual reference number

i. Number and mark of independent testing agency (if applicable)

Pipe and standard joints shall be submitted for all proposed sizes and pressure classes for the Engineer's approval.

The submittal shall clearly indicate or include the following:

a. Pipe manufacturer's name.

b. Proposed pipe diameters

c. Proposed pipe pressure class or rating for pressure pipes and ring stiffness for non pressure pipes

d. Proposed manufactured lengths

e. Proposed joint type

f. Proposed sealing ring material and manufacturer's name

g. Maximum depth of cover

h. Minimum depth of cover

i. Maximum internal operating pressure

j. Maximum internal test pressure

k. Maximum allowable external pressure

l Recent type test results according to the relevant standard of manufacture to prove the adequacy of the products.

Fittings, bends and specials for all proposed sizes and pressure classes shall also be submitted for the Engineer's approval. Samples shall be supplied according to the Engineer's request.

The uPVC material supplier shall demonstrate to the Engineer, that he has the capability of manufacturing the required uPVC pipelines of the sizes in accordance with the contract. The company shall have an internationally recognized quality management system in place and shall be accredited to ISO 9002 or equivalent.

Pipes, fittings and specials shall be delivered, handled and stored according to the manufacturer's recommendations along with the following provisions. Transportation, handling and storage shall at all times be performed in a manner to avoid product damage. Only nylon slings shall be allowed for lifting pipes and fittings. Steel chains, clamps or cables shall not be allowed for lifting purposes.

Steel chains or cables may be allowed for securing pipes during transport or storage provided protective padding or timber blocking is utilized.

Any pipes damaged during delivery, storage or installation shall be marked and set aside.

Proposals for repair of any damaged pipes shall be submitted in writing to the Engineer for approval.

No repairs to damaged pipes shall be attempted without the Engineer's approval.

Any damaged pipes deemed unsuitable for repair by the Engineer shall be removed form site and replaced at the Contractor's expense.

Elastomeric sealing rings (rubber gaskets) shall be stored in closed containers or out of direct sunlight until needed.

uPVC pipes shall be manufactured in metric sizes according to ISO standards, unless otherwise approved by the Engineer.

uPVC pipes shall be manufactured from new materials. Recycled PVC shall not be used.

Elastomeric sealing rings shall be manufactured with the following material in compliance with the following standards, unless otherwise approved by the Engineer:

EPDM material conforming to BS 2494 Type "D requirements for irrigation service.

Pipe specials shall be manufactured according to the manufacturer's recommendations or as approved by the Engineer.

Pipe surround shall conform to the requirements in Section 3 of CESWI 6th Edition and the same section of this document.

Solvent cement shall be as recommended by the pipe manufacturer.

Pipe layers

a) No piece of pipe shall be laid unless it is straight. The centerline of the pipe shall not deviate from a straight line drawn between the centres of the openings at the ends of the pipe by more than 5mm/metre of length. If a piece of pipe fails to meet this requirement check for straightness, it shall be rejected and removed from the site. Laying instructions of the manufacturer shall be explicitly followed.

b) If any defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner at no additional cost to the Employer. All pipe and fittings shall be thoroughly cleaned before installation, shall be kept clean until they are used in the work and when laid, shall conform to the lines and grades required. PVC pipe and fittings shall be installed in accordance with requirements of the manufacturer, or as otherwise provided herein.

c) As soon as the excavation is complete to normal grade of the bottom of the trench, bedding shall be placed, compacted and graded to provide firm, uniform and continuous support for the pipe. Bell holes shall be excavated so that only the barrel of the pipe bears upon the bedding.

The pipe shall be laid accurately to the lines and grades indicated on the Drawings. Blocking under the pipe will not be permitted. Bedding shall be placed evenly on each side of the pipe to mid-diameter and hand tools shall be used to force the
bedding under the haunches of the pipe and into the bell holes to give firm continuous support for the pipe. Bedding shall then be placed to 30 cm above the top of the pipe. The initial 90 cm of backfill above the bedding shall be placed in 30 cm layers and carefully compacted. Generally the compaction shall be done evenly on each side of the pipe and compaction equipment shall not be operated directly over the pipe until sufficient backfill has been placed to ensure that such compaction equipment will not have a damaging effect on the pipe. Equipment used in compacting the initial 90 cm of backfill shall be approved by the pipe manufacturer's representative prior to use.

d) All pipes shall be sound and clean before installation. When installation is not in progress, including lunchtime, the open ends of the pipe shall be closed by watertight plug or other approved means. Good alignment shall be preserved during installation. The deflection at joints shall not exceed that recommended by manufacturer.

Fittings, in addition to those shown on the Drawings, shall be provided, if required, in crossing utilities which may be encountered upon opening the trench.

e) When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a bell shall be beveled to conform to the manufactured spigot end.

f) The Engineer may examine each bell and spigot end to determine whether any preformed joint has been damaged prior to installation. Any pipe having defective joint surfaces shall be rejected, marked as such and immediately removed from the job site.

g) Each length of the pipe shall have the assembly mark aligned with the pipe previously laid and held securely until enough backfill has been placed to hold the pipe in place. Joints shall not be "pulled" or "cramped".

h) Before any joint is made, the pipe shall be checked to assure that a close joint with the next adjoining pipe has been maintained and that the inverts are matched and conform to the required grade. The pipe shall not be driven down to grade by striking it.

I) Precautions shall be taken to prevent flotation of the pipe in the trench.

j) When moveable trench bracing such as trench boxes, moveable sheeting, shoring or plates are used to support the sides of the trench, care shall be taken in placing and moving the boxes or supporting bracing to prevent movement of the pipe, or disturbance of the pipe bedding and the backfill. Trench boxes, moveable sheeting, shoring or plates shall not be allowed to extend below top of the pipe. As trench boxes, moveable sheeting, shoring or plates are moved, pipe bedding shall be placed to fill any voids created and the backfill shall be recompacted to provide uniform side support for the pipe.

k) Concrete thrust blocks shall be installed at all fittings and other locations as directed by the Engineer. Minimum bearing area shall be as shown on the Drawings. Concrete shall be placed against undisturbed material and shall not cover joints, bolts or nuts, or interfere with the removal of any joint. Wooden side forms shall be provided for thrust blocks.

Jointing

a) Joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined and pushed home with a come-along or by other means. Check that the reference mark on the spigot end is flush with the end of the bell. Pipe and fittings shall be jointed in accordance with the recommendations of the detailed instructions of the manufacturer. The pipe manufacturer shall furnish information and supervise the installation of at least the first five joints. The pipe manufacturer shall be available on site for 3 days to supervise and inspect installation.

b) All manhole connections shall be as shown on the Drawings except that concrete and mortared connections shall be equipped with an integral O-ring or other sealant such that a positive watertight seal is established.

7. Concrete Encasement

Where concrete bedding or surround is required, the backfill shall not be placed before the compressive strength of the site concrete has reached the specified strength.

Where concreting to pipeline is specified, a blinding layer of Grade as specified in the Contract shall be placed over the full width of the trench.

Pipes to be bedded on or cradled with concrete shall be supported on precast concrete setting blocks, the top face of each block being covered with a separation layer.

Concreting to the pipeline shall be either bed or bed and surround as shown on the Drawings and shall be of Grade as specified in the Contract drawings along such lengths as are shown on the Drawings or ordered by the Engineer.

The pipe shall be prevented from moving or floating during concreting.

Where concrete bed and surround is used with GRP and PVC-U pipes the maximum spacing between pipe joints shall be 3 m. For other pipe materials the maximum spacing shall be as directed by the Engineer.

In the case of concrete surround for pipes with flexible joints, the joints shall be interrupted in a vertical plane at the edge of the socket by a strip of fiberboard or any other approved joint filler.
In accordance with the following thicknesses:

Up to 300 mm nominal bore - 13 mm
Over 300 mm and up to 600 mm nominal bore - 25 mm
Over 600 mm and up to 1200 mm nominal bore - 38 mm
Over 1200 mm and up to 2000 mm nominal bore - 50 mm

Where concrete slab protection to GRP and PVC-U pipelines is required such protection shall extend a minimum of 200 mm either side of the pipe trench. The slab shall be of reinforced concrete as shown on the Contract Drawings.

8. Wadi Crossings

Work at any crossing of a wadi or other waterway shall be carried out as expeditiously as possible to the satisfaction of the Engineer and any responsible Government agency or other authority, with minimum interference to the free flow of water. Details of any temporary works which may affect the flow of the wadi shall be submitted to the Engineer at least 14 days before starting work.

Where pipelines passes underneath a wadi, ditch, open surface water channel, or other waterway, the pipelines shall be encased in concrete. The minimum thickness of encasement shall be 150 mm. Unless otherwise designated, the depth of cover shall not be less than 600 mm from the bed of the water course to the top of the concrete.

The Contractor shall fill the trench in both banks with rock fill or concrete up to the designated levels. The extent of this work may be varied to suit each individual crossing.

Unless otherwise ordered, the concrete encasement of the pipe shall extend at least to a section vertically below the tops of the banks. Protection against erosion to the banks shall be provided by means of stone pitching or riprap.

9. Pipe Supports

All weight of piping and contained fluids shall be transferred to a structures or foundation system through stools, brackets, pipe saddle supports, or overhead hanger systems

Supports shall be provided for each pipe at or near the point where it is connected to machinery or valves. Supports shall be provided for each valve and special fitting.

flexible joints shall be required at either ends of the support system, where necessary expansion joints shall also be provided

Pipe hangers and supports shall generally be fabricated in galvanized Mild Steel and if required by the Engineer to be coated with coal tar epoxy.

For pipelines to be fixed in culverts, the Contractor shall prepare proposals for thrust and anchor support and submit them to the Engineer for approval. Such approval shall not relieve the Contractor from his responsibility for the adequacy of his proposal. Additional

requirements for both location and details of supports may be shown on the Drawings or directed by the Engineer as the work proceeds to suit the actual conditions encountered.

10. Built-In Pipes to Structures

Pipes built in a concrete wall or structure shall be protected with a concrete surround integral with the external face of the structure as shown on the Drawings.

All internal and external protection membranes to the concrete shall be sealed around the pipe openings as recommended by the membrane manufacturer. When the pipe is later fixed, the remaining hole shall filled with non-shrinkage grout.

Any over-excavation adjacent to a structure or beneath the formation level of a pipeline, either to be constructed under the Contract or in a future contract, shall be backfilled with mass concrete as specified in the Contract Drawings..

Pipes and pipe specials through concrete walls and floors shall as far as possible be positioned and built in during construction. They shall be located exactly in the positions shown in the Contract Drawings and shall be true to line and level. The Contractor shall take particular care to ensure that fully compacted concrete is in contact with the pipe at all points.

Where it is impracticable to cast pipes and specials in the concrete, box outs shall be provided in the formwork. The box size shall be appropriate to the pipe diameter to give adequate clearance for the positioning and grouting of the pipe.

Unless otherwise shown on the Contract Drawings, where pipes pass through a concrete wall or structure they shall be protected with a surround of concrete with grade as specified in the Contract drawings integral with the external face of the structure.

For pipes of less than 500 mm diameter, the surround shall extend from the wall or structure by 300 mm and the width and depth of the surround beyond the outside face of the pipe at its horizontal and vertical diameters shall be a minimum of 300 mm or as otherwise indicated on the Drawings.

For pipes of 500 mm diameter or greater the surround shall extend from the wall or structure by 500 mm and the width and depth of the surround beyond the outside face of the pipe at its horizontal and vertical diameters shall be 500 mm or as otherwise indicated on the Drawings.

On socket and spigot pipelines except those of GRP or other plastic materials the socket end of the pipe passing through the wall shall be flush with the outside face of the concrete surround. On socket of spigot pipelines of GRP or other plastic materials the socket end of the pipe passing through the wall shall protrude 300 mm from the concrete surround. A protective synthetic rubber strip 6 mm thick and 150 mm wide shall be provided around the pipe at the limit of the concrete surround in accordance with the Contract Drawings.

On all other flexibly jointed pipes the plain end of the pipe shall protrude from the concrete surround by a maximum of 300 mm or that distance required to properly make the joint.

The first pipe that is clear of concrete surround beyond the external face of a concrete wall or structure shall be a short length of either spigot and socket or double spigot to suit the flow direction and pipe material. The effective length of this pipe shall be 1.5 times the nominal bore or 600 mm whichever is the greater.

For mechanically jointed pipes the plain end shall protrude from the surround by a maximum of 300 mm or that distance required properly to make the joint.

11. Fibre Optic Cable Protection Duct

1. The duct shall be a twin wall construction with a smooth internal finish and a corrugated outer wall. The duct shall be 110mm diameter. The duct shall be flexible, capable of diversion around a 1.2m dia manhole. The dual wall construction shall be such that the inner and outer walls will not separate or lose their specified load bearing properties in any respect under such flexure.
2. The duct shall be capable of resisting a static load of 450 N and allow application within a temperature range of -40˚C to + 75˚C without causing ant deformation to the pipe.
3. The fibre optic cable duct shall be laid along the route of the sewer of 700mm cover depth. All ducts shall be stored in a shaded area away from direct. sunlight.
4. The pipe shall be certified to British or European Standard

12. Cleanliness of Pipelines

Pipelines and manholes shall at all times be kept free of all silt, mortar, debris and other obstructions. When work is not in progress the open ends of the pipeline shall be securely plugged with an approved watertight plug or stopper firmly fixed.

The Contractor shall clear the inside of each fitting and pipe length immediately before jointing and shall swab all fittings and pipe lengths to remove all dirt, sand or other matter that may clog the pipeline or contaminate the fluid to be transported in the pipeline.

After jointing, the interior of the pipes shall be freed from any dirt, stones or other matter that may have entered them. For this purpose, a rubber disc, brush, or other suitable implement that will not harm the internal lining of the pipe shall be pulled through the pipe after jointing.

Pressure pipelines and treated sewage effluent pipelines shall be flushed and a swab passed through. Large diameter pipelines shall be visually inspected internally to the approval of Engineer.

13. Pressure Pipeline Marker Posts

Pressure pipeline marker posts shall be installed at all locations where the pipeline crosses boundaries or changes direction, but in no case shall the spacing exceed 200 m. Each marker post shall be set over the centerline of the pipelines with concrete base in accordance with the Contract Drawings. Marker posts shall incorporate a description of the pipeline and its service in Arabic and English to the approval of the Engineer. Offset marker posts may also be used in areas where the post could not be installed over the centerline of the pipelines.

14. Valve Chamber Marker Posts

Valve chamber marker posts shall be installed at all chambers, indicating the type of chamber, its reference number and distance from the marker post in Arabic and English to the approval of the Engineer.

Where the pipeline is in a footpath or verge, the marker post shall be installed against the wall or property boundary and facing the chamber cover, with concrete base surround.

15. Abandonment of Pipelines

Pipelines and service connections to be abandoned shall first be emptied completely.

Pipelines and service connections to be abandoned shall be filled completely with a cement slurry or concrete using method approved by the Engineer such that the discharge slurry or concrete can be forced into the pipeline under pressure.

The Contractor shall ensure that all existing connections to the sewer to be abandoned have been plugged or disconnected before beginning filling.

The Contractor shall inform the Engineer of his intention to begin this operation and shall obtain the Engineer's approval in writing for the abandonment of each particular length before beginning filling.

Upon completion of the above procedure, the Contractor shall undertake abandonment of Manholes, inspection chambers and other structures. Where a pipeline or service connection to be abandoned connects into a manhole or chamber to be retained, the connection shall be plugged at the chamber wall and the associated channel in the benching of the manhole or chamber shall be cleaned and filled with concrete as specified in the Contract documents.

Unless otherwise designated, existing pressure pipelines to be abandoned shall be emptied and sealed at each end of the pipeline with a removable expanding stopper to the Engineer's approval. The stopper shall include a valve for the purpose of venting and for the equalizing internal and external pressures removal. Any chambers located along the pipeline to be abandoned shall be demolished and the pipeline ends sealed as specified.

16. Manholes

16.1 General

Manholes shall be constructed as indicated in the Contract drawings. The blinding concrete shall be as specified in the Contract drawings and shall be protected with membrane tanking systems.

The cover slabs shall be surmounted by ductile cast iron/ equivalent manhole covers and frames of the quality specified and in accordance with OWSC standard details. The covers in roads and paved areas shall be set on pre cast concrete brickwork to the level and slopes of the roads or pavements.

In the case of shallow manholes, the cover and frame may be cast directly with the reinforced concrete cover slab as shown on the standard details drawings.

The internal surface of the manholes and access shafts shall be protected with an approved Liner sheets such as GRP or PVC Liner.

Benching shall be preformed with concrete and to protected with the same lining material.

16.2 Manhole Covers and Frames

Circular, corrosion resistant, heavy-duty, hinged, lockable, leak proof cover & frame shall be used on sewer manholes in accordance with the Standard Details drawings. For covers in private residences the manholes shall be the same as described but shall be medium duty. The locking mechanism shall be operated by a specialised tool to be supplied with the cover frame and units. The locking mechanism must not be operable by use of readily available tools.

Manholes Covers and frames shall be of class D 400 and in accordance with BS EN 124 with respect to design requirements, type of testing, marking, quality control etc…

The Covers Material shall be Ductile Iron, Composite Products or any other equivalent material and shall be fully complying with BS EN 124 and /or equivalent standard

The Covers shall be also manufactured to OWSC's requirements and in accordance with OWSC's Standard Drawings.

16.3 Marker Tape and Marker Posts

Marker tape for buried wastewater pipes, pressure pipes and vacuum sewers shall be yellow, heavy gauge polyethylene at least 150mm wide and shall be printed with the words 'CAUTION GRAVITY SEWER BELOW', 'CAUTION PRESSURE SEWER BELOW' or 'CAUTION VACUUM SEWER BELOW', in bold capital letters at intervals of no greater than 700mm throughout its length and shall incorporate a corrosion resistant tracing system for non metallic pipes.

All marker tape and signage shall be able to be read in Arabic and English.

Each Manhole shall have its own unique corrosion resistant marker plate on the manhole cover. This marker plate shall have a unique number and co-ordinate reference as approved by the Engineer. These marker plates shall be installed on non corrodible manhole marker posts located within 6 metres of the manhole, when the manhole is located in wadi's and open ground.

16.4 Mortar

Where indicated on the drawings or specified to use epoxy mortar for benching and channels in any other structure such as chambers, pump station wet-well, etc, they shall be formed to have a minimum of 10mm thickness of an approved epoxy-resin mortar system applied to the manufacturers instructions.

The epoxy mortar system shall be trowellable, two component epoxy resin system consisting of a prefilled base and unfilled reactor which when mixed shall produce a high strength, impermcable and chemically resistant mortar.

The epoxy mortar system shall have excellent chemical resistance to sodium chloride and sulphuric acid (shall pass the relevant chemical resistance test), and shall have a high impact of resistance. Typical properties are given in the following table:

Properties of Two Component Epoxy Mortar

Property	Test Method	Limit
Sag at 10mm thickness	-	None
Working Time	ASTM C308	>90 min at 25^{o} C
Full Cure at 25^{o} C	-	3 to 7 days
Setting Time at 25^{o} C	-	30 to 45 min
Water Absorption	ASTM C413	<0.07%
Comprehensive Strength	BS 6319:Part 2	>40 N/mm ^{2} at 25^{o} C 7 days cure
Flexural Strength	BS 6319:Part 3	>3 N/mm ^{2} at 25^{o} C 7 days cure
Tensile Strength	BS 6319:Part 7	>8 N/mm ^{2}
Bond Strength	BS 6319:Part 4	>30 N/mm ^{2}
Density	BS 6319:Part 1	1750kg/m ^{3}

When placed on a concrete substrate the epoxy mortar system shall have an adhesive strength of not less than the internal cohesive strength of concrete.

To achieve the necessary adhesion to the substrate an epoxy primer compatible for use with the mortar and the substrate shall be applied.

The epoxy mortar, to the primer where required, shall be suitable for application onto a substrate with moisture content of 4% or less as measured by the “wet-check” Moisture Meter or the other instrument approved by the Engineer.

The potlife of the mixed mortar shall not be less than one hour at the temperature to the place of application at the time of mixing. The Engineer may restrict application to such time as the ambient temperature is sufficiently low for the specified pot-life to be ensured.

There shall be a strict control of surface cleanliness between primer and epoxy mortar and between coats of the same. Vacuum removal of dust and sand shall be employed and water soluble contamination shall be removed as specified above. Where dirt or dust has become trapped in the rimed surface it shall be removed with suitable abrasive paper. The surface being primed shall be free of visible moisture throughout there operations.

The mortar manufacturer shall stipulate primer and epoxy re-coat intervals for all curing temperatures likely to be encountered and these shall be adopted with a maximum tolerance of +4hours. Where this is exceeded the surfaces to be re-coated shall be suitably abraded to remove gloss.

Mixing of the components shall be strictly in accordance with the Manufacturer's recommendations and care shall be taken to avoid the entrainment of air in the mixes.

Wet thickness gauge shall be used by the mortar applications continually to check that sufficient mortar is being applied to achieve the required thickness.

17. Precast Concrete Manholes and Soakaways

Precast manhole and soakaway units of circular cross-section shall comply with the relevant provisions of BS EN 1917 and BS 5911: Part 4. Units which bed onto bases shall be manufactured so that imposed vertical loads are transmitted directly via the full wall thickness of the unit. For joints between units and the underside of slabs, joint profiles shall be capable of withstanding applied loadings from such slabs and spigot-ended sections shall only be used where the soffit of the slab is recessed to receive them.

The wall thickness shall not be less than 125 mm for 1200 mm diameter reinforced barrel sections, and 150 mm for 1500 mm diameter reinforced barrel sections. Access openings shall be a minimum clear opening of 700 mm except as otherwise shown on the Drawings. Base, riser and cone sections shall have tongue and groove joints.

Portland cement shall be Type V, high sulfate resistant. All sections shall be cured by an approved method and shall not be shipped nor subjected to loading until the concrete compressive strength has attained 200 kg/cm2 and not before 7 days after fabrication and/or repair, whichever is longer.

Precast concrete barrel sections with precast top slabs shall be designed for a minimum of H-20 loading plus the weight of the soil above. Calculate earth load at a unit weight of 2000 kg/m^2.

Top section shall be concentric cone where cover over pipe exceeds 1.2 m; top section shall be flat slab where cover over top of pipe is 1.2 m or less.

The date of manufacture and the name and trademark of the manufacturer shall be clearly marked in a location on each precast section which will be visible upon delivery to site.

18. Precast Concrete Segments for Tunnels and Shafts

All concrete used in the manufacture of segments shall be at least compressive strength class C32/40 as defined in BS 8500:Part 1:2000. Concrete shall be sampled and tested for compliance with the specified strength class in accordance with the provisions of BS EN 206-1:2000, Clause 8.2.1. The concrete shall be subject to identity checks of not less than one sample per 20m^3 of fresh concrete. All the segments shall have the date of manufacture clearly marked in an appropriate position at the time of manufacture. Segments shall be subjected to test for water absorption in accordance with the provisions of BS EN 1916:2002 Annex F.

19. Prestressed Concrete Pipes and Fittings

Prestressed concrete pressure pipes and fittings shall comply with the relevant provisions of BS 4625 and BS EN 639. Prestressed concrete pipes and fittings for drainage and sewerage purposes shall comply with the relevant provisions of BS 5911: Part 1.

Unless steam cured, no pipes or fittings shall leave the place of manufacture until they have been allowed to cure and mature under suitable conditions for a total period of not less than 28 days. The surface finish shall be assessed in accordance with, and comply with, the provisions of BS EN 1916 2002 section 4.3.2 and BS 5911:Part 1.

20. HDPE Pre Fabricated Manholes and Chambers

20.1 The List of main standards to refer to are as follows. For undated references the latest edition of the published referred to applies:

CEN (Draft prEN 13476-1) “Thermoplastics piping systems for non-pressure underground drainage and sewerage – Structured-wall piping systems of Polyethylene”.

Draft CEN/TC155 WG 13 : Structured Wall Piping and Polyethylene

DIN 16961 – “Thermoplastic pipes and fittings with profiled outer and smooth inner surfaces”.

ISO 9969 – “Determination of Ring Stiffness of Plastic pipe by parallel plate loading”.

EN 1446 – Determination of Ring Stability of Plastic Pipe

DVS 2209 Part 1 – "Welding of polyethylene pipes by extrusion welding technique".

RIL – 77: 190 – "Plastic pipes laid in ground and water. Laying instruction".

ASTM D 2321 – "Underground Installation of Flexible Thermoplastic Sewer Pipe".

ASTM F 1759 – 97 "Design of High Polyethylene (HDPE) Manholes for Subsurface Applications".

ASTM F 714 – "Specification for Polyethylene (PE) Plastic pipes based on outside diameter

ASTM F 477 – "Specification for Elastomeric Seals (Gaskets) for joining plastic pipe".

ISO 4427:1996 (E) – "Polyethylene (PE) pipes for Water Supply".

DIN 8061 – "Unplastizied polyvinyl chloride pipe".

EN 1979 – Tensile Strength of a Seam

Where reference is made to one of the above standards, the latest revision in effect at the time of bid opening shall apply. Compliance with other equivalent, pertinent or comparable standards (e.g. ISO, DIN, BS, EN) shall be acceptable, provided the Contactor submits certification and complete documentation (including English-language versions of such other standards), to the satisfaction of the Engineer, proving that such other standards meet or exceed the specific requirements of the comparable Standards.

20.2. The prefabricated HDPE Trunk & Shallow manhole and chamber shall comprise of the following components,

Trunk Manhole	Shallow Manhole	Chamber
Lower Shaft	Lower Shaft	Shaft
Upper Reduction cone	Reduction cone	Benching
Lower Reduction cone	Benching	Inlet / Outlet
Upper shaft	Socket	
Benching	Adjustment shaft	
Inlet / Outlet	Inlet / Outlet	
Lifting lugs	Lifting lugs	
Anti-flotation fins		

Note: Anti-flotation fins shall be provided to prevent uplift due to the presence of ground water.

Lower Shaft

The main shaft also known as the carcass of the manhole shall be cylindrical and equal to the diameter of the manhole. The carcass shall be of twin wall construction for Trunk and Shallow manholes and single wall in case of chambers. The stiffness of the carcass shall be designed to withstand the radial pressure and effect of down-drag due to settlement of the soil.

All the manholes shall have headroom for easy access during cleaning and flushing operation. For manholes with internal diameter equal or greater than 1500 mm ID a transition shaft of 1000 mm ID shall be used. In such case the height of the main shaft shall have the minimum clearance of 2000 mm between the benching and the reduction cone for easy access during cleaning.

Upper Reduction Cone

The Upper Reduction cone shall be welded to the upper shaft or the lower shaft depending on the type of manhole.

The cone shall be fabricated or a molded type to suit the diameter of the Upper / lower shaft on one and the socket diameter on the upper shaft diameter on the other end.

Lower Reduction Cone

The Lower Reduction cone shall be used to connect the upper shaft and lower shaft in case of upper shafts of internal diameter above 2000 mm. The standard internal diameter of the transition shaft is 1000 mm.

Upper Shaft

A cylindrical shaft of a similar construction as the Lower shaft, stiffness to withstand the affect of radial pressure and drag due to settlement of soil. The minimum internal diameter of the transition shaft shall be 1000 mm.

Benching

The benching shall be a HDPE fabricated type in case of large diameter manholes and molded type in case of the shallow manholes and the chambers. The radius of the fabricated and molded type benching shall not be less than 100mm. Alternatively concrete benching could be constructed, with prior approval of the Engineer in charge. In case of concrete benching being used all inlet and outlet branches shall be provided with a puddle flange.

Inlet / Outlet

The inlet and outlet shall be duly welded to the benching of the manhole. In case of manholes with branch connections for pipes up-to & below 250 mm OD, inlets shall be socket and the outlet shall be spigot. Jointing shall be done by push fit method. For branch size 300 mm and above, jointing of both inlet and outlet shall be formed by extrusion welding.

External drop connections shall be by push-fit method for pipes up to 400mm and formed by extrusion welding for 450mm and above.

Lifting Lugs

All the manholes (Trunk & Shallow) be provided with lifting lugs for easy handling and placement. Lifting and handling of the manholes shall be done in accordance with the manufacturers instruction.

Anti-flotation fins

Where manholes are located in tidal zone or high ground water table anti-flotation fins shall be welded externally to the manhole to prevent uplift. The contractor at the time of approval shall submit calculations to demonstrate that adequate provision has been taken against uplift.

Jointing together of all the HDPE components of the manhole shall be performed using the same grade of material.

The manholes shall be subject to gravity flow only.

20.3. All the manhole components listed above shall be made from HDPE plastic compound having a cell classification of 334433C or higher, in accordance with specification ASTM D3350. The High Density Polyethylene (HDPE) material shall contain all those antioxidants, U.V. stabilizers and pigments necessary for conforming to this specification for its end use, including its weldability.

20.4. The HDPE material supplier shall demonstrate to the Engineer, that he has the capability of manufacturing the required HDPE manholes of the sizes in accordance with the contract. The company shall have an internationally recognized quality management system in place and shall be accredited to ISO 9002 or equivalent.

20.5. For resin evaluation, the results of the following tests shall be part of the manufacturer's permanent quality control records.

Melt Flow Index – ASTM D 1238

Density – ASTM D 1505 / ISO 1183D / ISO 1872/2

Carbon Black Content – ASTM D1603

Tensile Strength – ISO 6259

Hardness – ISO 868

Stress Crack Resistance FSO – ASTM 1693 Condition B

Thermal Stability Induction Time – EN 728

All manholes shall be free from all defects including indentations, delamination, cracks, bubbles, pinholes, inclusions or occlusions which, due to their nature, degree, or extent, detrimentally affect the strength and serviceability of the manhole.

Any manhole with defects, which, in the judgment of the Engineer, will affect the strength and serviceability, shall be repaired free of charge by the supplier.

Laboratory tests for stiffness shall be carried out in accordance with

ISO 9969 or any other equivalent specifications.

The Engineer or any other representative of the owner may inspect the manhole at site after delivery. The manhole shall be subject to rejection at any time on account of failure to meet any of the specified requirements, even though manholes may have been accepted as satisfactory at the place of manufacture. Manholes rejected after delivery shall be marked for identification and shall immediately be removed from the site.

20.6. The following markings shall be printed on the Manhole:

a) Name or trademark of the manufacturer
b) Nominal size, in mm
c) A production code from which the date and place of manufacture can be determined
d) Unique number for each manhole

20.7. Handling of the manholes shall be in accordance with the manufacturer's instruction and as specified herein.

Care shall be taken in loading, transporting and offloading, to prevent any cuts/gauges/scratches or damage to the inlet / outlet branches. Nylon Belts / ropes shall only be used during offloading, handling and lowering the manhole in the trench.

Use of steel chains, steel wire ropes and steel hooks shall not be permitted.

All the Manholes shall be stored upright on a clean, dry, level ground, free of sharp protrusions.

All the manholes shall be examined before installation for any damage to the components. In case any damage identified the same shall be repaired as directed by the Engineer.

High Density Polyethylene (HDPE) Pressure Pipe and Fittings

21. uPVC Property Connection Chambers

Property Connection manholes shall be uPVC with a cover and frame suitable for light traffic loading. The manhole shall be constructed by a build up of uPVC shaft units depending on the required cover level. A rubber gasket seal shall be used to push fit the shafts together. The benching shall be preformed to suit site conditions. The Manhole cover shall be medium duty, lockable, corrosion resistant and sealed.

22. Thrust Blocks

The Contractor shall construct thrust blocks at every bend and junction on pressure pipelines and where otherwise shown on the Contract Drawings or instructed by the Engineer.

Each thrust block shall to have a sufficient bearing area and shall be placed to safely transmit thrust to the surrounding original ground. If soft, spongy, unstable or similar material is encountered upon which the thrust block is to bear this unsuitable material shall be removed and replaced with mass concrete as specified in the Contract documents and as directed by the Engineer.

Thrust blocks shall be in-situ concrete, cast on undisturbed soil, with Grade as specified in the Contract documents.
Thrust blocks shall be placed between fitting and trench wall or trench bottom, as the case may be. All concrete shall be kept behind the sockets of fittings.

Formwork shall be constructed wherever necessary to confine the concrete to the prescribed dimensions for the block. All formwork shall be removed before testing.

No pressure shall be applied to thrust blocks until the concrete has reached it's characteristic strength.

The depth of cover to concrete blocks shall not be less than 600mm.

A ground check is to be carried out to confirm that design ground conditions are similar to those found on Site and if not then the design is to be revised accordingly.

For pressure mains where the gradient is steeper than 1 in 6 a self-restraining joining system or anchor blocks should be used. Where anchor blocks are proposed these should be designed to suit the loading from the main and the local ground conditions. All Thrust Blocks to be approved by the Engineer.

23. Property Connections Survey

The Contractor shall carry out a survey of existing facilities and prepare individual and prepare shop drawings for each property for which a sewerage connection is required.

The Shop drawing shall show existing plot boundaries, location of property and location of all affecting services including septic tanks. These shall be marked up to show the details of the proposed service connection and shall be submitted to the Engineer for approval.

No service connection work shall begin before approval to the proposed layout has been received in writing from the Engineer.

In special cases only, an inspection chamber may serve more than one service connection.
Locations of inspection chambers and the layout of service connections shall be as approved by the Engineer.

Service connections shall be laid at sufficient depths to allow for adequate gradient being continued throughout the properly drainage system without the pipelines becoming too shallow for adequate cover to be provided over the pipe.

24. Testing Of Pipelines

24.1 General

The Contractor shall submit for the Engineer's approval details of his proposed methods and Programme for testing (including details of test equipment) and shall arrange for all test to be witnessed by the Engineer or other person appointed by the Engineer.

Test equipment shall be approved by the Engineer and calibration certificates when requested by the Engineer shall be submitted. The Contractor shall provide all equipment necessary for carrying out testing and cleaning including pumps, gauges, piped connections, stop ends, and all other temporary works.

All water required for testing and cleaning the pipelines shall be from a source approved by the Engineer.

Pipelines shall be adequately restrained before being put under test. No testing will be permitted until seven days after thrust blocks and other holding down works have been completed. Trenches may not be left open at joints before testing pipelines except as permitted by the Engineer who may lay down certain restricting conditions.

In addition to any tests of individual joints or other interim tests which may be designated elsewhere, the Contractor shall submit all parts of the pipelines to a final test.

All pipelines shall be tested between manholes or valve chambers not exceeding 400 m.

On completion of testing the section of pipeline shall be properly sealed to prevent the intrusion of any extraneous matter, until connected to the pipeline network. The seal should be fitted with a valued vent to allow equalization of pressure before removal.

24.2 Testing Of Gravity Sewer Pipelines

Pipeline 600 mm or less in diameter may be tested by air test. Should any pipe fail the an test, the Engineer may order a water test to be carried out. Acceptance of the pipeline will then be based on the results of the water test. All pipelines up to and including 1200 mm shall be tested by air test in accordance with the requirements of BS 8005 : Part 1, Section 5.

The Contractor shall, at his own expense, furnish all equipment and materials for making the tests. Each pipeline shall be tested before backfilling. All pipelines shall be subjected to pass infiltration tests. All pipes are to be clean and empty at the time of testing. Tests shall be performed in the presence of the Engineer.

24.3 Air Test

- The Contractor shall plug all pipe outlets with suitable plugs, and brace each plug securely where needed.
- Air shall be pumped in slowly to the pipe until a pressure of 100 mm water.
- Gauge is indicated on a manometer connected to the system. After the internal pressure of 100 mm water gauge is obtained, 5 min shall be allowed for the air temperature to stabilize within the pipe.
- Air may be added to restore the pressure to 100 mm water gauge. During a further period of 5 min, the pressure shall not fall below 75 mm water gauge without further pumping.

24.4 Water Test

- All the joints of the pipeline shall be able to withstand a pressure of a minimum 5 m head of water, above the crown of pipe at the highest point of pipeline without leakage. A layer of embedding soil equal to the diameter of pipe shall be laid over the pipe to prevent the lifting of pipe while applying test pressure. However, all the joints shall be left open for the purpose of inspection for leakage if any. All branches and open ends shall be closed with stoppers, secured with longitudinal braces/thrust block, before testing begins
- water shall be filled from the lowest point and air allowed to escape through an air vent fixed for the purpose at the high points of the pipeline section under test.

The diameter of air vent shall be about one and half times the diameter of water inlet pipe to allow easy escape of air. No entrapped air shall remain in the pipeline while testing

- a pressure of 5 m head of water shall be maintained for one hour to allow initial absorption of water. After that the test pressure shall be maintained for 15min and water added shall be measured. If water consumption in 15 min does not exceed 0.1 l/ m2 of wetted inner pipe surface and if there are no visible leakage through joints, the pipeline shall be treated as passed.

24.5 Infiltration Test

- The upper ends of the sewer and service connections shall be closed sufficiently to prevent the entry of water and pumping of groundwater shall be discontinued until the groundwater surface reaches its natural level before beginning the infiltration test.
- The dewatering system shall be stopped, but not be removed until the infiltration test has been successfully completed or as otherwise permitted by the Engineer
- The infiltration shall not exceed 6 liters per millimeter diameter per kilometer per day of the portion of sewer being tested, including the length of service connection entering that section
- The total length tested in one section shall not exceed 400 m in length. This length is dependent upon the type of deflection measuring equipment proposed by the Contractor if flexible pipes are used.
- No gravity pipeline will be accepted if the total infiltration exceeds the above mentioned limit and joints will not be accepted if during an internal inspection, any infiltration is visible.

25 Pressure Pipelines Testing

The pipeline shall be tested between valve chambers or into sections not exceeding 400 in length or otherwise approved by the Engineer. The tests shall be performed as follows:

25.1 The pipeline shall be filled with water and all air removed as far as possible.

25.2 The pressure shall then be raised by pumping in water until the test pressure is reached and shall be maintained at this level by further pumping until it is steady.

25.3 Pumping shall then be stopped and the time taken for the observed pressure to fall by1.0 m shall be recorded.

25.4 Pumping shall then be resumed and the quantity of water pumped in order to restore the test pressure shall be recorded.

25.5 If after three hours the test pressure has not fallen by 1.0 m, pumping shall be resumed at that stage, the time being recorded as three hours.

25.6 The rates of loss shall then be calculated as the recorded quantity divided by the recorded time.

25.7 The test pump and gauge shall be connected to the pipeline at a location other than the highest point in the pipeline to facilitate release of air from the highest point.

25.8 The test pressure shall be such that the entire pipeline or section being tested is subjected to 1.5 times the working pressure, 1.25 times the maximum surge pressure or 800 kPa, whichever is the greatest.

25.9 The loss shall not exceed 0.02 liters per mm diameter per kilometer per 24 hours for each 0.1 MPa of head applied.

25.10 If the pipeline fails to pass the test, the faults shall be located and repaired and the pipeline retested until it passes the pressure test. All exposed pipe, fittings, valves and joints shall be visually inspected during the tests.

When all sections have been joined together after completion of section testing, unless otherwise directed by the Engineer, the entire pipeline shall than be subjected to final test as follows:

- All joints between individual test sections shall be left uncovered during this final test
- The final test shall be carried out using the same procedure as the section test

- In all cases of water tests, where the measured leakage rate exceeds the allowable, the Contractor shall, at his own expense, make all necessary repairs and carryout additional testing until a satisfactory result is obtained
- Before pressure testing is started the Contractor shall recheck pipes and valves for cleanliness and shall recheck the operation of all valves. The "open" ends of the pipeline or sections thereof) shall normally be stopped off by blank flanges or cap ends additionally secured where necessary by temporary struts and wedges. All anchor and thrust blocks shall have been completed and all pipe straps and other devices intended to prevent the movement of pipes shall have been securely fastened.

26. Cleaning Of Sewer Pipelines

The Contractor should note that pipelines, manholes, may have structural defects cracks etc., and may have been completely filled with sand, grit, sediment and other debris and the requirement to accurately measure the vertical inside diameter of the sewer necessitates that the invert of the sewer to be free of all sediment.

The Contractor shall allow for the removal of all such material and disposal of same to a disposal site approved by the Engineer. Cleaning of sewers shall progress downstream.

Sewer cleaning shall be thorough and shall only be carried out by methods approved by the Engineer to remove all deposits, foreign matter, solid or semi-solid and hard intruding material and all other debris including sand, silt, slime, sludge, sediment, grease, roots, loose flaky or soft pipe wall materials, loose concrete from walls and underside of cover slabs and benching of manholes from within sewers and manholes.

The Contractor shall take all necessary precautions to ensure that during the sewer cleaning operations there is no spillage of sewage and debris onto the streets and other areas. When spillage occurs, the Contractor shall immediately remove all spillage and clean all surfaces to their original condition.

Pump station wells shall be cleaned where necessary to permit pipeline cleaning.

27. CCTV Survey

The Contractor shall on written instruction of the Engineer undertake a CCTV survey on designated lengths of pipelines laid during the execution of the Works, including pipeline cleaning where necessary and submission of a Survey Report, as part of the final inspection CCTV survey shall be carried out only after satisfactory cleaning of the pipeline.

The CCTV survey shall include but not be limited to:

(a) Production of color video tape recording on compact disc (CD) and coding.
(b) Accurate profiling of the cross-section of sewers and measurement of deflections.
(c) Recording the complete survey on a computer database.

The Certificate of Completion for the Works or part thereof shall not be issued until the CCTV Survey, including provision of the Survey Report, and any subsequent sewer remedial works have been completed to the satisfaction of the Engineer.

Should any length of the surveyed sewer between adjacent manholes, or the manholes indicate failure to comply with the requirements of the Contract, the whole cost of any sewer cleaning, the CCTV Survey, Survey Report and any subsequent remedial works carried out to the satisfaction of the Engineer shall be borne by the Contractor.

The CCTV Survey shall be carried our by an approved specialist subcontractor. The subcontractor shall provide suitable documentation to verify previous experience in undertaking CCTV Surveys to the satisfaction of the Engineer.

28. Sewer Rehabilitation

28.1 General

This Part includes the specifications for all work necessary to rehabilitate sewers, manholes and chambers.

The scope of work related to this part shall include but not limited to:
(a) Sealing of sewers and manholes
(b) Manhole rehabilitation
(c) Manhole lining
(d) Sliplining of sewers
(e) Deformed pipe lining
(f) Cured-in-place pipe (inversion method)
(g) Spiral wound profile liner
(h) Pipe cracking or bursting.

The Contractor shall allow in his Programme of work for the requirement that he shall work at many locations at any one time. However, at least one team shall be fully engaged on each length of sewer, and shall finish all rehabilitation works required on that length of sewer including manholes and chambers before beginning work on a new length of sewer.

28.2 Methodology

The Contractor shall provide methods statements for each of the rehabilitation methods and systems he proposes to use.

As cleaning and inspection work proceeds, the Contractor shall submit weekly sewer and manhole condition reports to the Engineer. In the reports, the Contractor shall include his confirmation that his proposed method of rehabilitation meets the required performance criteria. Should the originally proposed method not meets the performance requirements for lengths of sewer, or manholes, the Contractor shall submit his proposals to meet the performance requirements for such lengths of sewers or manholes to the Engineer for approval.

The Engineer and the Contractor shall agree on the locations and systems to be used for rehabilitation if necessary, and if necessary the Contractor shall review and revise his programme of work and submit to the Engineer for approval.

Sewer cleaning, inspection and over pumping work shall be satisfactorily completed before undertaking sewer rehabilitation.

Before installing lining in sewers the Contractor shall ensure that the sewers are clean of debris and gauged to ensure that they can accommodate the liners.

The Contractor shall inspect by CCTV the section or sections to be lined and shall record the internal status including any obstructions and service connections

The Contractor shall over pump the sewage flow around the section or sections of the pipeline that are to be lined. The over pumping shall be carried at in accordance with the Engineer’s instruction. Leaks in the pipes due to groundwater infiltration shall be stopped by grouting or other appropriate methods approved by the Engineer. The Contractor shall clear the pipeline of obstructions, solids, dropped joints, or tree roots or collapsed pipe that will prevent the insertion of the liner. Where inspection or gauging reveals an obstruction that is not at the location of the entry shaft, the Contractor shall remove the obstruction by means of a cutting machine inserted into the sewer line.

Where this is not possible, the Contractor shall make an excavation to expose and remove or repair the obstruction as directed by the Engineer.

28.3 Joint Sealing of Pipes

Joints shall be sealed using the internal joint sealing method. Where bell cracks or chips are evident from pipe section offset, sealing shall be undertaken where the offset is small enough to allow proper seating of the sealing packer on both sides of the joint to be sealed.

Sealing for longitudinal cracks or broken pipe shall not be accepted. The Contractor shall supply all the adequate equipments and tools required for sealing sewers of the various diameters. Joint shall be sealed by injecting chemical sealing compound into or through faulty joints using a system of pumps, hoses, and sealing packers. Jetting or driving pipes from the surface that could damage the pipelines or impair their structural integrity will not be permitted. Uncovering the pipe by excavation of pavement and soil will not be allowed.

28.4 Sealing of Manholes

During cleaning and inspection work the condition of manholes shall be observed and their structural soundness shall be evaluated by the Contractor and reported in the cleaning and inspection reports. Sealing work shall only be carried out on manholes which the Engineer considers structurally sound and which experience extraneous water leakage.

Cracks and openings to be sealed shall be marked out in detail on the concrete elements by the Contractor and agreed with the Engineer before proceeding with sealing operations.

28.5 Slip Lining of Sewers

The scope of work consists of rehabilitating sewers by the insertion of liner pipe into existing sewers. The finished liner shall extend the full distance detailed in the project specific documentation, which may be for localized repair, or extend the full sewer length. In either case the lining shall be completely sealed and watertight.

Slip lining shall be carried out using polyethylene liners. Where excavations for insertion of liner are made, the Contractor shall locate the excavations on the basis of the location of the sewers to be slip lined, pulling distances, and traffic conditions subject to Engineer’s approval.

Excavation locations shall be such as to minimize traffic disruption, and the number of excavations reduced by inserting the pipe in both directions from a single opening. Insertion shafts shall be designed to avoid imposing a bending radius of less than 35 times the outside diameter of the liner. Insertion shafts shall be sloped gradually from the ground surface to the soffit of the sewer. The Contractor shall provide sufficient sheeting and bracing to the excavation as required. The soffit of the existing sewer shall be exposed and the crown of the pipe shall be removed as necessary for insertion of the liner. Care shall be taken not to disturb the bottom portion of the existing pipe.

Jointing shall be by thermal butt-fusion welding in accordance with the manufacturer's recommendations. All fusion jointing shall be carried out by trained personnel with equipment designed for butt-fusion welding of thermoplastic pipe. Sections of liner shall be jointed above ground either at the Site or at a remote location.

29 Handrails, Flooring platforms and Staircases

29.1 Material

All aluminium alloy must be marine grade 6082 to BS 1474, fully heat treated T.6. condition, except that T.4. condition shall be used for the upper and lower tubular horizontal handrails. (Note: handrail tube T.4. condition is more ductile and allows bends to be formed).

Material certificates are required to be issued to the Employers representative to demonstrate conformity.

29.2 Precautions against Electrolytic Action

Precautions should be taken in damp or moist conditions to avoid Electrolytic action between dissimilar metals, particularly with aluminium. The good corrosion resistance of aluminium and its alloys is attributable to the protective oxide film which forms on the metal surface spontaneously on exposure to air. The protective film is relatively inert and forms naturally. After fairly rapid initial formation of the oxide film, very little further action occurs. Such behaviour is consistent for practically all external freely exposed conditions and for all internal or shielded conditions, except where extremes of acidity or alkalinity can develop. Aluminium is in general considered maintenance free. However, in damp or wet conditions aluminium can be adversely affected by being allowed to come into direct contact with dissimilar metals and some building materials including concrete.

Protection, in general, can be provided by painting the contact surface of the aluminium with 2 coats of bituminous paint. Bolts used for fastening in adverse conditions should be provided with plastic ferrules and washers for the bolt shank and under the bolt head and nut.

Unprotected 'mill finish' aluminium is highly weather resistant and lasts for many years even in an exposed environment. Where it is desirable to provide added protection, then anodising the metals to BS1615 grade AA25 can be considered.

29.3 Handrails

29.3.1 Handrails for walkways, platforms and stairs within BSEN ISO 14122-2001. will generally come under the category of 'General Duty' with a loading requirement of 0.36kN/m or Heavy duty with a loading requirement of 0.74kN/m.

29.3.2 Handrail for General Duty (0.36kN/m)

Handrails and standards shall be of aluminium alloy grade 6082 (T.6. condition for handrail standards and T.4. condition for handrails), to be type EPS A510 complying with the requirements of BSEN ISO 14122-2001 (BS5395:Pt 3:1985), having top and intermediate rails at 550mm centres.

Handrails shall be constructed from 38.1mm o/d tube (minimum 3.25mm wall thickness), complete with all bends and internal joints. Handrail joints to be of the internal ferrule type.

Handrails shall be supported by tubular type handrail standards spaced at not greater than 2000mm centres.

Standards shall be constructed from 50.8mm o/d tube (minimum 6.35mm wall thickness) and be fitted with a die cast top tee and a high duty die cast aluminium (LM25) base, secured to shank with 2 no. M8 stainless steel grub screws.

Bases shall be purpose made (minimum 170mm x 90mm x 15mm thick) twice drilled for 2 no. M12 resin anchor bolts, having stainless steel studs grade 316.

Handrail standards to be fitted with stainless steel grub screws to secure handrails in position.

Handrails to platforms, walkways and landings to be 1100mm high and between 900mm and 1000mm above the pitch line

29.3.3 Handrail for Heavy Duty (0.74kN/m)

Handrails and standards shall be of aluminium alloy grade 6082 (T.6. condition for handrail standards and T.4. condition for handrails), to be type EPS A510 complying with the requirements of BSEN ISO 14122-2001 (BS5395:Pt 3:1985), having top and intermediate rails at 550mm centres. Handrails shall be constructed from 38.1mm o/d tube (minimum 3.25mm wall thickness), complete with all bends and internal joints.

Handrail joints to be of the internal ferrule type.

Handrails shall be supported by tubular type handrail standards spaced at not greater than 1500mm centres.

Standards shall be constructed fro 50.8mm o/d tube (minimum 6.35mm wall thickness) and be fitted with a die cast top tee and a high duty die cast aluminium (LM25) base, secured to shank with 2 no. M8 stainless steel grub screws.

Bases shall be purpose made minimum 170mm x 90mm x 15mm thick) twice drilled for 2 no. M12 resin anchor bolts, having stainless steel studs grade 316.

Handrail standards to be fitted with stainless steel grub screws to secure handrails in position.

Handrails to platforms, walkways and landings to be 1100mm high and between 900mm and 1000mm above the pitch line on the stairs.

Finish: Natural untreated mill finish, powder coated or anodised AA25.

29.3.4 Toe Plates

Toe plates shall be provided to all platforms and walkways and shall be of extruded section type EPS-A, minimum height 160mm. Toe plates shall be secured to handrail standards with clamp plate and strap, to avoid any distortion along its length. All joints in toe plates shall be made secure with 3mm thick joint plate.

All corners shall be complete with cleat connections, again of bolted construction using grade 316 stainless steel fixings.

Finish: Natural untreated mill finish, powder coated or anodised AA25.

29.3.5 Ladders (Fixed Vertical or Near Vertical)

All access ladders shall be fabricated from aluminium alloy grade 6082 T6 as type EPS A530, complying with the requirements of BSEN ISO 14122-2001 (BS5395:Pt 3:1985).

Ladders shall be constructed from minimum 65mm x 10mm stringers, spaced 380mm apart, fitted with 20mm diameter solid or tubular rungs at 250mm centres of all welded/riveted construction.

Fixing stays shall be provided at centres not greater than 1.8m.

Ladders rising more than 2.3m should be fitted with a safety cage. Handholds shall be provided to all ladders.

Ladders rising above the floor level to which they give access shall be fitted with handholds type 'B' where access is to one side or type 'D' for a walk through access, the latter shall be fitted with safety chains.

Where ladders terminate below floor level to which they give access (manhole type) they shall be fitted with type EPS A530 B retractable handholds.

Safety cages shall be constructed from 50mm x 8mm flat hoops, complete with 3 vertical straps.

Hoops shall be provided at centres not greater than 900mm and shall be of bolted constructions, bolts to be M10 stainless steel countersunk type or have dome heads on the inside of safety cages.

Finish: Natural untreated mill finish, powder coated or anodised AA25.

29.3.6 Step Ladders

Step ladder shall be of aluminium alloy grade 6082 T6 and shall comply with the design requirements of BSEN ISO 14122-2001 (BS5395:Pt 3:1985), constructed from 130mm x 10mm flat stringers 550mm apart, cleated top and bottom for fixing and fitted with type EPS A521 open type aluminium alloy treads, (or solid treads type EPS A520),complete with end plates welded on and twice drilled at each end for fixing to the stringers with M10 stainless steel bolts.

A single line handrail shall be provided on each side of the step ladder, having 50.8mm o/d x 6.35mm tubular shanks and purpose made high duty cast aluminium side palm bases, secured to the step ladder with 2 nos. M12 stainless steel bolts.

Handrails shall be opened out at the top to a minimum of 610mm and shall be turned to form continuity with the platform handrail type EPS A510.

Finish: Natural untreated mill finish, powder coated or anodised AA25.

29.3.7 Safety Chains

Safety chains shall be of 8mm diameter long link made from grade 316 stainless steel, bright finish complete with grade 316 stainless steel fixings.

Alternatively , polypropylene rope may be used as a substitute for chain, fitted with reinforced loops and stainless steel fittings.

29.3.8 Open Type Flooring

(i) Open type flooring shall be of aluminium alloy grade 6082 T6 as Euro Deck type EPS A521 having 24% open area, complying with the requirements of BSEN ISO 14122-2001 (BS5395:Pt 3:1985).

Suitable for a super-imposed loading of 5kN/m.sq. in accordance with the requirements of BS 4592.

The flooring shall be of a reinforced extruded section with integral inverted 'T' section stiffening webs, made up into suitable size panels for ease of handling and complete with welded on nosing bars.

The mass of any individual panel shall not exceed 40kg. Where floor panels are supported on structural members, adjustable type fixing clips shall be provided with a minimum of 4 clips per panel, securing each corner.

Where floor panels are contained with angle curbing fixing clips are not required. Where angle curbing is provided, this shall be type EPS A520 L or EPS A520 Y and shall be complete with purpose made lugs.

Curbing shall provide adequate seating for the flooring and should also match the depth of the flooring.

Flooring shall be of a depth to ensure that deflection does not exceed span/200 or 100mm whichever is lesser, when fully loaded.

All necessary intermediate support beams shall be provided, including all necessary cleats and fixing bolts to facilitate easy removal where necessary.

Fixing clips shall be type EPS A521 FCP, aluminium alloy with M8 nickhead stainless steel fixing screw, spring washer and nut.

Finish: Natural untreated mill finish, powder coated or anodised AA25

29.3.9. Solid Floor Plates

Solid floor plates shall be aluminium alloy grade 6082 T6 as type EPS A520 and shall comply with the requirements of BSEN ISO 14122-2001 (BS5395:Pt 3:1985). Suitable for a super imposed loading of 5kN/m.sq.

Floor plates shall be of a reinforced extruded section with integral inverted 'T' section stiffening webs.

The floor plates shall be supplied in suitable size panels for ease of handling and complete with welded on nosing bars.

The mass of any individual panel shall not exceed 40kg. Where floor plates are supported on structural members, adjustable type fixing clips shall be provided with a minimum of 4 clips per panel securing each corner.

Fixing clips shall be type EPS A520 FCS aluminium alloy with M8 nick head stainless steel fixing screws.

Where floor panels are contained within angle curbing, fixing clips are not required.

Where angle curbing is provided this shall be type EPS A520 L or EPS A520 Y and shall be complete with purpose made lugs.

Curbing shall provide adequate seating for the flooring and should match the depth of the floor plate for which it is provided. Floor plates shall be of a depth to ensure that deflection does not exceed span/200 or 10mm whichever is the lesser, when fully loaded.

All necessary intermediate support beams shall be provided, including all cleats and fixing bolts to facilitate easy removal where necessary.

Where cut outs are required in flooring around pipework or other obstruction, a continuous nosing bar shall be welded to all load bearing bars around the cut out. The clearance around the obstruction shall not exceed 30mm.

Finish: Natural untreated mill finish, powder coated or anodised AA25.

29.3.10 Staircases

Staircases shall be of aluminium alloy grade 6082 T6, complying with the requirements of BSEN ISO 14122 - 2001 (BS5395:Pt 3:1985).

Staircases shall have a rake not exceeding 38 degrees and shall have a width of 800mm or 1 metre as shown on drawings.

Handrails shall be provided on both sides as type EPS A510 and shall be continuous with toe plate type EPS A to horizontal areas (not stringers).

Stairs shall be fitted with open type aluminium alloy treads type EPS A521 (or solid treads type EPS A520), treads shall be complete with end plates welded on and each twice drilled for M12 stainless steel fixing bolts for attaching to the stair stringers.

The going of each tread shall be 250mm and the maximum rise shall be 190mm.

The stair stringers shall be of minimum 180 x 10mm flat section aluminium alloy and shall be cleared top and bottom for fixing, stringers at the bottom of the staircase shall not extend more than 50mm beyond the lowest tread.

Stairs shall have no more than 16 rises or nor less than 3.

Where stairs have a rise exceeding 3040mm, intermediate landings shall be introduced. Staircases shall be designed for a uniform distributed loading of 5kN/m.sq.

Finish: Natural untreated mill finish, powder coated or anodised AA25.

29.3.11 Stainless Steel bolts, nuts and fittings

All fittings provided in stainless steel shall be grade 316 S31 and are to be supplied with full material certificates to demonstrate conformity.

29.3.12 Heat Treatment of aluminium alloys specified

Material grade 6082 to BSEN ISO 755-part 2 (BS1474).

Heat treated to T4 (H30TB) and T6 (H30TF) condition to BSEN ISO 515.

30 Cable Ducts

30.1 Installation of Ducts in Trenches

Rigid ducts shall consist of:

Unplasticised PVC pipework, complying with BS 4660. Rigid ducting shall have proprietary, self-aligning, water tight joints and a smooth internal bore.

All joints in the duct system shall be achieved by the use of proprietary accessories made of the same material as the duct. All changes in direction in the duct system shall be achieved by the use of draw pits.

The maximum length of a straight duct run (between draw pits) shall be 100 m.

Ducts shall be installed at 90° to roadways carrying vehicular traffic and shall be hunched in concrete to prevent damage.

There shall be a minimum of 750 mm of cover above the crown of the duct and the duct shall be extended beyond kerbs by a minimum of 750 mm.

Ducts shall be laid on and surrounded by a backfill material that will not cause damage to the duct.

30.2 Drawpits

30.2.1 General

The minimum size of drawpits shall be 750 mm square;

If possible, drawpits shall be provided with suitable drainage. The sizing of drawpits shall facilitate cable installation and maintain the required cable segregations without contravening the minimum bending radii of the cable.

30.2.2 Installation of Cables into Ducts

If draw cords are used to pull cables through ducts, a replacement draw cord shall be drawn through with the cables.

Proprietary pulling socks shall be used to attach a draw line to larger cables and care shall be taken to ensure that cable tensions are maintained below cable manufacturer's specifications.

If practicable, cables shall be pulled directly off the drum into the duct system. They shall not contain twists or kinks resulting from manual handling.

Where any cable exits a duct, it shall be supported between the duct exit and the start of the fixed wiring support system or entry into another duct.