STANDARD SPECIFICATIONS FOR CONSTRUCTION WORKS

2008

Module – 17 – Sewerage Pipeline and Pipework
Introduction

The Standard Specifications are published as a series of 21 stand-alone modules each addressing a single distinct area of the construction process. This stand-alone module 17 is an integral part of the Standard Specifications.

The purpose of the MoW STANDARD SPECIFICATIONS FOR CONSTRUCTION is to provide the design professional with a guide for accepted construction practices for Ministry of Works projects. As an aid to the designer, these Standard Specifications are provided for the inclusion in proposed development projects for ease, efficiency and cost savings.

The Standard Specifications are not intended to limit the design responsibility of the design professional. However, they establish a minimum acceptable criterion and/or quality for use within Ministry of Works projects.

The design professional may increase the requirements of an item contained in the Standard Specifications to meet job requirements, but when this is done, there should be no reference for that item on the drawings to the Ministry of Works Standard Specifications and a new specification should be included with the drawings or project contract documents.

The design professional must review all Standard Specifications to be sure that they are adequate for the proposed project based on the job site conditions; the design professional is solely responsible for the designs submitted under his seal.

In order to keep design standards current with changing regulations and improved construction materials and practices this section will be updated and maintained by the concerned authorities of the Ministry of Works. Prior to starting a new project, the design professional should contact the concerned Directorate of the Ministry of Works to verify that he/she has the latest document revisions.
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Foreword

This specification provides the basis for pipelines for sewers and drains. It covers the main requirements for all plant, labour, materials, transport, testing, and so on, involved with the installation or erection of pipelines for sewers and drains.

This specification must be read in its entirety, as it is structured in order of work-flow, which means that items or activities appear in several places in the specification corresponding to the progression of the construction process.

For larger or more complex or specialist projects, a project-specific Particular Specification for sewerage pipelines and pipework may also be provided.

Absence of clauses for materials and methods does not necessarily signify that they can not be used. Proposals for use of innovative methods and materials are encouraged and are subject to review and approval by the Client.

Where the word approved is used in this specification, this means that the Client or Engineer has been consulted and has confirmed that the item or procedure is acceptable in the specific context for which approval has been requested.
1. PART 1 GENERAL

1.1 Scope

This Module for Sewerage Pipelines and Pipework includes:

- Pipelines for sewers and drains, up to the property boundary
- Pressure pipes including those for rising mains, non-potable water and irrigation
- Trenches
- Valves and fittings
- Manholes and chambers
- Ductwork
- Testing water retaining structures
- Thrust boring and micro-tunnelling
- Irrigation sprinklers and emitters

1.2 Existing Underground Services

The Contractor shall take all practical steps to avoid damage to existing underground services. These steps shall include but not be limited to:

- Making contact with all relevant authorities to establish location records of existing services
- All services indicated as being within 5 m of the works shall be located by tracing or other means
- All traced services which are within 1 m of the edge of an excavation shall be identified by hand excavation of trial holes/trenches.
- Before digging, the Contractor shall notify the relevant Authorities and shall comply with all the requirements, specifications and restrictions imposed by them.

Extreme care and caution shall be exercised when working in the proximity of HV electric cables or coaxial telephone cables carrying national or international circuits.

All exposed existing cables, pipes, ducts, and so on, shall be adequately supported and protected to the satisfaction of the Engineer and the relevant Authority.

1.3 Compliance with Existing Statutory Authority Requirements

The Contractor shall take due account of any specifications issued by and/or specific requirements pertaining to the respective adopting Statutory Authority. Should an instance arise where the Authority’s specified requirements conflict with this specification, and unless instructed to the contrary by the Engineer, the Authority’s specified requirements shall prevail.

1.4 Definitions

Structured-Wall Pipes and Fittings – products which have an optimized design with regard to material usage to achieve the relevant performance requirements.

Profile wall – a pipe wall construction that presents a smooth surface in the waterway but includes ribs or other shapes, which can be either solid or hollow that help brace the pipe against deformation.

1.5 Pressure Pipes and Pressure Ratings

Pressure pipelines shall be those pipelines through which fluid is pumped or which at any point operate under an internal pressure in excess of 3 m head of water.
The pressure ratings for all pipes and fittings shall be those calculated to give a minimum service life of 50 years at an ambient temperature of higher than 40°C.

Pressure ratings for valves shall be those calculated for maximum working pressure at an ambient temperature of 20°C. Maximum working pressure shall be either 1.5 times the working pressure or the closed valve pressure, whichever is the greater.

1.6 Rigid Pipes

Rigid pipes include concrete, vitrified clay (VC) and cast iron (CI) pipe. Rigid pipes are specified by Strength Class which is defined as the crushing strength in kN/m divided by one thousandth of the nominal diameter in mm; rigid pipes shall be Class 120 or higher.

1.7 Flexible and semi-rigid pipes

Flexible pipes include: Unplasticised polyvinyl chloride (PVC-u), Reinforced thermosetting resin (RTR), polyethylene (PE), steel and ductile iron (DI). The pipes are designated by their stiffness/pressure rating as specified in the relevant material specifications in Section 3.

1.8 Dimensional

Apart from specials, rocker pipes and cut to suit lengths, pipes shall be supplied in any standard lengths allowed under the specification. Unless otherwise specified the tolerance on all pipe dimensions shall be ± 5 mm.

1.9 Marking of Pipes and Fittings

Each pipe, special and fitting shall be clearly and indelibly marked at the place of manufacture with:

- The name or distinctive mark of the manufacturer
- The date of manufacture
- The class or pressure rating
- The nominal diameter
- The manufacturing standard to which it has been produced
- For rigid pipes, crushing strength (in kN/m) or class
- For flexible pipes, stiffness (in N/m²)
- Storage procedure code for stock items
- Storage procedure for onsite use

1.10 Quality Assurance and Pipe Supply

All pipes, valves and fittings shall be furnished by a single manufacturer who is experienced in the manufacture of the items to be furnished; however, it shall not be a requirement that the pipe and fittings be manufactured by the same manufacturer, provided that the pipe, valve and fittings are compatible in both compounding and size. The pipe, valves and fittings shall be designed, constructed and installed in accordance with the best practices and methods and shall be suitable for the intended service.

Pipes shall wherever possible be compatible with existing pipes used on the Bahrain Sewerage and Drainage Projects. If the pipes are not compatible, the Engineer will require the Contractor to supply a number of couplings for construction or repair purposes.

In general, channel inverts/benchings on the Trunk Sewer shall be either pre-formed RTR, or half round RTR pipes with in situ benching.

In general, channel inverts in manholes and inspection chambers on the Branch/Lateral sewers, shall be formed with half round clayware channels.
Manufacturers design and engineering shall be performed by personnel who are experienced in the design of pipes similar to those specified.

All pipes, valves and fittings shall be inspected and tested at the factory as required by the standard specifications to which the material is manufactured. The Contractor shall notify the Engineer in sufficient time to allow Engineer, or his representative, to witness the testing if so desired. The Contractor shall furnish in duplicate to the Engineer certificates of such tests and their results prior to the shipment.

Prior to dispatch from the factory, the contractor shall notify the Engineer in sufficient time to allow Engineer, or his representative, to inspect the pipes and fittings, if so desired.

All notification shall be made by written Inspection Request.

An advance copy may be faxed to the Engineer’s office, but the original must arrive or be submitted before the schedule day of inspection or testing.

Minimum notification times must be as follows:

- 24 hours on site.
- 72 hours for areas within the Kingdom of Bahrain.
- 3 weeks outside of the Kingdom of Bahrain.

The Contractor shall store pipes in the shade in a properly prepared and maintained storage area demarcated in respect of pipe sizes and manufacturers.

1.11 Inspection at Site

Inspection of the pipe, valve or fitting will be made by the Engineer or other representatives of the Owner after delivery. The items shall be subject to rejection at any time on account of failure to meet any of the requirements specified herein, even though items may have been accepted as satisfactory at the place of manufacture. Items rejected after delivery shall be marked for identification and shall immediately be removed from the job or where permitted, repaired.

All pipes, valves and fittings shall be subject to visual inspection at any time and shall meet the following requirements set out in Tables 1 (a), 1 (b) and 1 (c). Any damage shall be notified to the Engineer for a decision as to the acceptability, with or without repairs or remedial work. The criteria set out below will be used for guidance, but are not to be regarded as representing necessarily all grounds for rejection. The final decision will be taken by the Engineer based on his judgement of the suitability of the items for the purpose intended.
### Table 1 (a) - Rigid Pipes

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<th>Concrete</th>
<th>Vitrified Clay</th>
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<td>Ellipticity</td>
<td>± 3% on mean diameter for diameters up to 500 mm.</td>
<td>± 2% on mean diameter</td>
</tr>
<tr>
<td></td>
<td>± 1% on mean diameter greater than 500 mm.</td>
<td></td>
</tr>
<tr>
<td>Wall thickness</td>
<td>± 5% of mean thickness at any pipe cross section</td>
<td>± 5% of mean thickness at any pipe cross section</td>
</tr>
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<td>Cracks</td>
<td>Unreinforced pipes shall contain no cracks.</td>
<td>There shall be no cracks running in a longitudinal direction, and no cracks of longer than 25 mm running in a circumferential direction.</td>
</tr>
<tr>
<td>Voids, chips and cavities</td>
<td>There shall be no honeycombing or open texture.</td>
<td>There shall be no broken blisters and no chips or other cavities measuring more than 25 mm in a longitudinal or 50 mm in a circumferential direction or 0.25 times the pipe wall thickness in depth.</td>
</tr>
<tr>
<td>Protuberances</td>
<td>There shall be no protruding aggregates.</td>
<td>There shall be no blisters of diameter greater than 50 mm or height 2 mm.</td>
</tr>
<tr>
<td></td>
<td>There shall be no protuberances of any sort extending more than 2 mm from the normal surface.</td>
<td>There shall be no protuberances extending more than 2 mm from the normal internal surface.</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>Where glazing is specified not more than 5% of the surface area (excluding pipe ends) shall be free from glaze.</td>
</tr>
<tr>
<td>Condition</td>
<td>Requirements</td>
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<td>-----------------</td>
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</tr>
</tbody>
</table>
| Ellipticity     | **Unplasticised Polyvinyl Chloride/Polyethylene** ± 1% on mean diameter  
|                 | **Reinforced Thermosetting Resin** ± 1% on mean diameter.                                                                                                                                                   |
| Wall thickness  | Pipe wall thickness measured at any point must be such that the Standard Dimension Ratio calculated on that thickness is within the stipulated range.  
|                 | Pipe wall thickness must be within ± 10% of design value at any point and within ± 5% when the average thickness is measured along any single straight axial line.                                                      |
| Surface finish  | There shall be no flaking or indication of disintegration.  
|                 | There shall be no evidence of extrusion dye-marks or ‘spiderlines’.  
|                 | There shall be no crazing of internal or external gelcoats or resin rich layers.  
|                 | Resin dry areas not exceeding 6mm dia. internally or 60 mm dia. externally may be accepted if made good.                                                                                                   |
| Scratches       | No internal scratches. External surfaces shall be free from longitudinal scratches and circumferential scratches longer than 100 mm or deeper than 5% of the pipe wall thickness.  
|                 | Scratches not exceeding 0.3 mm deep may be accepted without repair. Scratches exceeding 1 mm deep may be accepted if satisfactorily made good.                                                             |
| Cracks          | All pipes shall be free from cracks.  
|                 | **Longitudinal cracks:**  
|                 | There shall be none on internal surfaces. External cracks may be accepted after repair if less than 200 mm long.  
|                 | **Circumferential cracks:**  
|                 | No cracks shall be of sufficient depth to expose glass fibres. Cracks not exceeding 200 mm length may be accepted after repair.  
|                 | “Star Cracks” may be accepted after repair if all cracks are contained within a circle of 100 mm diameter.                                                                                                   |
| Voids           | No visible voids will be accepted  
|                 | Voids (or blisters) may be accepted after repair if not greater than 2 mm diameter and 1 mm depth provided that not more than 0.5% of surface area is affected                                                                 |
| Protuberances   | There shall be no protruding aggregates.  
|                 | There shall be no protuberances of any sort extending more than 2 mm from the normal surface.  
|                 | There shall be no protruding fibres from the internal surface of the pipe. Wrinkles and undulations shall not exceed 3 mm in height.                                                                       |
| Inclusions      | There shall be no visible inclusions or extraneous matter  
|                 | There shall be no visible inclusions or extraneous matter, other than permitted fillers of aggregates.                                                                                                |
| Delamination    | Not applicable  
|                 | There shall be no visible delamination.  

Table 1 (b) - Flexible Pipes
Table 1 (c) - RTR Fabricated Items (other than Pipes)

<table>
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<tr>
<th>Condition</th>
<th>Requirements</th>
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<td><strong>Surface finish</strong></td>
<td>There shall be no crazing of gel coats or resin rich layers.</td>
</tr>
<tr>
<td></td>
<td>Resin dry areas not exceeding 6 mm diameter on moulded and corrosion resistant surfaces may be accepted if made good. Not more than 0.5% of the surface area shall be so affected.</td>
</tr>
<tr>
<td></td>
<td>There shall be no resin dry areas on other surface after repair.</td>
</tr>
<tr>
<td><strong>Scratches</strong></td>
<td>Scratches not exceeding 0.2 mm deep to moulded and corrosion resistant surfaces may be accepted without repair provided that no glass fibres are exposed. Scratches exceeding 0.2 mm deep but not exceeding 0.5 mm deep may be accepted if satisfactorily made good. The total extent of scratching shall not exceed 200 mm length per 1 m$^2$ surface area. Alternatively, where small scratches are grouped together, the affected area shall not exceed 1% of the surface area.</td>
</tr>
<tr>
<td></td>
<td>Scratches to other surfaces may be repaired provided that the structural integrity of the laminate is not impaired.</td>
</tr>
<tr>
<td><strong>Cracks</strong></td>
<td>For moulded and corrosion resistant surfaces there shall be no cracks of depth greater than 0.5 mm or of sufficient depth to expose glass fibres. Cracks up to 0.5 mm depth not exposing glass fibres and not exceeding 200 mm in length may be accepted after repair but such cracks shall not present to an extent greater than 1 crack per 5 m$^2$ of surface area.</td>
</tr>
<tr>
<td></td>
<td>Cracks not exceeding 200 mm in length to other surfaces may be repaired provided that the structural integrity of the laminate is not impaired.</td>
</tr>
<tr>
<td></td>
<td>“Star Cracks” may be accepted after repair if all cracks are contained within a circle of 100 mm diameter and a maximum of 0.2% of the area of any one moulding is affected.</td>
</tr>
<tr>
<td><strong>Voids</strong></td>
<td>Voids (or blisters) at moulded and corrosion resistant surfaces may be repaired if not greater than 2 mm diameter and 1 mm depth provided that the voids occur in discrete areas of discrete clusters and the sum of the areas does not exceed 0.5% of the total moulded area. Voids to other surfaces may be repaired if they do not extend to more than 20% of the laminate thickness and not more than 3% of the surface area is affected.</td>
</tr>
<tr>
<td><strong>Protuberances</strong></td>
<td>There shall be no protruding fibres from the internal surface of laminates.</td>
</tr>
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<td></td>
<td>Wrinkles and undulations shall be gradual and the internal surface shall be continuous at such locations. Such defects shall not appear extensively on single mouldings and shall not be repeated through a production run.</td>
</tr>
<tr>
<td><strong>Inclusions</strong></td>
<td>There shall be no visible inclusions or extraneous matter, other than permitted fillers of aggregates.</td>
</tr>
<tr>
<td><strong>Delamination</strong></td>
<td>There shall be no visible delamination.</td>
</tr>
</tbody>
</table>
1.12 Submittals

The contractor shall submit to the Engineer for approval, shop drawings and product data required to establish compliance for all pipes, valves and fittings. Submittals shall include at least the following:

- Shop drawings including piping layouts and schedules shall be submitted to the Engineer and shall include dimensioning, fittings, locations of valves and appurtenances, joint details, methods and locations of supports and all other pertinent technical specifications to be furnished.
- Shop drawing submittals for piping under this Section shall include all data and information required for the complete piping systems. All dimensions shall be based on the actual equipment to be furnished. Types and locations of pipe hangers and/or supports shall be shown on the piping layout for each piping submittal.
- Certificates of factory tests and their results prior to the shipment.
- Method statements in accordance with Module 01

In addition, for RTR pipe and fittings, the Contractor shall submit the following:

- Documentation of manufacturer’s qualifications and experience, with pipes and fittings similar to those specified.
- Manufacturer’s installation instructions, recommended field quality control procedures and specific field handling and storage requirements.
- Resin manufacturer’s corrosion service data for the proposed resin systems. Corrosion service data shall show satisfactory long term service in similar physical and chemical environments to those specified herein.
- Sample coupons of laminate not less than 300 mm x 300 mm square. Sample laminate coupons shall be supplied for each method of manufacture.

In addition, for valves and meters, submit the following:

- The total weight of each item
- Materials of construction and coating details.
- Certified hydrostatic test data, per manufacturers standard procedure.
- For each valve specified to be manufactured, tested and/or installed, submit a certificate of compliance with the appropriate standards, including certified results of required tests and certification of proper installation.
- Operating and maintenance data

In addition, for HDPE pipes, submit the following:

- Calculations covering the soil pressure on the buried pipe and restraint of expansion or contraction. Restraint anchors shall be provided if required. Manholes may be regarded as such restraint blocks, provided that they can be shown to provide the necessary resistance
- Provide proof of successful past use of the HDPE pipes and fittings on work of a similar environment and scope to that for this project
- Method statement including details on connection of pipe to manhole lining materials to ensure protection of connection on lined concrete manhole
- Detailed shop drawings showing all relevant details including:
  - Connections to manholes
  - Jointing to existing mains
  - Joints detail
- Samples of the proposed connections between the pipe and manhole lining when used with lined concrete manholes and test certificates as required by the Engineer
- As built drawings in accordance with the requirements of Sanitary Engineering Planning & Projects Directorate
- Representative samples of each type
- Different sizes and types of pipes and fittings, even if from the same manufacturer, shall be placed in separate submittals
The responsibilities for submissions, number of copies, contents of submissions and review procedure are specified in Module 01.

1.13 Health & Safety for Working in Confined Spaces

The Contractor's attention is drawn to the possible presence of high levels of hydrogen sulphide gas existing in the sewerage system and the resulting toxic environment created.

The Contractor shall not permit any employees to enter any live manholes, sewers or wet wells without the approval of the Engineer and then only when wearing approved breathing apparatus. Permission will only be given on the standard form "Authority to work within a Live Sewer", copies of which may be obtained from the Engineer.

The Contractor's attention is drawn to the fact that in addition to shafts, tunnels, closed tanks, and so on, any confined space with limited ventilation, including trenches, which also gives access to water in or from a closed conduit or borehole or by seepage and is below ground level shall be treated as a potentially hazardous location. In these and similar situations dangerous gases may be present and prior to entry by his employees or those of the Engineer or Employer safety precautions must be taken.

The Contractor shall provide adequate ventilation and efficient apparatus to keep all such confined spaces, excavations and trenches free from all dangerous gases, whether generated in the strata or arising from any other cause, and he shall take precautions to ascertain that they are in a safe condition before allowing workmen to enter or descend. In this connection the Contractor is reminded that the existing method of sewage disposal in much of Bahrain is by septic tanks which allows the liquid fraction to permeate into the ground. Previous trench excavations, particularly in the inner built up areas, have shown high levels of hydrogen sulphide gas present in the surrounding soil.

The Contractor shall check whether there are any other known hazards such as chlorine, methane, paint fumes, organic deposits, oxygen deficiency, and possible sudden discharges from pumping stations, and so on.

In addition to the hazards of working in confined spaces generally, the Contractor is required to familiarize himself and all his employees with the dangers of working in live sewers and at sewage treatment works; in particular the risk of physical injury, of bacterial infection from contact with sewage and of explosion of sewage gases.

Where work in potentially flammable atmosphere is unavoidable the Contractor shall use non-sparking safety hand and power tools and wear flame resistant clothing.

The Contractor shall observe the following minimum requirements in respect of personnel requiring entry to chambers, pumping stations or other structures into which sewage, sewage gas or other dangerous gases can enter.

- The following equipment must be available:
  - 2 No. sets of gas detection equipment for oxygen deficiency, flammable gases and hydrogen sulphate (stain tube or electronic types)
  - 3 No. 15 m lifelines with hook (12 mm diameter).
  - 3 No. safety harness, full body to BS EN 363.
  - 3 No. helmets and safety lamps (intrinsically safe).
  - 2 No. sets of self-contained positive pressure breathing apparatus
  - 2 No. sets of air-line type respiratory apparatus with adequate length of hose.
  - 1 No. set of resuscitation equipment.

- Naked lights shall not be used in the vicinity of the structure. No smoking shall be permitted.
- At least two people thoroughly familiar with the use of emergency breathing apparatus and other safety equipment and procedures shall remain at the point of entry.
• Ventilation shall be provided by removing access covers to upstream and downstream structures at least 60 minutes before the structure is entered or such other method adopted as is appropriate for the structure including, where necessary, forced ventilation.

• The atmosphere shall be tested at points of entry and exit and continuously monitored while personnel are present. If dangerous gases are present, ventilation must be continued and the atmosphere retested until such time as no dangerous gases are detected.

• Entry must be authorized by an appointed responsible person. The Contractor shall supply a list of the names of such persons to the Engineer before any work in live sewers, and so on, is carried out.

• All electrical equipment, for example, power drills, shall be intrinsically safe (that is, non-sparking)

• All equipment shall be inspected and tested regularly and all air cylinders for breathing apparatus shall be filled with air from compressors manufactured for that specific purpose and housed and used in accordance with the manufacturer's instructions.

• The nearest telephone and the telephone number of the nearest hospital must be noted.

• Transport shall be available at the site for use in emergencies.

It is emphasized that the foregoing requirements are a minimum and the Contractor’s attention is drawn to the relevant manuals listed at the back of this document, for example, those published by the National Joint Health and Safety Committee for the Water Service (UK) to which reference should be made.

Without prejudice to any provision under any clause in the agreement imposing liability on the Contractor, the Ministry's Health and Safety Officer or any employee of the Ministry designated as Health and Safety Officer shall have authority to visit the site at any time to ensure that the Contractor abides by health and safety requisites and that health and safety measures provided by him conform to standard working practices.

If in the opinion of the Health and Safety Officer any performance of any part of the works is liable to endanger lives of those on site or near it or users of roads passing through the site, he shall have authority to suspend the unsafe part of the works and to instruct the Contractor to take necessary measures to make it safe.

Work so suspended shall not be resumed until the Contractor has satisfied the Health and Safety Officer as to the adequacy of safety precautions employed.

The Contractor shall not be entitled to claim any compensation in terms of extra time, extra cost or otherwise based on delay caused by any order of the Health and Safety Officer.

The Contractor shall ensure that his employees have been adequately trained in safety techniques for working in live sewers and at sewage treatment works. His employees shall have been so trained that they are fully aware both of the risks inherent in such works and of the working methods necessary to minimise and overcome such risks. The contractor shall give to the Engineer such evidence as the Engineer may reasonably require to show that the Contractor’s employees have been so trained.

1.14 Abatement of Noise

The Contractor will not normally be permitted to operate plant between the hours of 10 p.m. and 6 a.m., except for pumps dealing with sewage flow of dewatering excavations.

Piling operations shall be further restricted to within the hours of 8 a.m. and 5 p.m.

All pneumatic breakers shall be fitted with mufflers.

The Contractor shall make every effort to keep the nuisance by noise to a minimum and consideration must be given to using the quietest plant available. If instructed by the Engineer, the Contractor shall use electric dewatering/overpumping pumps with silent generator, if required, located remotely to reduce the noise. The costs of providing such electric pumps shall be deemed as included in the rates for the work.
1.15 Cleaning of Septic Tanks

Before backfilling of septic tanks and soak pits, the tanks and pits shall be thoroughly cleaned and all solids and liquids removed in an approved manner. Dumping of such materials on the Site will not be permitted. Disposal arrangements for these materials shall be to the approval of the Engineer and Municipality. The sides and bottoms of the tanks and pits shall be thoroughly disinfected with chlorine powder or similar approved disinfectant. Where it is found impossible to pump dry a soak pit due to ingress of groundwater, the pit will be filled to the water level with approved fill mixed with disinfectant as directed by the Engineer. Existing chambers shall be cleaned in a similar manner to septic tanks before final connection is made.

1.16 House Connections

Existing house sanitation commonly consist of septic tanks located in adjacent access roads which retain solid matter but allow liquid to overflow either to existing drains or to the ground. The Contractor shall position a new suitably sized inspection chamber adjacent to each dwelling as directed by the Engineer and connect it to the sewerage system. The Contractor shall redirect sewage flows from the dwelling to discharge to the inspection chamber. Where necessary the inspection chamber shall be constructed within the old septic tank after the latter has been cleaned in accordance with Clause 1.15.

During construction the Contractor shall provide alternative drainage facilities for every live house connection and sewer effected and shall at all times ensure that no flooding or damage occurs as a result of his work. This will normally entail over-pumping, although some agreements with individual house-holders may be possible. The Contractor will not be allowed to complete a house connection until the sanitary facilities of that dwelling have been inspected and approved by the Engineer.

Some plots are as yet undeveloped and in these cases chambers generally are be built to suit the future drainage details shown on the Drawings. Such details however, are tentative only and the Engineer may relocate these chambers whenever it is deemed necessary. Where a development has started, connections, where possible, will be made to suit; this may involve the laying of a spur connection from the branch sewer to the plot boundary with no chamber provided. It shall be the responsibility of the plot developer or owner to connect his foul drains into the chamber provided or spur line (in the latter case he will be expected to connect the line into his own chambers). However, if arrangements are made for the Contractor to make these connections as well then the conditions as for connections inside compounds shall apply. In any case live connections will only be allowed as and when all downstream sewerage is complete and only with the written approval of the Engineer.

1.17 Access over Trenches

The Contractor shall maintain vehicular access wherever possible at all times whilst working in roads or traffic routes. He shall maintain suitable steel plates over his trench to cater for heavy duty axle loads.

The Contractor shall observe the code “Traffic Control at Roadworks” prepared by the Ministry of Works, Power and Water.

1.18 Obligations to the Public

The Contractor’s work shall be so arranged that use of the roads and highways affected by the work shall be restored to the public with the minimum of delay. Laying of pipelines, backfilling, testing of the pipelines, temporary reinstatement and clearance of the site shall follow closely behind excavation and, unless permission in writing is obtained from the Engineer, the Contractor shall not occupy more than 100 m length of road or highway at any time on any one section of work.

The Contractor shall carry out the work in such a manner as to cause minimum interference with the public use of highways, footpaths and other thoroughfares, and only such plant, materials,
tools, and so on, as shall from time to time be required for immediate use shall be deposited thereon.

The Contractor shall maintain a clean, safe and adequate passageway for pedestrians along highways and to each adjoining property. Where necessary for the safety and convenience of workmen, public, or livestock, or for the protection of the Works, the Contractor shall at his own expense provide adequate temporary walkways and fencing. Unless he shall obtain the written consent of the Traffic Police to close the road, he shall also maintain a satisfactory passageway for vehicular traffic.

The Contractor shall carry out the work in such a manner as to cause minimum nuisance to the public and the environment. This shall include:

- minimising noise from plant by using electric plant where appropriate
- ensuring rubbish and dirt is cleaned daily.

In addition to his obligations in respect of the public, the Contractor shall nominate a Bahraini national who, in conjunction with the Engineer, will liaise with the public regarding all aspects of the work and its effect on persons and property. He will be employed full-time on the Works and shall be fluent in English.

1.19 Disposal of Groundwater

Disposal of water shall be carried out in such a way as to avoid undermining any part of new or existing works or adjacent structures.

Permission to discharge into the existing sewer system will be subject to the Contractor obtaining the necessary permission. Should such permission be granted, the Contractor shall provide a settlement tank (ref. Roads and Sewerage Directorate Drawing D40/53B) to trap any silt/sand present in the groundwater before discharge to the sewer. The tank should be adequately covered and regularly cleaned to prevent carry over of silt/sand. Ground water discharge into any sewer shall be restricted such that the capacity of that sewer is not exceeded at any time, the limit on any pumped input being determined by the Engineer's Representative.

2. PART 2 PROTECTION AGAINST CORROSION

2.1 Environmental Considerations

Systems of protection against corrosion and for decorative purposes shall in all cases be suitable for exposure to their contact environment conditions which may include any or all of the following:

- The climatic and corrosive conditions detailed in environmental information as specified, with particular emphasis, where appropriate, on the consequential effects of UV light, temperature variations, high surface temperatures and high humidities.
- Septic sewage with a pH value of less than 1.0.
- Hydrogen sulphide and other gases released from sewage, septic sewage and sewage sludges.
- Sulphuric acid solution formed in sewage slimes in concentrations up to 15% by weight and at temperatures of between 30ºC and 50ºC.
- Sea water or saline groundwater with high chloride or sulphate contents both below the water table and in soil zones above the water table where capillary action and the presence of oxygen may cause extremely severe conditions.
- Treated waters with a pH range between 4 and 10 and a free chlorine content normally up to 2 mg/l but occasionally up to 100 mg/l.
- Wind blown chlorides.
- Wind blown abrasive sands.

The Contractor shall ensure that suppliers and manufacturers of materials for protective systems are made aware of the above conditions.
2.2 General Requirements for Protection Materials

The Contractor shall only be allowed to use protective coatings which are delivered to the Site in sealed cans or drums bearing the name of the manufacturer and properly labelled as to contents, quality, storage, mixing, application instructions, materials expiration date and usage period after opening.

Tints and shades of final coats shall be in accordance with technical schedules where included or as directed by the Engineer. The Contractor shall ensure that each coat to aid visual checking. Colouring pigments shall not contain lead.

The Contractor shall maintain a high standard of surface cleanliness between successive coats. Any inadvertent accumulation of dust or sand shall be removed by vacuum, and liquid contamination removed in an appropriate manner. Where foreign matter is trapped on the coated surface it shall be removed by suitable abrasive methods.

Time intervals between coatings shall be within the limits recommended by the manufacturer for the ambient temperature at the time of application and curing. In cases, when this is exceeded, the surface shall first be suitable abraded to remove any gloss so as to provide a mechanical key for the subsequent coat.

The Contractor’s attention is drawn to the fact that some materials meeting this Specification have flash points in the region of 25°C to 32°C, some are toxic, and certain materials can cause irritation or skin diseases. The Contractor shall ensure that all work areas are well ventilated and shall enforce all protective measures recommended by the manufacturer or required by the Engineer during the application of such materials.

2.2.1 Approvals

Application shall be made to the Engineer or approval to all manufactured products to be used in the Permanent Works.

The applications shall be accompanied by manufacturers detailed product specifications together with installation instructions in the case of membranes and liners, and application instructions in respect of coatings. Three copies of all approved product and user specifications shall be provided by the Contractor and they will be deemed to be part of these Specifications unless noted otherwise.

The Contractor shall arrange for a representative of the manufacturer to instruct his labour in the correct method of installation or application of his products including the use of all necessary specialist equipment and shall demonstrate to the Engineer that adequate instruction has been provided.

Where products from different manufacturers are used together the Contractor must ensure that they are compatible.

2.3 Inspection and Testing

2.3.1 Testing of Linings and Coatings

Following installation or application as appropriate at site, tests shall be carried out as follows:

- Protective Linings

After fixing, linings shall be offered for inspection and testing. Two sets of the appropriate testing equipment (such as feeler gauges and spark testers) shall be maintained and be available at all times for the sole use of the Engineer.

- Protective Coatings

Each coat shall be visually inspected for pin holding and adhesion. Any necessary filling, re-coating or other remedial work shall be carried out before application of the subsequent coat.
2.3.2 Repairs

All repairs shall be retested. Linings and coatings will not be accepted by the Engineer until they have been shown to comply with the relevant clauses of this Section.

2.4 Concrete Protection

2.4.1 General

Concrete structures shall be protected externally and internally where indicated on the Drawings or in Technical Schedules where included.

All protection system shall be applied strictly in accordance with the approved manufacturer’s instruction and shall only be applied when the humidity is less than 85%.

The permissible rate of permeation of any protection system shall not exceed 0.0027 perm inches (ASTM, 1 perm inch = 1 gm of water per hour per square foot (0.0929 m²) per ml (0.0254 mm) of the thickness for a 1 inch (25.4 mm) difference in Hg vapour pressure on each side of a membrane.)

The approved system must have adequate flexibility to cope with the thermal movement of concrete without cracking, delamination or leakage.

2.4.2 Concrete Surface Preparation for Coatings and Membranes

The purpose of surface preparation is to remove from the faces of the concrete to be protected all traces of loose material, laitance, shutter oil, grease, wind blown deposits and other contaminants which could prevent the proper adhesion of, or result in adverse reaction with, the protective system.

Prior to protection all expansion and contraction joints shall be covered on both sides with an approved flexible masking tape securely bonded to the concrete to prevent reaction between joint sealants and protective materials.

Concrete surfaces to be protected shall be free from pinholes and other surface defects. The Engineer’s approval shall be obtained for any method of repairing surface defects. Any preparatory filling required shall normally be carried out using an approved non-shrinking mortar.

Methods of surface preparation proposed for each system are listed in Table 2. These should be confirmed with the material manufacturers and alternatives submitted if necessary.

Surfaces prepared by blast cleaning shall have all dust and other loose material removed before applying any protection. Acid wash shall not be used on a concrete structure without the Engineer’s prior approval for the specific structure, which will not normally be given for reinforced or prestressed concrete.

When acid wash has been used the concrete surface shall be thoroughly washed with clean water and dried before applying any protection.

Walls to be tanked with a bituminous sheet membrane shall be brushed to remove all dust and other loose material.

Blinding concrete prepared for receiving base slab protection shall be free from sharp edges and projections. The surface shall be cleaned by an oil free air blast where practicable or as otherwise directed by the Engineer and primed with one coat of bituminous primer.

Walls to be coated with bituminous based coating shall be wire brushed, either by hand or with power tools. All dust and other loose materials shall be removed.

2.4.3 Concrete Protection Materials

Materials and systems to be used for the protection of concrete surfaces are detailed in Table 3.
2.4.4 Method of Application or Installation

2.4.4.1 Coatings and Membranes

Coating materials shall be applied by brush, roller, trowel or as recommended by the manufacturer and in a consistent manner so as to achieve the pre-determined coat thickness. The number of coats indicated is the minimum likely to achieve the specified thickness by brush application but for some materials further coats may be necessary for this purpose. Where the manufacturer's specified methods of application include airless spray, the Engineer will give consideration to request by the Contractor to adopt this method, and if satisfied that the Contractor has compiled with the relevant requirements of Clause 2.2, the Engineer may permit the use of spray techniques in situations where, in his opinion, this would be appropriate.

During backfilling, coatings and membranes shall be protected from damage by the use of fibre board, hardboard or other approved material. If the Engineer considers that the method of backfilling around the structure has caused damage to the protected surface, he may require removal of the backfill material to allow an inspection to be made. Any damage to coatings or membranes shall be rectified and the ensuing delay will not constitute grounds for a claim.

Where a membrane has been applied to blinding concrete for protection of a base slab, care shall be taken to prevent damage during the fixing of steel reinforcement and the pouring of concrete.

Unless otherwise detailed, membranes shall be fixed by unrolling vertically down vertical surfaces allowing an overlap of 150 mm onto adjacent rolls. Between the junction of vertical wall and horizontal base of roof surfaces, an extruded bitumen triangular fillet shall be placed in the return prior to the laying of the membrane and covered with a 300 mm wide strip of membrane to reinforce the angle.

Coatings or membranes shall totally enclose the substructures so as to prevent any contact between groundwater and the concrete surface. Protection shall extend to the top of the structure or at least 500 mm above finished ground level or to such greater limits as may be shown on the Drawings.

2.4.4.2 Liners

RTR liners shall generally be used in manholes and chambers in accordance with Clause 3.27. RTR liners shall meet the general material requirements of Clause 3.4. Tolerances shall be ±10 mm provided a tight fit is achieved between the wall and slab liners.

Liners shall be designed to resist distortion in transit, storage, handling and during concreting. The Contractor shall provide details of linings for approval of the Engineer prior to manufacture.

The installation methods adopted shall be such as to ensure that a completely water and gas tight seal is made preventing any exposure of concrete to the corrosive liquids and gases present.

PVC sheet linings shall be fixed such that the keys or ribs are cast into concrete surfaces. The lining shall be capable of taking up the required profile of the concrete.

Site operatives for employment on installation work shall be certified by the manufacturer as trained to a satisfactory standard in fixing and welding techniques, and such certificates shall be provided to the Engineer if requested.

Any damage resulting from resulting from the method of attaching PVC linings to the inside of formwork will not be permitted. Where nailing must be used this shall be restricted to a minimum and the nails shall be driven in regular vertical lines to facilitate subsequent repairs to the lining and to reduce the risk that nail holes may be missed.
2.4.4.3 System

Concrete structures shall be protected externally and internally where indicated on the Drawings or in Technical Schedules.

Where the Contract does not indicate a protective system for a particular situation the Engineer will instruct the Contractor as to the system to be adopted.

Materials for use in concrete protection systems are detailed in Table 3 and typical application of these systems in different environments are shown for guidance in Table 2.

The Contractor will be required to submit details of his proposed materials and manufacturers in the Schedules.
Table 2 - Concrete Protection System

<table>
<thead>
<tr>
<th>Typical Application Condition</th>
<th>Anticipated</th>
<th>System Preparation</th>
<th>Surface</th>
<th>Sequence of Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber benching</td>
<td>Severe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pointing to corbelling or coating of concrete under chamber covers</td>
<td>Severe</td>
<td>C1</td>
<td>Wire brush</td>
<td>Primer followed by trowel / gun application as appropriate</td>
</tr>
<tr>
<td>Internal surfaces to valve chambers, and so on</td>
<td>Normal</td>
<td>C2</td>
<td>Wire brush</td>
<td>Primers applicable followed by minimum 2 coats. Airless spray / brush applied.</td>
</tr>
<tr>
<td>Internal chamber walls (circular), soffits and cover raising elements</td>
<td>Severe</td>
<td>C7</td>
<td>Not applicable</td>
<td>Walls and soffits braced and surrounded in concrete</td>
</tr>
<tr>
<td>Internal chamber walls (rectangular) and soffits</td>
<td>Severe</td>
<td>C6</td>
<td>Not Applicable</td>
<td>Fixed to formwork and cast into concrete</td>
</tr>
<tr>
<td>External buried surfaces to minor structures</td>
<td>Normal</td>
<td>C4</td>
<td>Wire brush</td>
<td>Primer followed by 3 coats brush applied</td>
</tr>
<tr>
<td>External buried surfaces to minor structures (incl. under base)</td>
<td>Severe</td>
<td>C5</td>
<td>Wire brush</td>
<td>Bituminous primer brush applied followed by self adhesive laminate</td>
</tr>
<tr>
<td>External buried surfaces to major structures (incl. under base)</td>
<td>All</td>
<td>C5</td>
<td>Wire brush</td>
<td></td>
</tr>
<tr>
<td>Under base slabs of minor structures</td>
<td>Normal</td>
<td>C8</td>
<td>Blinding concrete free from sharp edges or projections and brushed to remove all loose material</td>
<td>Blinding concrete</td>
</tr>
<tr>
<td>System</td>
<td>Material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>Solvent free epoxy mortar, minimum thickness 10 mm unless otherwise recommended by the manufacturer and approved by the Engineer. Minimum compressive strength 10 N/mm² (BS 6319). Minimum tensile strength 10 N/mm² (BS 6319). Maximum water absorption 0-15% (ASTM C413). Minimum bond strength 1.5 N/mm² to wet or dry engineering or grade 50 concrete brick (ASTM C321). Resistant to long term attack from weak alkalies and 10% sulphuric acid at 40°C. When immersed in 10% sulphuric acid at 40°C, the mortar shall reach or closely approach a maximum weight gain at which time there shall be no evidence of and penetration beyond 33% of the specified (or approved) coating thickness. At this time or after 84 days, whichever is the greater, there shall be no softening and no visible degradation of the mortar except for surface discoloration.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>Solvent free coal tar epoxy. Brush application. Minimum finished system thickness 50 microns with minimum two coats plus primer.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>Penetrative bituminous primer and high build bituminous based coating. Brush or towel applied. Capable of being applied to a vertical surface without running or sagging at a wet film thickness equivalent to a DFT of 350 microns. The dry film shall not run or sag at service temperature at 400°C when applied as a three coat system of 1 mm thickness.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C5</td>
<td>Self-adhesive rubber modified bituminous sheet membrane, minimum, thickness 1.5 mm, minimum puncture resistance 200 N (ASTM E154), minimum tensile strength 200 N/mm² (BS 2782), maximum water absorption 0.3% (ASTM D570). Applied to concrete after application of manufacturer’s recommended primer. The material to have a solar shield where exposed above ground level.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3 - Concrete Protection Materials and Systems (Cont’d)

<table>
<thead>
<tr>
<th>System</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>C6</td>
<td>Black PVC sheet having a tensile strength of 15,000 kN/m² manufactured from polyvinyl chloride, plasticizers and pigments in permanently flexible sheet form. At least 99% of the resin used in the formulation shall be PVC resin. The sheet shall have a minimum thickness of 1.5 mm and for fixing to concrete surfaces shall be formed by extrusion to have on one side locking keys or ribs of T or diamond section at centres not greater than 75 mm. Non-ribbed sheets for welding to pre-fixed PVC keys at 0.6 m centres both ways may be used for plane vertical surfaces. The sheets shall be capable of forming a continuous 100% effective seal with the use of welding strips or other approved method and shall be supplied with all materials and tools for making joints and fixing to inserts. All weld strips, patches and other sheets used in the permanent fixings shall be of a material having the same composition as the main sheet material.</td>
</tr>
<tr>
<td>C7</td>
<td>RTR liners meeting material requirements of Clause 3.4</td>
</tr>
<tr>
<td>C8</td>
<td>Polythene sheet, minimum thickness 1 mm.</td>
</tr>
<tr>
<td>C9</td>
<td>Waterproof building paper Class B</td>
</tr>
</tbody>
</table>

Note:

Systems C1-5 shall be supplied with appropriate primers where required by the manufacturers.

2.5 Metalwork Protection

2.5.1 General

All metalwork, including structural steel work, valves and other pipeline fittings, shall be protected from corrosion by an approved system. Unless specified or detailed elsewhere, protection shall be as indicated in Table 4.

Protective and decorative paints including primers and undercoats shall be obtained from approved manufacturers with guarantees of coating compatibility. All containers of paints and other coating system shall show date of manufacture, shelf life and pot life where applicable.

The Contractor shall ensure that all mating or jointed surfaces are sealed or insulated as appropriate as specified below:
The mating surfaces of aluminium shall be sealed with an approved material.

Where dissimilar metals are mated including bolts, nuts and washers, the mating surfaces shall be insulated one from the other in an approved manner to provide protection against galvanic action.

Where like metals are to be jointed at the manufacturers works, priming coats shall be applied prior to jointing.

The mating surfaces of structural steelwork shall be sealed during erection with putty recommended by the paint supplier as compatible with the surface coating system adopted.

The Contractor shall ensure that all machined, polished or bright surfaces, whether internal or external, are protected against corrosion and damage. Spindles to valves and penstocks shall be given a final greasing after completion of any protective coatings.

On delivery of items to site, any defect in shop applied protective coatings shall be made good in accordance with the manufacturer’s instruction. The Contractor shall protect coated surfaces on site from damage by weather or by his subsequent operations and shall make good any defects as soon as they are discovered.

2.5.2 Surface Preparation

In general surface preparation will comprise a system selected from the methods detailed in Table 5 prior to which all surface defects in metals to be coated including cracks, surface laminations, shelling and deep pitting shall be made good as specified in BS 5493. All fins at saw cuts, burrs and sharp edges shall be similarly removed. Where the specified coating system is preceded by blast cleaning and extensive grinding has been necessary, the dressed areas shall be re-blasted to restore the surface to the required standard of cleanliness and roughness.

All cutting and drilling shall be completed before surface preparations are carried out.

2.5.3 Materials

Materials for use in metalwork protection systems are detailed in Table 6. Reference numbers are given to simplify Table 4 which lists the uses of each material and their approved combinations.

2.5.4 Methods of Application

2.5.4.1 Paints and Coatings

All cutting and drilling shall be completed before application of any of the specified materials.

All paints or other coating materials shall be applied immediately after completion of the required surface preparation.

Primer and first undercoats shall be roller or brush applied; spray application for these coats will not be permitted. Application shall be in accordance with the manufacturer’s instructions.

Proprietary items shall have all surface protection applied at the place of manufacture.

Works and site coating shall only be applied when the surface to be coated is completely dry, the humidity is less than 85% and the temperature is greater than 4°C.

Where necessary stripe coats shall be applied to maintain the specified thickness at joints, welds and other vulnerable areas.
2.5.4.2  **Protective Wrappings for Pipeline Components**

The normal protective system for wrapping pipeline components at pipe joints shall consist of:

- Application of a rust inhibiting compound for bolts and steel work.
- Application of a mastic or comparable non hardening filler, compatible with the inhibitor, in sufficient quantities to cover all protruding edges, bolt heads and sharp edges of flanges so as to give a smooth external profile.
- Wrapping in an approved waterproof protective tape, spirally wound around the pipeline component in such a way as to provide a half width overlap. The wrapping shall extend along 150 mm of the barrel of the pipe on each side of the component. Alternative methods such as heat shrinkable sleeves may be submitted for approval.

2.5.4.3  **Systems**

Protective systems for use on metalwork are given in Table 4. The use of a particular system will depend on the environment and the metal to be protected.

Table 5 details surface preparation and Table 6 details materials to be used in the various systems.

The Contractor will be required to submit details of his proposed materials and manufacturers on Schedules. This schedule must be completed but the Contractor may include (but as alternatives only) other systems and materials for consideration and approval by the Engineer.
## Table 4 - Metalwork Protection System

<table>
<thead>
<tr>
<th>Environment</th>
<th>Material</th>
<th>System</th>
<th>Surface Preparation</th>
<th>Sequence of Material Application</th>
</tr>
</thead>
</table>
| Immersion in, or less than 0.2 m above sewage; buried in or less than 0.2 m above ground; Exposed to weather or moist atmosphere without decorative finish | Cast Grey Iron  | M1     | SP1 and SP2, SP4 ad SP5 | Shop Coating: 1st P4, 2nd P8, 3rd P8, 4th - , 5th -  
                             |                 |        |                     | Site Coating: 1st P9, 2nd - , 3rd - , 4th - , 5th - |
| Ductile Iron                                                                | M2              | SP1 and SP2, Also SP3 if 1st coat P1 (i) SP5 and SP5 | Shop Coating: 1st P1 (i) or (ii), 2nd P2, 3rd P4, 4th P8, 5th P8  
                             |                 |        |                     | Site Coating: 1st P9, 2nd - , 3rd - , 4th - , 5th - |
| Exposed to weather or moist atmosphere with decorative finish (not including items in system M7) | Cast Grey Iron  | M3     | SP1 and SP2, SP4 and SP5 | Shop Coating: 1st P4, 2nd P8, 3rd P8, 4th - , 5th -  
                             |                 |        |                     | Site Coating: 1st P6, 2nd P7 |
| Ductile Iron                                                                | M4              | SP1 and SP2, Also SP3 if 1st coat P1 (i) SP4 and SP5 | Shop Coating: 1st P1 (i) or (ii), 2nd P2, 3rd P4, 4th P8, 5th P8  
                             | Steel           |        |                     | Site Coating: 1st P6, 2nd P7, 3rd P7, 4th - , 5th - |
| Not exposed to weather or moist atmosphere (not including items in system M7) | Cast Grey Iron  | M5     | SP1 and SP2, SP4 and SP5 | Shop Coating: 1st P3, 2nd P5, 3rd - , 4th - , 5th -  
                             |                 |        |                     | Site Coating: 1st P5, 2nd P7, 3rd - , 4th - , 5th - |
| Ductile Iron                                                                | M6              | SP1 and SP2, Also SP3 if 1st coat P1 (i) SP4 and SP5 | Shop Coating: 1st P1 (i) or (ii) P2, 3rd P5, 4th - , 5th -  
                             | Steel           |        |                     | Site Coating: 1st P2, 2nd P3, 3rd P5, 4th P5, 5th P7 |
| Electrical switchgear and motor control panels                              | M7              | SP1 and SP2 | Shop Coating: 1st P1 (ii) P2 (ii) P3 P5, 2nd - , 3rd - , 4th - , 5th -  
                             |                 |        |                     | Site Coating: 1st P11 to moulded joints and mechanical couplings |
| Buried pipes and out falls                                                  | Steel           | M8     | -                   | Shop Coating: 1st P10, 2nd - , 3rd - , 4th - , 5th -  
                             |                 |        |                     | Site Coating: 1st - , 2nd - , 3rd - , 4th - , 5th - |
| Any                                                                         | Aluminum        | M9     | -                   | Shop Coating: 1st P10, 2nd - , 3rd - , 4th - , 5th -  
<pre><code>                         |                 |        |                     | Site Coating: 1st - , 2nd - , 3rd - , 4th - , 5th - |
</code></pre>
<table>
<thead>
<tr>
<th>Ref.</th>
<th>Surface Preparation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP1</td>
<td>Degreasing</td>
<td>Shop cleaning to remove Group 1 contaminants</td>
</tr>
<tr>
<td>SP2</td>
<td>Blast Cleaning</td>
<td>Blasting in accordance with BS EN ISO 11124 with a maximum 100 micron profile to remove rust and mill scale for steel, or to S.A 2 with maximum 100 micron profile for cast grey and ductile iron. Blasting materials shall be free of deleterious substances.</td>
</tr>
<tr>
<td>SP3</td>
<td>Pickling</td>
<td>Chemical cleaning after blast cleaning, by the Duplex or Footer processes.</td>
</tr>
<tr>
<td>SP4</td>
<td>Pre-coat cleaning</td>
<td>Immediately before priming and before painting is commenced, all dirt, oil or grease shall be removed from the surface with an approved emulsion cleaner, thoroughly scrubbed in a continuous flow of clean fresh water and dried before coating.</td>
</tr>
<tr>
<td>SP5</td>
<td>Wire wool, abrasive cloth or sand paper</td>
<td>On site preparation to remove high spots and to provide a key for primers, undercoats and finishing coats.</td>
</tr>
<tr>
<td>SP6</td>
<td>Powered wire brush</td>
<td>On site preparation of welds in steel.</td>
</tr>
</tbody>
</table>

Notes:

(a) Cleaning and preparation of metal surfaces will generally be in accordance with BS 7773

(b) The use of systems SP1 – SP5 is detailed in Table 4
### Table 6 - Metalwork Protection Materials

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Zinc Metallization:</td>
</tr>
<tr>
<td></td>
<td>(i) Zinc-dip coating (SB2), Table 4B. Minimum coating weight as detailed in BS EN ISO 1461</td>
</tr>
<tr>
<td></td>
<td>(ii) Zinc-spray coating (SC6Z), Table 4C, Part 1 Note subsequent pretreatment and sealing times in P2 (ii). Nominal thickness 150 microns</td>
</tr>
<tr>
<td>P2</td>
<td>Pretreatment primers and sealers:</td>
</tr>
<tr>
<td></td>
<td>(i) Etch primer (T-wash) for zinc-dip coatings, Section 11.3.2(c).</td>
</tr>
<tr>
<td></td>
<td>(ii) Pretreatment primers and sealers for zinc-spray coatings (CP2 and CP3 to CP6). Primer and sealer to be applied within 4 hours and 24 hours of zinc spraying respectively. (See note (d) below)</td>
</tr>
<tr>
<td>P3</td>
<td>Zinc phosphate primer (FP2A or FP3A) DFT 35.</td>
</tr>
<tr>
<td>P4</td>
<td>Zinc phosphate/epoxy primer (KPIA), DFT 35.</td>
</tr>
<tr>
<td>P5</td>
<td>Drying oil undercoat under coat (FU1A or Fu2A), DFT 35.</td>
</tr>
<tr>
<td>P6</td>
<td>Drying oil/MIO undercoat (FU1B), DFT 40. (See Note (C))</td>
</tr>
<tr>
<td>P7</td>
<td>Drying oil finishing coat (FF5B), DFT 35</td>
</tr>
<tr>
<td>P8</td>
<td>Low solvent content epoxy/MIO undercoat, DFT 75. (See Note (c) below)</td>
</tr>
<tr>
<td>P9</td>
<td>Coal tar epoxy finishing coat (KF3C), DFT 60.</td>
</tr>
<tr>
<td>P10</td>
<td>Reinforced hot applied bitumen</td>
</tr>
<tr>
<td>P11</td>
<td>Hydrocarbon paste, mastic and tape</td>
</tr>
</tbody>
</table>

**Notes:**

(a) Bracketed references and table references are from BS 5493: Tables 4A to 4M.

(b) DFT means minimum dry film thickness in microns as determined by non-destructive magnetic flux or eddy current test method, BS 5493 Section 4, Paragraph 41 references

(c) For coatings containing micaceous iron oxide (MIO), pigments shall contain at least 80% MIO and have a lamellar (i.e. plate like) particle shape, the pigment volume concentration shall be between 35% and 45% solids volume not less than 64% and not more than 5% of anti-settling agent.

(d) For P2 (ii) select pretreatment primer and sealer to suit subsequent coatings as detailed in Section 11.2.2 of BS 5493.
3. PART 3 MATERIALS FOR PIPEWORKS AND ANCILLARIES

3.1 Polyethylene Pipes

Polyethylene pipes and fittings for rising mains shall comply with BS EN 13244 ‘Polyethylene piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage’, Parts 1 to 5 covering:

- Part 1 – General
- Part 2 – Pipes
- Part 3 – Fittings
- Part 4 – Valves
- Part 5 – Fitness for purpose of the system.

Pipes shall be made from PE100 material unless otherwise agreed. Sewerage pipes shall be black.

Pipes shall be designed for a working pressure as specified. The design of the pipe shall incorporate a surge allowance of 40% above the working pressure of the pipe.

Pipes and fittings shall effectively resist the corrosive effects of sewage effluent with a normal maximum temperature of 40°C. PN values shall be specified at 20°C and down rated by a third for 40°C.

The Contractor shall supply the pipes for a life of not less than 50 years. Copies of the Design Calculations shall be submitted to the Engineer for approval. Approval by the Engineer shall not relieve the Contractor of his responsibility for the Calculations and satisfactory performance of the pipes.

Joints shall be installed such that the connection of HDPE pipe sections will form a continuous line free from irregularities in the flow line.

The Contactor shall have the pipe jointing carried out by the pipe manufacturer or certified personnel, familiar with the jointing technique, using equipment, and techniques specially designed for the pipe diameter and material being jointed.

3.2 Vitrified Clay Pipes and Fittings

Vitrified clay pipes and fittings for gravity pipes shall be spigot and socket type with flexible mechanical joints and elastomeric sealing rings in accordance with BS EN 295 or BS 65. They shall be of super strength class unless otherwise described in the Contract.

Pipes shall be capable of withstanding an internal water pressure of 0.6 bar for 5 minutes without failure. Vitrified clay jacking pipes shall be in accordance with BS EN 295 Part 7.

3.3 PVC-U Pipes

All pressure PVC-U pipes shall comply with BS EN 1456: Part 1 or other approved standard.

Unless a higher class is noted elsewhere in the Contract Documents, PVC-U pipes for pressure applications shall be PN10 at 20°C. The permitted pressure will be derated by a third for 40°C. If the working pressure of the system is greater than 4.5 bar, the pressure class of the pipe shall be at least 2.2 times greater than the working pressure.

The material shall have a minimum extrapolated hoop tensile strength of 17.5 MN/m² at 50 years and at a temperature of 35°C.

Where PVC-U pipes are used for drainage purposes, they shall be Type SN4 in accordance with BS EN 1401: Part 1.
Joints for gravity pipe shall be made by means of rubber ring seal connections.

Slotted PVC-U pipes for land and storm water/land drains shall be of an approved design giving infiltration rates at least equal to those specified in BS 5911 for porous concrete pipes and they shall comply with BS EN 1401: Part 1.

Any pipe or part pipe with discoloration, scratching, abrasion, pit marks or otherwise considered unsuitable by the Engineer shall be rejected.

3.4 Reinforced Thermosetting Resin

The supply, manufacture, installation, and testing of RTR pipes and fittings manufactured from thermosetting resins reinforced by glass fibres shall be the responsibility of the Contractor. Pipes shall be manufactured in accordance with BS EN 14364 and installed in accordance with this specification and manufacturers recommendations. Pipes that are permanently exposed to sunlight shall be UV resistant.

Reinforcement for pipes manufactured by a centrifugal casting or conventional filament wound method shall be standard E glass or an approved acid resistant glass. Reinforcement for pipes manufactured by a continuous filament wound process shall be an approved acid resistant glass. Veiling used in surface areas shall be Class C glass or an approved high acid resistant glass.

The thermosetting resin shall be isophthalic polyester, bisphenol-A polyester or vinyl ester. The use of additives to modify the resin viscosity prior to cutting is permissible, but the incorporation of pigments is not permitted. The resin material shall be stabilized against ultraviolet light. Cured resin must have a minimum 4% elongation to break.

The aggregate if used in RTR pipes shall be graded silica sand, or granules of approved glass, of size between 0.05 mm and 3 mm.

The incorporation of sand into the outside resin rich layer is permitted but otherwise fillers or extenders shall not be used in the resin rich layers.

Resin rich layers shall be provided on the outside and inside surfaces of the pipe.

The resin rich layer on the inside surface of the pipe shall have an average thickness of 2.0 mm with a minimum thickness of 1.5 mm and maximum thickness (except at local overlaps in reinforcement) of 2.5 mm. This liner shall comprise a surface layer of between 0.25 mm and 0.75 mm thickness containing 10% by weight of veil reinforcement, and a barrier layer containing 20 to 35 percent by weight of chopped strand standard E glass or approved high acid resistant glass.

The resin rich layer on the outside surface of the pipe shall be of the same construction as the inner liner, except that the overall thickness shall be 1 mm and the minimum thickness 0.5 mm.

No structural reinforcement shall be allowed to penetrate the barrier layers and where pipes are made by the filament wound process a method statement shall be submitted describing how compliance with this requirement will be ensured.

All RTR gravity pipes shall be of sufficient stiffness compatible with loading, backfill and soil materials and shall be supplied in minimum lengths of 6 m. Generally pipes shall have a minimum stiffness of 5,000 N/m².

RTR Rising Main pipework shall have a pressure rating of 12 bar, and a minimum specific initial stiffness of 10,000 N/m².

When pipes pass through an anchor/thrust block, wrapping of pipe shall be carried out using suitable compressible filler to prevent contact with sharp edges.
Pipes and fittings shall be jointed with a double bell coupling and rubber rings. Couplings shall be of similar material to that of the pipes and fittings unless otherwise required or directed.

Pipes and fittings shall effectively resist the corrosive effects of septic sewage or effluent with a normal maximum temperature of above 40°C.

The Contractor shall supply the pipes for a life of not less than 50 years. Copies of the design calculations shall be submitted to the Engineer for approval.

Pipes shall be joined by RTR double socket coupling type joints, all with EPDM synthetic rubber rings to BS EN 681. Joints shall allow at least 3 degrees of deflection for sizes up to and including 500 mm, 2 degrees for sizes up to and including 900 mm and 1 degree for larger sizes, all with no loss of water tightness. The design of the joints shall be in accordance with ASTM D4161.

Rubber Lined Stainless Steel Grade 316 L couplings shall be used at changes of pipe material. After installation and before backfilling the stainless steel couplings shall be wrapped with Denso tape or equal approved.

The Contractor will comply with the pipe manufacturer's handling/laying specification at all times, unless otherwise ordered by the Engineer.

All cutting, machining, chamfering, on-site repairs, and so on, of RTR pipes shall be carried out as per the pipe manufacturer's instruction, and shall be to the approval and satisfaction of the Engineer.

The Contractor shall submit to the Engineer for approval details of proposed trench construction, pipe bedding material, method of bedding, pipe laying, backfilling and compaction. The choice of design parameters, shall be subject to the approval of the Engineer. When Class I material is used as a bedding material, a Geo-Textile filter membrane shall be used to line the trench bottom and walls to prevent migration of the native soil into the bedding and backfill.

A field representative of the Manufacturer shall be present during installation.

The design of pressure pipes shall incorporate a surge allowance of 40% above the working pressure of the pipe.

Ultra Violet Stabilizers shall be incorporated in the pipe and fitting construction. The RTR pipe shall have a minimum total wall thickness of 10 mm.

### 3.5 Precast Concrete Pipes and Fittings

Precast concrete pipes and fittings of circular cross-section used for the conveyance of sewage or surface water shall comply with the appropriate parts of BS EN 1916 and BS 5911. Concrete manholes and inspection chambers shall comply with BS EN 1917 and BS 5911. All precast concrete shall be made using sulphate resisting cement.

Concrete jacking pipes shall comply with the relevant provisions of BS 5911 and BS EN 1916. The Contractor shall ensure that the pipes can withstand the jacking loads without damage.

All pipes and fittings shall have gasket spigot and socket type joints unless noted otherwise. Strength class shall be 120 unless noted elsewhere in the Contract. Strength class is minimum crushing load in kN/m divided by one thousandth of nominal diameter in mm. Concrete shall comply generally with the requirements of Module 02 Concrete.

### 3.6 Ductile Iron Pipes and Fittings

Ductile iron pipes and fittings shall be in accordance with BS EN 545 or ISO 2531 for water pipelines and BS EN 598 for sewerage applications. They shall be supplied by an internationally recognised and approved manufacturer. Ductile iron pipes and fittings shall be supplied, store,
laid, backfilled and tested in accordance with this specification and manufacturers recommendations.

The pipes shall not exceed 5.5 m in length and push-in or flexible mechanical joints shall be used unless stated otherwise.

Where the ends of pipes are described as 'plain or spigot ended', they shall be suitable for jointing with a mechanical coupling comprising centre sleeve, end flanges, wedge-shaped sealing rings and nuts and bolts.

The internal and external surfaces of all ductile iron pipes and fittings shall be protected as specified below.

3.7 External Protection to Ductile Iron Pipelines and Fittings

External protection of ductile iron pipes and fittings shall be provided by a works applied coating of metallic zinc with a finishing coating of bituminous material all in accordance with BS EN 545 for water pipelines and BS EN 598 for sewerage applications.

Unless described otherwise, pipes laid in the ground shall, in addition to the wrapping, be externally protected with site applied black polythene sleeves complying with BS 6076 of 250 microns and minimum thickness of 200 microns. It shall have a Melt Flow Index of not more than 2.5 g/10 minutes when determined by Method 720A, of BS 2782: Part 7 and a nominal density of not less than 915 kg/m³ and not greater than 930 kg/m³. The tensile strength of the film shall not be less than 11 N/mm² and the elongation of the film shall not be less than 300% when tested in accordance with Method 326C of BS 2782: Part 3, the specimen thickness being the film thickness and not that specified in BS 2782. The film shall be free from gels, undispersed raw materials and particles of foreign matter. Sleeves shall have a circumference 100 mm greater than the pipe. Sleeve ends shall be taped to the pipe and overlayed by 300 mm. Sleeve overlaps and pipe joints shall be separated by a minimum of 500 mm. Where sections of BS 2782 have been withdrawn, the relevant replacement code shall be used and the material shall be demonstrated to achieve the requirements indicated above.

3.8 Internal Protection to Ductile Iron Pipelines and Fittings

Ductile iron pipes and fittings shall be lined at the manufacturer’s works internally with a cement mortar lining in accordance with BS EN 545 for water pipelines and BS EN 598 for sewerage applications. The lining shall extend over all internal surfaces including flange faces, socket interior surfaces and the outside of spigot ends.

Any damage to the internal lining shall be repaired strictly in accordance with the manufacturer’s instructions.

The lining shall be capable of withstanding a maximum operating temperature of 35°C and acidic conditions in slime layers with a pH of 1.0.

3.9 Flanged DI Pipework

All flanged pipe work shall be joined using Grade 316 (BS EN 10250: Part 4) stainless steel nuts, bolts and washers unless stated otherwise. The threaded portion of bolts shall be of such length that at least two threads shall protrude beyond the nut when tightened.

Flanges for pipes and pipeline fittings shall, unless otherwise required by the Contract, comply with BS EN 1092: Part 2 for 16 bar nominal pressure rating.

Gaskets for flanged pipe joints shall be of the inside-bolt-circle type as described in BS EN 1514: Part 1. Gaskets shall be manufactured from material complying with the provisions of BS EN 681: Part 1 for Type W rings with a hardness range of 76 – 84.
3.10 Steel Pipes and Fittings

Steel pipes shall comply with BS EN 10224 and BS EN 10216 (for seamless) or BS EN 10217 (for welded).

Steel flanges shall be to BS EN 1092: Part 1 Type PN 16.

Welded pipes shall be made from not more than two plates with two longitudinal welds; no circumferential welds will be permitted except for built-up bends and flanges. When welded up, each pipe barrel shall be truly cylindrical and circular in cross section and shall comply with the tolerance laid down in the BS quoted above.

Steel pipes for other than potable water supply purposes shall be internally and externally protected by the application of 3 coats of an approved high build acid resistant epoxy paint to a minimum thickness of 1,000 microns.

Couplings and flange adaptors shall be mechanical couplings comprising centre sleeve, end flanges, wedge-shaped rubber sealing rings, and nuts and bolts.

Couplings shall be nylon-coated and nuts, bolts and washers shall be stainless steel, Grade 316 (BS EN 10250: Part 4). Installed couplings and flange adaptors shall be protected in accordance with Clause 2.5 of this specification.

3.11 Pipe Joints General

Unless specified elsewhere, rubber joint rings for water mains and drainage purposes shall be types W and D respectively complying with the relevant provisions of BS EN 681: Part 1 and shall generally be obtained from the pipe manufacturers. The elastomer used for the manufacturer of the rings shall be first grade plantation rubber complying with BS ISO 4659 styrene butadiene or BS 6014 for ethylene propylene rubber.

3.12 Gate Valves

Gate valves for use in sewage, sewage effluent and sludge shall comply with BS 5150. Parallel slide gate valves shall comply with BS EN 1171. Valves to BS 5163: Part 1 shall be used for all clean water purposes. Flanged valves shall be faced and drilled to type PN16 as defined in BS EN 1092: Part 1 unless directed otherwise. Non-rising spindles shall be used unless specified otherwise. They shall have gunmetal faces on body and wedge. All valves and penstocks shall be anti-clockwise opening unless otherwise specified.

Gate valves shall have extension spindles, tee keys or headstocks to suit the situation, as detailed. Headstocks shall be marked to indicate closed, ¼, ½, ¾ and open position of the valve. Valves shall have clockwise closing.

Gate valves larger than 400 mm shall be fitted with a studded cast iron cover at the bottom of the valve body for inspection, cleaning and flushing purposes unless they are buried underground.

Hand operated gate valves shall have hand wheels sized such that the operating effort does not exceed 220 N. The maximum acceptable size of hand wheel is 450 mm. Hand wheels shall show directions for opening and closing. Where gate valves are hand-operated through gear boxes, the design of the gear box shall be such that the operating effort does not exceed 220 N. All valves of 450 mm diameter and over shall be geared.

Where valves are underground, they shall have the extension spindles protected by cast iron protection tubes especially made to fit the valves. The protection tube shall have a suitable bushing at the top to stop ingress of dirt. This bushing shall also have been designed to take the weight of the spindle where deemed necessary.
The bodies of gate valves above 350 mm diameter, which are mounted with the spindle in the horizontal plane, shall be fitted with renewable gunmetal machined gate slides and the gates shall have renewable hard bronze shoes accurately machined to reduce sliding friction.

3.13 Diaphragm Valves

Diaphragm valves shall comply with BS EN 13397 and shall be arranged for clockwise closing. The valves shall be of the straight through or weir type, as detailed. The requirements for all ancillary equipment shall be as for penstocks. Body lining and diaphragm shall be of materials suitable for the fluid or gas being carried.

3.14 Check Valves

Check valves shall be flanged, shall conform to BS EN 12334 and shall have cast iron bodies and lids with heavy doors. The valves shall have machined gunmetal sealing faces positively fixed in position to give a watertight joint. The design of the valve shall be such that all internal moving parts can be completely withdrawn for repair or renewal without disturbing the pipework. All check valves shall have external mild steel heavy duty operating levers complete with adjustable counter-weights. Long pattern valves will generally be used. Door spindles shall be located with a non-torque transmitting collar to positively locate the Grade 431 S29 stainless steel square spindle.

3.15 Butterfly Valves

Butterfly valves shall conform to BS EN 12334 and shall have cast iron bodies.

3.16 Penstocks

Penstocks shall conform to BS 7785. The penstock shall be either hand operated by hand wheel, square cap and gearbox or power operated by electromechanical actuators.

Penstock leakage shall not exceed $2.07 \times 10^{-5} \text{ m}^3/\text{s}$ per metre of sealing perimeter.

3.17 Plug Valves

Plug valves shall conform to BS 5158.

3.18 Air Release Valves

Air release valves shall be of the double orifice kinetic ball type for non potable mains. The valve assembly shall include isolating, sluice and scour valves as required.

Air release valves for potable water mains shall be as shown on the Drawings. Flanges shall be compatible with the main pipeline.

3.19 Protection of Valves

All iron valves shall be protected internally and externally by an approved fusion bonded powder epoxy coating to a minimum DFT of 200 microns applied by the manufacturer. Care shall be taken in handling, transporting and installing the coated valves. Any minor damage shall be made good on site in accordance with the manufacturer’s recommendations.

3.20 Mechanical Couplings for Pipelines and Fittings

Mechanical couplings and repair clamps, excluding those for use with MDPE and HPPE pipelines and fittings, shall comply with BS EN 598.

Mechanical joints and fittings for use with MDPE and HPPE shall comply with BS EN ISO 15494.
and BS EN 13244. All fittings for MDPE and HPPE shall be Type 1 end load restraining and have an internal pipe support.

All fittings shall be protected against corrosion by the application of a polymeric barrier coating. All internal and external surfaces shall be coated to Class B as a minimum.

All fasteners shall be protected from corrosion by the application of zinc and a polymeric barrier coating.

Gaskets shall comply with BS EN 681.

### 3.21 Step Irons

Step irons for manholes shall be in accordance with BS EN 13101 and shall be hot dip galvanized in accordance with BS EN ISO 1461 to provide a minimum coating thickness of 85 microns.

### 3.22 Embossed Letter

Manholes, chambers and pits shall, unless identified by embossed lettering on cast iron covers to the approval of the adopting authority. All covers shall be embossed as follows in both English and Arabic.

<table>
<thead>
<tr>
<th>English</th>
<th>Arabic</th>
</tr>
</thead>
<tbody>
<tr>
<td>STORMWATER</td>
<td>مياه أمطار</td>
</tr>
<tr>
<td>FOUL SEWER</td>
<td>محارى</td>
</tr>
<tr>
<td>TREATED SEWAGE EF</td>
<td>مياه صرف صحي معالجة</td>
</tr>
</tbody>
</table>

### 3.23 Cast or Ductile Iron Covers & Frames

Cast ductile iron covers and frames shall be of the size, type and grade shown on the Drawings and shall comply with BS EN 124 or DIN 1229. They shall be lockable unless noted otherwise. If specified elsewhere to be airtight, they shall be capable of resisting an internal pressure of 100 kN/m². All covers shall be obtained from approved manufacturers to the sizes, grades and pattern numbers as detailed. Where no grade is detailed, Class D400 shall be used in paved areas and Class B125 in Figure 9a BS EN 124 in areas where there is no vehicular access.

Covers shall be supplied complete with 5 sets of lifting keys obtained from the cover manufacturer. Frames and covers for sewers shall have a removable self-sealing GRP or similar corrosion-resistant plate that fits securely between cover and frame such that the minimum surface area of the frame is exposed to the atmosphere within the manhole. The design of the frame, cover and plate shall be to the approval of the Engineer. Covers and frames to air valve chambers shall be of ventilated type.

### 3.24 Cast or Ductile Iron Surface Boxes, Gully Gratings and Frames

Cast ductile iron surface boxes, gully gratings and frames shall be heavy duty complying with BS 5834: Part 2 and BS EN 124 Class D400 loading except for kerb gullies which shall be Class C250 loading. Kerb gullies shall have reversible covers capable of preventing the ingress of sand and shall suit the kerb profile. Kerb gully frames shall include an internal GRP grating and road retaining bar. The weir entrance to the road gully shall be barred vertically to prevent the ingress of objects larger than 75 mm.

### 3.25 Gullies

Road gullies shall be polypropylene or GRP dimensioned in accordance with BS 5911, 450 mm internal diameter by 900 mm or 1,050 mm deep with 150 mm outlet and without trap for soakways but with trap for a positive drainage system. They shall be complete with GRP perforated basket and incorporate a 100 mm diameter opening in the base, unless otherwise directed by the Engineer.
3.26 Protection to CI Manhole Covers, and so on

Gratings, covers and frames shall be prepared in accordance with the relevant clause for preparation of steelwork prior to protective treatment and shall be coated with heavy duty abrasion resistant epoxy paint to a minimum DFT of 375 microns prior to installation.

Contact surfaces of covers and frames (other than machined covers) shall be coated with approved heavy duty grease immediately prior to final fitting of covers. Surfaces of machined covers and frames shall be coated with approved graphite grease immediately prior to final fitting of covers.

3.27 Manhole Linings

Manhole linings shall effectively resist the corrosive effects of septic sewage or effluent with a normal maximum temperature of up to 40°C.

The lining shall be subjected to the following test. The lining shall be fully resistant to 10% W/V sulphuric acid at 50°C when subjected to an immersion test which shall last a minimum of 100 days. The laboratory and method of testing shall be to the approval of the Engineer.

Manhole linings shall have a resin rich lining having a nominal thickness of 1.5 mm consisting of an inner most 0.3 mm layer reinforced with ‘C’ glass. The remainder of the lining shall consist of acid resistant chopped ‘ECR’ glass strand or mat and having a glass content between 25% and 30% by weight. Manhole linings shall be provided with a resin rich outer layer reinforced with ‘C’ glass veil.

The resin to be used for the resin rich lining of the manhole lining shall be an epoxy-based Vinylester resin. For the structural wall of the manhole lining high grade Isophthalic polyester resin shall be used. No dark pigments shall be used. Fine silica sand containing no impurities and complying with requirements of BS EN 14364 – may be added to the structural layer to achieve adequate stiffness.

All glass reinforcement except for the inner and outer surfaces of the manhole lining shall be of the acid resistant ‘ECR’ type.

The internal surface of the liner material shall be smooth and both the internal and external surfaces shall be clean and free from defects such as protruding fibre, voids, pits, bubbles, cracks, blisters or foreign matter which would impair their performance in service.

The external surface of the lining shall have suitable GRP lugs moulded on the surface at appropriate spacings to allow adequate bonding to the concrete.

The manufacturing tolerances shall be ± 0.5%. All deviations from roundness, with the exception of deformation due to self weight, shall be contained within this tolerance.

At no position shall the thickness of the manhole liner material be less than 4.5 mm.

Circular lining material shall be able to withstand an external hydrostatic head of 7 m without deforming.

The lining material shall have adequate strength to withstand loading, off-loading and site handling. It shall not buckle or distort so as to affect circularity, water-tightness or continuity of laminate when a concrete surround is being placed. Internal bracing whilst pouring concrete shall be adopted if required.

Joints, where permitted, shall be as detailed and shall be made using an external purpose-made sleeve or plate bonded by an approved solvent to the liner and shall be equal or superior in performance to the lining, in both the circumferential and longitudinal directions. Overbonding shall extend for a minimum of 150 mm on each side of the joint.
A representative sample of the liner material shall be submitted to the Engineer for testing and for comparison with the product as delivered to Site, together with full details of the chemical properties of the resins, all of which must be approved by the Engineer in writing before use.

3.28 Ladders

Aluminium alloy ladders shall be of approved design and obtained from an approved manufacturer.

All ladders shall comply with any dimensional provisions of BS 4211, Class A and PD 970.

Low carbon steel ladders for vertical fixing shall comply with BS 5395: Part 1.

After fabrication, low carbon steel ladders shall be hot dip galvanised in accordance with BS EN ISO 1461.

Aluminium ladders for vertical fixing shall be fabricated from Grade 6082 aluminium complying with BS EN 515, BS EN 573: Part 3 and 4, BS EN 755: Parts 1 to 9 and BS EN 12020: Part 1 and 2.

After fabrication, aluminium ladders shall be anodised in accordance with BS EN ISO 1461

GRP ladders shall be manufactured and tested in accordance with BS EN 131: Part 1.

3.29 Safety Chains

Mild steel safety chains shall be 8 mm nominal size Grade M(4) non-calibrated chain, Type 1, complying with BS EN 818. After manufacture, mild steel safety chains shall be hot dip galvanized in accordance with BS EN ISO 1460.

Stainless steel safety chain shall be manufactured from Grade 316S31 steel complying with BS EN 10088. Chain links shall be welded and have an internal length not exceeding 45 mm and an internal width of between 12 mm and 18 mm. The fins caused by welding shall be removed and the weld shall be smoothly finished all round. When tested in accordance with Clause 7.3 of BS EN 818, each chain shall withstand a breaking force of 30 kN and a proof force of 15 kN.

3.30 Water Stops

Rubber water stops shall have the following properties when tested in accordance with the relevant Part of BS 903:

<table>
<thead>
<tr>
<th>Standard BS 903</th>
<th>Property</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A1</td>
<td>Density</td>
<td>1,100 kg/m³ (± 5%)</td>
</tr>
<tr>
<td>Part A26</td>
<td>Hardness</td>
<td>60 – 70 IRHD</td>
</tr>
<tr>
<td>Part A2</td>
<td>Tensile strength</td>
<td>not less than 17.5 N/mm²</td>
</tr>
<tr>
<td></td>
<td>Elongation at break point</td>
<td>not less than 450%</td>
</tr>
<tr>
<td>Part A16 (BS ISO 1817)</td>
<td>Water absorption (48 hours immersion)</td>
<td>not exceeding 5%</td>
</tr>
<tr>
<td></td>
<td>Water absorption (48 hours immersion)</td>
<td>not exceeding 5%</td>
</tr>
</tbody>
</table>

Rubber water stops shall be suitable for storage, handling, installation and service within a temperature range of 0°C to + 40°C.
Rubber water stops, where specified, shall be extruded natural rubber with solid outer bulbs. Factory made intersections shall be used for all connections, mitres and changes of section. Site jointing shall be by hot vulcanisation in accordance with the manufacturer’s instructions.

PVC water stops shall comply with National regulations. Factory made intersections shall be used for all connections, mitres and changes of section. Site jointing shall be in strict accordance with the manufacturer’s instructions.

3.31 Filter Fabric

Filter fabric surround to soakaways and land drains shall be suitable for subsurface filtration. Geotextile is to have a minimum tear resistance of 225 N. A minimum permeability of 90 l/m².s and a mean O90 size of 0.18 mm shall be required. The Contractor shall demonstrate the suitability of the geotextile for the particular application including submission of calculations together with soil grading curves to the approval of the Engineer. Geotextile shall be laid with 500 mm overlaps at joints unless indicated elsewhere in the Contract.

3.32 Marker Tape

Marker tape shall be provided where directed and conform to the requirements of Clause 7.12 and 8.1.

3.33 Oil Separators

The design of oil separators is to conform to the pollution prevention guidelines of UK Environmental Agency “Use and Design of Oil Separators in Surface Water Drainage Systems: PPG3” or to similar requirements by other regulatory agencies where approved by the Engineer.

A full retention separator type Class I is to be provided with sufficient storage volume as approved in the design.

An oil level alarm shall be provided to indicate both a visual and audible warning when the level reaches 80% of its maximum capacity. The sensor shall be rated to IP68 or higher.

3.34 Steel Storage Tanks

Steel water tanks shall be pre-fabricated glass coated mild steel, placed on an epoxy coated reinforced concrete base, with a PVC coated steel roof. The glass coat shall be able to resist acid pH value 2.0 at 50°C and to resist alkalinity pH value of 11 at 50°C. The glass shall be fused to the steel to produce a bond strength of 34,000 kN/mm². The coat at both sides and all edges shall be minimum 0.18 mm thickness and the integrity of the coating shall be tested with approved detectors on site prior to erection of the tank. The testing of the coating shall be in accordance with manufacturer’s guidelines, and in the event of a test failure, the Contractor shall make good in accordance with manufacturer’s recommendations and re-test.

The final storage volume is to be no less than the stated net water volume in the Contract.

The colour of the tank shall be white, and the Contractor shall submit samples workshop drawings and colour samples for the approval of the Engineer prior to Construction.

Bolts nuts and washers shall be ABS coated galvanized steel. Plastic “snap-on” caps shall be provided for all nuts. The galvanized steel must not come into contact with the water.

Mastic joint sealer shall be able to resist the acid and alkalinity specified above. A certificate for the mastic sealer shall be provided. Excess mastic on the outside of the tank must be cleaned off to the satisfaction of the Engineer. For specification of epoxy coatings and their application refer to Module 11.
3.35 **Drip Emitters**

All drip emitters shall be pressure compensating, made of rigid, black, ultraviolet resistant plastic.

Drip emitters in hydroseeded areas shall be fitted with dust caps. Drip emitters for trees and shrubs buried below gravel can be installed without dust caps if documentation for clog-free operation meets the approval of the Engineer.

Emitter outlets shall be pressure compensating and have the following flow rates when working in the pressure range of 1 to 2.7 bar.

<table>
<thead>
<tr>
<th>Nominal flow</th>
<th>Minimum Flow</th>
<th>Maximum Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>l/h</td>
<td>l/h</td>
<td>l/h</td>
</tr>
<tr>
<td>2.0</td>
<td>1.8</td>
<td>2.5</td>
</tr>
<tr>
<td>4.0</td>
<td>3.8</td>
<td>4.5</td>
</tr>
</tbody>
</table>

The emitters shall be designed for insertion into a pre-cut hole in 15 mm (1/2”), 18 mm (5/8”) or 22 mm (3/4”) emitter lines.

Holes cut in the emitter lines must be made by a special tool for this purpose and based on emitter manufacturer’s specification. If water leaks from the hole during operation of the emitter, the emitter lines shall be rejected. The emitters shall flush at the start and end of each irrigation cycle and be continuously self-flushing. The emitters shall not be dislodged from the emitter lines below 4 bar.

3.36 **Solenoid Valves**

The solenoid valve may be a combination type of pressure regulating/electric remote control valve with manual open/close control. The pressure regulating valve and electric control valve may also be separate valves.

The body and cover of the valve shall be glass filled nylon with spring of stainless steel. The cover shall be fixed with stainless steel bolts to mating brass body inserts for service without removal from the line. All internal parts shall be able to resist water with a pH value of 4.5. The valves shall be normally closed requiring the solenoid to open only when energized.

The flow control shall be non-rising stem with O-ring seal adjustable from outside for permanent throttling or complete closing of the valve.

The maximum working pressure is 9 bar, the inlet pressure varies from 3.7 bar to 7.5 bar, the outlet pressure shall be 2.7 bar with the rate of flow as specified. Pressure regulating valves shall maintain a constant downstream pressure regardless of fluctuations in demand.

All internal orifices shall be resistant against corrosion as well as clogging-free from deposits. Each control valve shall be equipped with an easily cleanable Y-strainer with screen openings according to the requirements of the control valve manufacturer.

3.37 **Hose Couplings**

Bauer couplings shall be 150 mm diameter quick fit hose connectors manufactured from mild steel and galvanized in accordance with BS EN ISO 1461.
4. PART 4 TRENCHES

4.1 Trench Excavation

Prior to commencing any excavation, the Contractor shall submit to the Engineer for approval his proposals for the provision of any necessary traffic control measures and the erection of safety barriers and night-time lighting. This shall not relieve the Contractor of any responsibility for complying with the requirements of the Police Department, local Municipality or any other Authority, and the Contractor shall make himself fully aware of these requirements prior to his submission to the Engineer. Barriers when moved for access shall be immediately replaced. Barriers shall be of uniform design, interlockable and ballasted.

Before opening a section of trench, the Contractor shall satisfy himself that the line of the trench is clear of underground obstructions by excavating trial holes on the line of the trench.

Trenches shall be excavated to the lines shown on the Drawings and to levels that will allow for the pipe wall thickness and bedding thickness, if any. Trenches shall not be excavated more than 50 m in advance of pipe laying without the prior agreement of the Engineer and shall be of a width which complies with the criteria laid down below.

Sight rails shall be set up and fixed securely into the ground and maintained at intervals not exceeding 25 m. A minimum of three sight rails shall be maintained for every length of trench being excavated to one grade.

The widths of trenches shall be:

<table>
<thead>
<tr>
<th>Nominal internal Diameter (mm)</th>
<th>Minimum Distance from inside of Pipe Wall to trench Wall (mm) for Narrow Trench Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid pipes</td>
<td>Flexible pipes</td>
</tr>
<tr>
<td>100 – 350</td>
<td>225*</td>
</tr>
<tr>
<td></td>
<td>300*</td>
</tr>
<tr>
<td>400 – 600</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>400</td>
</tr>
<tr>
<td>700 – 1,000</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>500</td>
</tr>
<tr>
<td>1,000 or greater</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>500</td>
</tr>
</tbody>
</table>

*Trench width not less than 750 mm for sewers, drains and laterals

In no instance shall there be less than 150 mm clearance between the barrel of the pipe and the side of the excavation or timber or other sheeting, but the width measured between undisturbed faces of the trench sides at a level of 300 mm above the crown of the pipe shall not, unless approved or required by the Engineer, exceed the outside diameter of the pipe being laid plus 550 mm for pipes up to and including 800 mm diameter, and plus 750 mm for pipes over 800 mm in diameter. If the width of the trench exceeds the specified dimension or the trench supports move so as to disturb the ground in the trench side at or below crown level, the Contractor shall, at his own expense, extend the bedding to the full width of the trench. The Contractor shall be responsible for the disposal of surplus excavated material off site to an approved area.

If any loose, soft or bad ground is encountered, the Contractor shall report this to the Engineer and, where directed, shall excavate the same to a solid foundation and replace this with concrete or Class I fill material (as in Clause 4.5) or other approved fill, as directed, and generally in compliance with Modules 02 and 03.

The Contractor shall ensure that all excavation and trench side support is carried out in a careful manner, that it is rendered secure and safe, and that all necessary measures are taken to prevent the removal or falling-in of material beyond the trench dimensions detailed. The Contractor shall maintain all trench side support until the completion of the work to the satisfaction of the Engineer and shall promptly remove any material which has collapsed into the
excavation. Except where described in the Contract or approved by the Engineer, excavations shall not be battered.

The Contractor shall protect his excavation with suitable supports where such support is necessary to ensure the safety of the workmen, the integrity of adjoining structures and work generally. The Contractor shall provide calculations showing adequacy of the trench support. Where soft ground conditions and/or adjacent property stability considerations require, the Contractor shall permanently leave steel sheet piling, plain or interlocking steel sheeting or timbering in excavations, trenches or headings in agreement with the Engineer.

A clear space of a minimum of 2 m or greater if instructed by the Engineer shall be left between the edges of excavations and the inner toes of spoil banks. No construction, vehicles or other heavy machinery is permitted to operate within this clear space.

When a void occurs between the sides of the excavation and the trench supports, this shall be filled with loose (free of fine material) granular sand or aggregate well-compacted in 200 mm layers up to ground level immediately after the final positioning of the trench supports. Backthrowing shall not be allowed and all materials shall be brought to the surface and formed in heaps clear of the excavation.

Where two pipes are to be laid side by side in the same trench, but at different levels, the excavation shall first be taken down to a level 200 mm above formation level for the upper pipe; the excavation for the lower pipe shall then be carried out and the lower pipe laid, jointed and completed; backfilling shall then be carried out up to formation level of the upper pipe, the remainder of the excavation for the upper pipe completed, and the laying of the pipe completed. Unless otherwise approved by the Engineer, sewers shall be laid from the downstream end. Chamber locations shall be staggered where gravity pipelines are laid in the same trench.

Except where indicated elsewhere in the Contract, the minimum depth to the top of pipes shall be 1,200 mm under roads and other trafficked and hard standing areas and 900 mm elsewhere.

All flexible pipelines will be subjected to in situ deflection measurements, firstly after placing and compaction of the surrounds and secondly not less than four weeks following completion of backfill. Any section of pipe failing to meet the deflection criteria defined in the table below shall have its surround material re-compacted, such procedure being repeated until the in-situ pipe is found to satisfactory. Pipes will be regarded as damaged and shall be removed from the trench and condemned if their in situ deflection at any time exceeds the values stated in the table below. Such pipe shall be removed from site and shall not be used in any part of the Works.

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>SDR ((^{(a)}))</th>
<th>Permissible range (vertical diameter elongated only) after completion of surround</th>
<th>Maximum measured in any plane at any time more than four weeks after completing the trench backfill</th>
<th>Deflection at which pipe is damaged and not to be re-used</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC-U/PE</td>
<td>10–15</td>
<td>0–1</td>
<td>1</td>
<td>2.25</td>
</tr>
<tr>
<td>PVC-U/PE</td>
<td>15–25</td>
<td>0–1.5</td>
<td>2</td>
<td>3.75</td>
</tr>
<tr>
<td>PVC-U/PE</td>
<td>25–35</td>
<td>0–2</td>
<td>2.5</td>
<td>5</td>
</tr>
<tr>
<td>PVC-U/PE</td>
<td>&gt; 35</td>
<td>0–2.5</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>RTR</td>
<td>30–40</td>
<td>0–1.5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>RTR</td>
<td>40–50</td>
<td>0–2</td>
<td>2.5</td>
<td>5</td>
</tr>
<tr>
<td>RTR</td>
<td>&gt; 50</td>
<td>0–2.5</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>DI</td>
<td>&lt; 55</td>
<td>0–0.5</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>DI</td>
<td>55–70</td>
<td>0–0.5</td>
<td>0.5</td>
<td>2</td>
</tr>
<tr>
<td>DI</td>
<td>71–90</td>
<td>0–0.5</td>
<td>0.75</td>
<td>2.25</td>
</tr>
<tr>
<td>DI</td>
<td>&gt; 90</td>
<td>0–0.5</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

---

**(a)** See Table 8 - Deflection Criteria for Flexible Pipes.
Footnotes:
(1) “Deflection Criteria” is defined as the maximum difference between the measured in-situ diameter and the stated non-deflected diameter on any axis, divided by the non-deflected diameter.

(2) “SDR” is the Standard Dimension Ratio which is defined as the pipe diameter (measured at midpoint of wall) divided by pipewall thickness.

4.2 Pumping and Dewatering

Excavations shall be kept free from water at all times and adequate pumping plant, including special dewatering equipment, shall be provided together with means of conveying away the pumped water from excavations. Sumps, when used, shall be formed clear of excavations for permanent works. Silt traps shall be provided unless directed otherwise by the Engineer.

The Contractor shall submit details of his proposed dewatering methods to the Engineer for approval. All dewatering will be subject to relevant discharge approvals.

4.3 Sub-Drains

If necessary for the construction of the Works, the Contractor shall lay sub-drains, where directed, to convey the water to pumping sumps or soakaways. Sub-drains shall be laid unjointed with the invert not less than 300 mm below the formation level of the permanent works, and shall be covered with gravel to formation level. The Contractor shall ensure that these drains are kept free from silt. The pipe materials for sub drains shall be to the approval of the Engineer.

4.4 Trenches under Roads

The Contractor shall satisfy the Engineer as to the proper consolidation of all backfilling in trenches. Any subsidence shall be made good and the trench thoroughly tested by rolling to the Engineer’s satisfaction. Damage to the road or surfaced area foundation or surface due to subsidence of trench filling shall be made good at the Contractor’s expense.

The Contractor shall close sheet and adequately support all trenches across existing roads. Care shall be taken by the Contractor to ensure that existing roads and services are not damaged by road crossing operations and that the safety of the workforce and general public is maintained. Loss of surface due to inadequacy of trench support will be Contractor’s responsibility.

The standards and methods of trench backfill and compaction shall be as specified and be to the written approval of the Engineer.

Backfill materials more than 300 mm above the tops of ducts and pipes and all materials around and over manholes, soakaways, and so on, shall be well compacted in approved layers by mechanical compactors so that a minimum 95% relative compaction is achieved throughout.

Where trenches have been cut through existing paved roads the trench backfill shall be brought up to formation level whereupon the pavement layers shall be reinstated and rolled to the Engineer’s satisfaction using similar approved materials, and generally in accordance with Module 19.

4.5 Material for Pipe Bedding and Trench Filling

Material to be used for pipe bedding and trench backfill (divided into Classes I, II and III ) shall be free from organic and perishable matter and shall be obtained from sources approved by the Engineer. They shall comply with the following particular requirements:
**Class I Trench Fill** shall be free-draining, rounded, granular material consisting of natural gravel or similar material.

For pipes up to and including 300 mm, the nominal size shall be 10 mm; for pipes exceeding 300 mm but not exceeding 900 mm diameter, the nominal size shall be 14 mm; above 900 mm diameter, the nominal size shall be 20 mm. The overall grading shall be such that the material shall have a Compaction Fraction of 0.10 or less.

**Class II Trench Fill** shall consist of approved granular material obtained from excavations or borrow pits and shall exclude stones larger than 25 mm in size. The material shall be capable of being compacted to a stable mass and shall achieve a laboratory CBR of 20% after 96 hours soaking, when compacted to 95% of the laboratory maximum dry density tested in accordance with BS 1377: Part 1.

**Class III Trench Fill** shall consist of approved granular material obtained from excavations or borrow pits, shall be capable of being compacted to a stable mass and shall achieve a laboratory CBR of 20% after 96 hours soaking when compacted to 95% of the laboratory maximum dry density.

Where separate bedding material is required for pressure pipes up to and including 300 mm diameter, it shall consist of Class I Trench Fill.

4.6 **Bedding for Pipes**

Unless directed otherwise by the Engineer, should any trench invert be over-dug, it shall be made good with the class of material specified for the layer immediately overlaying it.

If any bedding material is damaged by water, sewage, collapse of trench sides or in another way, it shall be removed from the trench and replaced with new material before any pipes are laid or re-laid.

The required bedding and surround for rigid pipes shall conform to one of the following three categories:

- **Class B bedding** shall comprise a Class I Trench Fill bed at the base of the pipe with a Class II Trench Fill surround to the sides and the crown.

- **Class G bedding** shall comprise a full Class I Trench Fill surround to the pipe. The minimum thickness of fill material shall be 150 mm.

- **Class Z bedding** shall comprise a full mass concrete bed and surround as specified, and generally in accordance with Module 2.

The category of bedding used in the Works shall be as noted on the Drawings or instructed by the Engineer.

Where Class Z bedding is required, the backfill shall not be commenced until at least twenty-four hours after the placing of the concrete has been completed. Heavy rammers shall not be used nor shall traffic loads be imposed until at least seventy-two hours after concreting, or as directed by the Engineer.

Where Class B or Class G bedding is required, the bedding material shall be hollowed out to receive the sockets and allow proper jointing and wrapping. The bedding shall be completed to the required level and compacted such that the pipes are evenly supported over their entire lengths.

Bedding for pipes shall be constructed by spreading and compacting material over the full width of the trench.
The flexible pipe shall be bedded and surrounded strictly in accordance with ASTM D2321. Backfill from the pope bedding up to 300 mm above the top of the pipe is critical for the successful performance of the pipe. It provides necessary structure support to the pipe and controls pipe deflection. Therefore, special care should be taken in the placement and compaction of the backfill material. Special emphasis should be placed upon the need for obtaining uniform backfill material and uniform compacted density throughout the length of the pipe so that unequal pressure will be avoided. Extreme care should be taken to insure proper backfill under the pipe in the haunch zone. The backfilling details are shown on the typical drawing.

The surrounding backfill shall be placed across the entire width of the trench and shall maintain a minimum depth of 300 mm above the pipe. A minimum of 24 hours shall elapse prior to backfilling the remaining portions of the trench with other backfill material.

In the selection of appropriate backfilling material, consideration should also be given to possible migration of fines from adjacent native soil materials into backfill. Where potential for such migration exists, separation geotextile shall be installed between the native soil and the backfill. The geotextile should be approved by the Engineer.

Where directed by the Engineer the geotextile shall be supplied in rolls to widths to suit the work. After excavation and trimming to the required profile the filter fabric shall be unrolled over the prepared formation care being taken in the case of trenches to ensure that the material is dressed well into the sides and bottom of the trench so that subsequent placement of the filter or fill material does not impose strain on the fabric or cause it either to tear or to pull away from the trench side leaving voids. Joints or laps between successive sheets shall be formed in accordance with the manufacturer's instructions.

No vehicles will be allowed to run over filter fabrics.

Any damaged sections shall be cut out and removed, and after restoration of the surfaces to its required formation, replaced with the new fabric overlapping the undisturbed and undamaged sections by a margin of 500 mm at any point.

4.7 Backfilling to Pipes

During placing or compaction of backfill, the Contractor shall take all precautions necessary to prevent movement or flotation of pipes.

The side fill shall be placed and compacted as soon as possible after pipe-laying and testing, or as soon as it is safe to do so without damaging concrete beddings or surrounds.

Timbering or sheeting shall be withdrawn progressively as filling proceeds where practicable to ensure that no voids are left in the filling.

Initial backfill shall be placed over the pipe as soon as possible to provide a protective layer of material, hand-compacted to a level 300 mm above the crown of the pipe. Remaining backfill shall then be placed and thoroughly compacted in layers not exceeding 200 mm thick.

Material shall not be dropped from an excessive height. Where required, water may be added to assist compaction.

Power operated rammers or other mechanical compaction equipment shall not be used within 300 mm of the top of the pipe.

Heavy mechanical equipment shall not be allowed to cross any pipeline until the trench has been completely backfilled and compacted.

4.8 Standards of Compaction

The standards of compaction of trench fill materials shall be as follows:
- **Well-compacted:** The material shall be compacted by mechanical means in layers not exceeding 200 mm compacted thickness. The density obtained in each layer shall not be less than 95% of the maximum dry density determined using Tests 13 and 15 of BS 1377 or as directed by the Engineer. Tests shall be carried out as instructed by the Engineer, up to a maximum of two tests per layer per 100 m of trench.

- **Hand-compacted:** The material shall be thoroughly compacted by hand in layers not exceeding 100 mm compacted thickness, using an iron rammer weighing not less than 4.5 kg. The density obtained in each layer shall not be less than 95% of the maximum dry density determined using Tests 13 and 15 of BS 1377 or as directed by the Engineer. Tests shall be carried out as instructed by the Engineer, up to a maximum of two tests per layer per 100 m of trench.

### 4.9 Concrete Surround

Concrete provided as a protective surround to pipes shall comply with the requirements for mass concrete as detailed in Module 02. Where pipes with flexible joints are used, concrete protection shall be interrupted over its full cross section at each joint by a shaped compressible filler consisting of 20 mm thick bitumen impregnated filler unless specified otherwise in the Contract. Such joint filler shall be provided at each pipe joint as indicated on the drawings unless directed otherwise by the Engineer.

### 5. PART 5 CONSTRUCTION OF PIPEWORK AND MANHOLES

#### 5.1 Pipework and Manholes – General

The Contractor shall construct pipelines, manholes and chambers to the lines and levels shown on the drawings and provide the materials in accordance with the Specification. Where there is no change in the diameter in the manhole, the invert shall follow the same gradient as the outgoing pipe.

All pipes, half-pipes, junctions, bends, fittings, and so on, shall be of first-class quality and obtained from an approved manufacturer.

#### 5.2 Concrete Stools, Anchor and Thrust Blocks

Except where welded steel pipelines or self anchoring joints are used, thrusts from bends and branches in pressure pipes shall be resisted by concrete thrust blocks cast in contact with undisturbed ground. Concrete stools, anchor and thrust blocks, and other supports for pipes shall be cast in situ or fixed after the installation has been finally positioned to the lines and levels shown on the drawings but before loading or charging the installation.

Unless otherwise directed by the Engineer, concrete shall be cast directly against the undisturbed face of the trench excavation. The Contractor shall maintain correct clearances in order that bolts, nuts and joints may be tightened or removed after supports have been installed. The Contractor shall provide temporary supports pending the casting of fixing of permanent supports, fixings, fittings, anchors and stools. Any additional excavation required to accommodate thrust blocks shall be carried out after the bend or branch is in position and the thrust face shall be trimmed back immediately prior to concreting.

Where thrust blocks are cast against flexible pipes the pipe shall, prior to concreting, be wrapped with 2 layers of an approved tape of minimum thickness 1.15 mm applied with 50% overlap.

All bends and stop-ends on pressure mains shall be securely anchored by concrete placed between the bend or stop-end and the solid undisturbed vertical face of the trench. The concrete shall be as detailed on the drawings.
If directed by the Engineer, the Contractor shall provide detailed drawings and calculations of his proposed supports and thrust blocks for approval.

Unless otherwise directed, thrust blocks shall be allowed to develop adequate strength with a minimum setting time after casting of 24 hours before any pressure is applied to the pipeline.

5.3 **Unloading and Laying out Pipes**

Pipes and specials shall be unloaded with great care to avoid breakages and allow inspection of their state on arrival. If they are shipped in packs or pallets, each pack or pallet shall be lifted individually with suitable lifting equipment. If the pipes have to be unloaded singly and by hand, this shall be done by means of skids and check ropes and no pipes shall be dropped or allowed to roll unchecked. Pipes shall not be allowed to roll together and shall be wedged to prevent further movement. The Contractor shall submit the manufacturer’s proposals for unloading, stacking and laying out pipes.

PVC-U pipes shall be uniformly stacked along the pipe length and shall be given side support. Stacks shall be limited to 1 m in height or 4 layers; whichever is the lesser. Pipes shall be stored completely in the shade at all times.

Pipes or specials shall not be laid out in such a manner as to impede traffic, or obstruct paths or accesses to properties. Pipes or specials shall not be laid out in beds of ditches; every precaution shall be taken to preserve their cleanliness before laying.

All pipes and specials shall be carefully examined before laying and any damage to the pipe coating or lining shall be made good to the approval of the Engineer.

Before the trench is backfilled, the pipes shall again be inspected by the Engineer and any further damage caused to the coating during laying shall be made good and written approval from the Engineer given of the repair.

5.4 **Laying and Jointing Pipes**

All pipe systems shall be laid to true and even falls and to the lines and levels shown on the drawings. The Contractor shall supply and fix all necessary bends, tees, tapers, valves and other specials, and shall carry out all necessary cutting, coring, drilling holes, jointing and connecting to new and existing work.

Pipes shall be kept free from mud, debris and other obstruction during laying and until handed over, and suitably sized stoppers shall be used to block up the ends of all pipes, junctions, and so on, while preparing the trench for the next pipe or after working hours. The excavation shall in all cases be carefully completed at least 6 metres but not more than 50 m in advance of the laying of the pipes, unless agreed otherwise by the Engineer.

Where ground water is encountered, it shall be kept below the formation level of the trench.

Before laying, each pipe shall be brushed out and examined for any damage. Damaged pipes shall not be used.

Each pipe shall be carefully lowered onto the prepared bed by means of the necessary slings and tackle. If the prepared bed is damaged and if stones are dislodged into the trench, the pipe shall be raised and the bed made good and stones removed before pipe laying is continued.

All pipes except HDPE shall not be jointed before being lowered into the trench.

Joint lubricants for sliding joints shall have no deleterious effect on either the joint rings or pipes, and be unaffected by the liquid to be conveyed.

No pipe or pipeline may be used for trench drainage purposes without the permission of the Engineer.
Where pipes with flexible joints are required to be laid to curves, the deflection at any laid joint shall not exceed two thirds of the maximum deflection recommended by the manufacturer.

Between adjacent manholes, the total length of pipeline shall remain uncovered until it has been inspected and satisfactorily tested. Such inspection shall not relieve the Contractor of his responsibility for delivering the whole of the Works in a watertight, correct and perfect condition.

No pipe shall be covered up until it has been inspected and satisfactorily tested as specified.

Unless otherwise approved by the Engineer, sewers shall be laid from the downstream end with the pipe sockets facing upstream.

Where pipes are built into manholes, pits, chambers, thrust blocks and other firmly-founded structures, at changes in class of pipe bedding and at other locations where differential settlement can be expected, a flexible joint shall be provided as close as is feasible to the outside face of the structure and a second pipe (rocker pipe) provided as set out below in Table 9:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>First Pipe (maximum length projecting)</th>
<th>Second Pipe (rocker pipe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 to 600</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>600 to 750</td>
<td>450</td>
<td>1,000</td>
</tr>
<tr>
<td>Larger than 750</td>
<td>450</td>
<td>1,250</td>
</tr>
</tbody>
</table>

Pipe shall be installed in accordance with the manufacturer’s recommendations. Pipe shall be checked before being lowered into the trench to ensure that no manufacture’s defects or cracks exist that might prevent jointing of the pipe or its operation. The open end of the pipe in the trench shall be suitably covered to prevent entrance of trench water. Precautions shall be taken to ensure that displacement of the pipe in the trench does not occur through soil displacement or floatation due to the pressure of trench water. Pipe that has been displaced shall be removed from the trench and re-laid at the contractor’s expense.

Unless otherwise authorized by the Engineer, the laying of pipe on the bedding shall be started at the downstream end and shall proceed toward the upstream end. The minimum clear distance between the outer surfaces of adjacent pipes in case of multiple installation of HDPE shall be equal to 600 mm.

Where HDPE corrugated pipes are embedded in manhole walls, the minimum embedded length of pipe shall be 2 multiplied by the corrugation pitch or the lengths given in the table below, whichever is the greater. A hydrophilic sealing ring shall be placed around the pipe within the manhole wall, to ensure a watertight seal.

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter (mm)</th>
<th>Minimum Embedded Length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>75</td>
</tr>
<tr>
<td>250</td>
<td>85</td>
</tr>
<tr>
<td>300</td>
<td>100</td>
</tr>
<tr>
<td>350</td>
<td>120</td>
</tr>
<tr>
<td>400</td>
<td>150</td>
</tr>
<tr>
<td>500</td>
<td>175</td>
</tr>
<tr>
<td>600</td>
<td>200</td>
</tr>
<tr>
<td>700</td>
<td>200</td>
</tr>
<tr>
<td>900</td>
<td>275</td>
</tr>
</tbody>
</table>
5.5 Protection of Pipe

No heavy construction equipment shall be permitted to traverse the pipe trench until a minimum depth of cover above the pipe has been established. Unless otherwise specified, the minimum depth of cover shall consist of fill compacted to a depth of at least one pipe diameter above the pipe. Prior to adding each new layer of loose backfill material, until a minimum of 30 mm of cover is obtained, inspection shall be made of the inside periphery of the structure for local or unequal deformation caused by improper construction methods. Evidence of such shall be reason for such corrective measures as directed by the Engineer. Pipe damaged by the contractor shall be removed and replaced at no additional cost to the Ministry.

5.6 Cutting Pipes

Pipes shall be cut by a method which provides a clean square profile, without splitting or fracturing the pipe wall, and which minimizes damage to any protective coating. Where necessary, the cut ends of pipes shall be formed to the tapers and chamfers suitable for the type of joint to be used and any protective coatings shall be made good. Spigot ends shall be prepared for reuse in accordance with the manufacturer’s instructions.

Where GRP or ductile iron pipes are to be cut to form non-standard lengths, the Contractor shall comply with the manufacturer’s recommendations in respect of ovality correction and tolerances to the cut spigot end. Where concrete pipes are cut, any exposed reinforcement shall be sealed with an approved epoxy resin mortar.

5.7 Junctions

The Contractor shall install junctions where directed. Before the trench is refilled, he shall make accurate measurements of the distance from each junction to the centres of the nearest manholes upstream and downstream, and record the invert level of the branch and shall furnish this information to the Engineer, with details of the size and direction of the branch.

5.8 Constructing Manholes and Chambers

The Contractor shall build-in pipes and form grades as directed. Short pipes, as specified elsewhere, with flexible joints shall be used immediately adjacent to manholes and chambers. Benching shall include a surface layer of acid resistant epoxy mortar at least 25 mm thick or GRP lamination of minimum 5 layers. Benching shall be left completely smooth.

The concrete in walls and surrounds shall be formed using properly constructed formwork. Manholes and chambers shall be constructed concurrently with the adjacent pipe lengths. Where flexible pipes are to be cast into concrete, the Contractor shall submit his proposals for ensuring flexibility.

After the concrete has hardened sufficiently and the protective tanking has been completed, selected material shall be carefully filled and rammed behind the concrete and compacted in accordance with the requirements of the specification.

All manholes and chambers shall be watertight to the satisfaction of the Engineer. The Contractor shall thoroughly clean out and flush manholes with clean water.

Sulphate resisting brickwork, where detailed under manhole covers and frames, shall be solid concrete bricks generally in accordance with BS EN 771. The standard block shall be 190 mm x 90 mm x 65 mm high with a minimum compressive strength of 40 N/mm²; unless shown otherwise.

Manholes shall be constructed concurrently with the laying of the adjacent pipelines.

5.9 External Protection of Manholes and Chambers

The external faces of manholes and chambers shall be protected in accordance with Clause 2.4.
5.10 Internal Protection of Manholes and Chambers

Unless described elsewhere in the Contract, the internal faces of manholes and chambers shall be protected by an epoxy resin coating except where a GRP liner is provided.

The epoxy resin coating shall be a two component 100% solids solvent free and pitch extended material. The material shall be applied in at least two coats to give a total of dry film thickness of at least 400 microns.

The surface preparation fillers and coating shall only be applied on shaded surfaces.

Surface preparation shall include an epoxy resin fairing coat applied in accordance with manufacturer’s instructions.

The coating shall be heavy duty, waterproof, and flexible. It shall be abrasion resistant and have demonstrated resistance to sulphuric acid and chemicals present in the sewage treatment environment.

The final surface shall be smooth and pinhole free.

Material test requirements are as follows:

<table>
<thead>
<tr>
<th>Material Strength Criteria</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond Strength</td>
<td>2.4 N/mm²</td>
</tr>
<tr>
<td>Reduction in chloride ion penetration (diffusion cell method)</td>
<td>More than 98%</td>
</tr>
<tr>
<td>Able to bridge crack of width at least</td>
<td>0.25 mm</td>
</tr>
<tr>
<td>Water absorption (ASTM D570)</td>
<td>Less than 0.01%</td>
</tr>
</tbody>
</table>

5.11 Puddle/Anchor Flanges

Where pipes are built through concrete walls, puddle/anchor flanges shall be provided. Cast-on or welded flanges shall be provided. This requirement shall apply to all concrete structures and chambers except manholes.

5.12 New Manholes on Existing Sewers

Where directed, the Contractor shall excavate down to and around existing sewers. Concrete foundations shall be formed under the existing pipe. A manhole shall be constructed on this foundation in accordance with the Specification and a new pipe laid from there to the new sewer.

The section of the existing pipe inside the new manhole shall then be carefully removed and new benching formed as specified. The ends of any disused pipes shall be sealed off with a concrete plug rendered over with acid resistant epoxy mortar 25 mm thick.

Care shall be taken to ensure that no materials from the excavation, or debris of any kind, enters the sewers during the construction of manholes.

The Contractor shall comply with the safety standards of the Client and Municipal Authority.

5.13 Sealing Future Connections

Vitrified clay or polypropylene stoppers of approved pattern with flexible joints shall be used to seal off the ends of all vitrified clay, GRP or PVC-U pipes left for future connections. Cast iron
caps shall be used to seal off the ends of all iron pipes and asbestos cement pipes for future connections.

5.14 Connections to Sewers

No sewage shall be discharged to new sewers until the whole of the Works are completed to the satisfaction of the Engineer except that where a substantial part of the scheme has been completed to his satisfaction, the Engineer may permit connections to such part of the scheme.

Care shall be taken to ensure that no materials from the excavation or debris of any kind enters the existing or new sewers whilst connections are being made.

The alignments and elevation of the connection pipes and chambers of manholes shall be determined by the Engineer.

6. PART 6 TESTING

6.1 Testing General

The Contractor shall ensure that all pipes, fittings, specials, and so on, are true to line and level and watertight to the satisfaction of the Engineer.

All of the pipelines and pipework shall be subject to water testing. The test procedure shall follow the general provisions. The contractor shall submit a method statement for the Engineer’s approval, covering details of his proposed methods and programme for testing including details of test equipment.

The Contractor shall supply all the necessary labour, blank flanges, anchors, air-valves, test pumps, gauges, clips, stoppers, and so on, for testing. Prior to use, the pressure gauge shall be tested at an approved independent testing laboratory and test certificates provided to the Engineer.

Water required for testing shall be obtained from an approved source. The pipeline shall be filled in such a way that the pipework is not damaged in any way. The Contractor shall supply and dispose of the water for testing.

The Contractor shall give the Engineer adequate notice in writing of his intention to test any pipeline (at least 24 hours for pressure pipelines). Testing shall not proceed until permission to do so has been received from the Engineer. Permission to test shall not imply approval of the method nor relieve the Contractor in any way of his responsibilities in connection with the Works.

All pipes shall be cleaned and tested as the work proceeds. If three months or more shall elapse between the final test and the pipeline being taken over, the Engineer may require the pipeline to be retested.

Pipes, fixtures and fittings which fail under test, or are broken by or found to be broken under test, or considered by the Engineer as a result of the test to be unserviceable shall be rejected and removed from the site forthwith and shall be replaced. Replacement shall be at the Contractor’s expense if, in the opinion of the Engineer, failure is due to the Contractor’s treatment, faulty installation of the component or inadequate inspection. After replacement the testing shall be repeated.

In the event of failure of a section of pipeline causing damage to any adjacent road, pavement, structure or existing service, the Contractor shall be liable for all remedial work necessary to restore the damaged item to its original condition.

On completion and prior to disinfection, if so required, pipes and specials shall be cleaned out and flushed with water, all silt, mortar, concrete debris and other obstructions being removed.
Such testing or inspection of any of the Works shall not be held to relieve the Contractor from his responsibility to deliver the whole of the Works in a sound and clean state, free from leakage and other defects under the maximum test or operating pressure, whichever is the greatest. Upon satisfactory testing of a pipeline or section of a pipeline the Contractor shall submit a test acceptance form in a format to be mutually agreed, for signature by the Engineer. This form shall be the true record of all acceptable tests. The Contractor shall retain one copy on site at all times.

6.2 Testing of Foul Sewers and Laterals

All sewers, junctions, risers, laterals, feed, washout and sludge pipes, and so on, up to and including 600 mm diameter shall be tested with air at the completion of each working day or when 20 m of pipe have been laid.

A gauge in the form of a glass U-tube shall be provided and air shall be blown or pumped into the length of pipes until a pressure equal to 125 mm of water is indicated on the gauge.

Without further blowing or pumping the pressure shall not have fallen below 100 mm after a period of 5 minutes. The pipes shall continue to withstand this pressure without further loss and without blowing or pumping for a further period of 5 minutes.

When a section of pipeline between manholes or such other sections as may be agreed by the Engineer or his representative has been completed, and whilst uncovered, the pipeline shall be tested with water at a minimum pressure equal to 3.0 m head of water or such pressures as the Engineer may determine both before and after backfilling.

When testing pipes with water or final effluent, the test pressure shall be applied at the upstream end of the test length, but in no case shall the resultant pressure at the downstream end exceed 6.0 m head, including the 3.0 m test head.

The test pressure shall be applied for a sufficient period to allow for initial absorption, and so on. The test shall then be carried out over a period of one hour, and the pressure restored to the test pressure by the addition of water at 10-minute intervals. On each test length the acceptance criteria shall be the addition of no more than 0.042 litres of water per hour per linear metre per metre of pipe diameter of the pipe under test, to maintain the test head.

The test head or pressure shall be maintained while the refilling of the trenches proceeds until there is a consolidation depth of 1,200 mm over the barrel of the pipes. Should the loss of head or pressure then exceed the maximum permitted, the Contractor shall excavate to the pipes and make good any defects to the Engineer’s approval, after which the test shall be repeated.

On completion of testing, in the case of pipes up to and including 450 mm diameter where a visual inspection is not possible, a wooden ball 25 mm less in diameter than the diameter of the pipe shall be passed through each length, or the pipeline proved to be clean and unblocked in another approved manner.

In addition to the above, all pipelines shall be inspected on completion to ensure that infiltration of ground water, where the pipeline is below the water table, does not exceed 0.042 litres per hour per linear metre per metre of pipe diameter for each manhole length.

Where directed, pipelines shall be re-tested by means of the air test or water test, as previously specified, at the time of final inspection before commissioning the pipelines, the type of test to be instructed by the Engineer.

6.3 Testing of PVC-U Pipelines

In addition to the other tests as described in the Contract, immediately after backfilling, a wooden ball 3% smaller than the pipe bore shall be passed through PVC-U pipelines. A further test using a wooden ball 5% smaller than pipe bore shall be carried out prior to the pipeline being put into service.
6.4 Testing of HDPE Pipelines

The amount of short and long-term deflections shall be in accordance with the maximum limits as specified below. No deflection is allowed at joints or couplings. All pipes more than 100 mm diameter shall be subjected to deflection test. The initial test shall be conducted by a deflectometer for pipe size equal to and less than DN 600 mm and by manual measurement or deflectometer pipe size greater than DN 600 mm.

The following cases for deflection tests are required:

Case (1) a deflection test to be carried out after placing of the surround material, and after withdrawal of trench sheeting to above the crown of the pipe, but before the backfilling. For the gravity pipe, the permissible percentage deflection will be accepted only as an elongation of the vertical diameter, and no reduction will be accepted at this stage.

Case (2) a deflection test to be carried out not less than four weeks after completion of backfilling.

Case (3) a deflection test to be carried out not less than 1 year after completion of backfilling, but prior to expiry of maintenance (guarantee) period.

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Case (1)</th>
<th>Case (2)</th>
<th>Case (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN 600 mm ≤</td>
<td>2.5</td>
<td>3.0</td>
<td>5.0</td>
</tr>
<tr>
<td>DN 600 mm &lt;</td>
<td>0.625</td>
<td>0.750</td>
<td>1.25</td>
</tr>
</tbody>
</table>

The mandrel shall have a cylindrical cross section, with a diameter not smaller than 1 mm less than the minimum acceptable pipe diameter, given in the table above.

Deflection shall be calculated as a percentage of the difference between the measured in-situ diameter (on any axis) and the stated non-deflected diameter, divided by the non-deflected diameter, pipe surround shall be removed from all sections of pipe failing to meet the specified deflection criteria.

- Undamaged pipes may be re-backfilled and tested again.
- All action taken to correct the pipe deflection shall be at the contractor’s expense.
- Pipes so rejected shall be indelibly marked, removed from the site and replaced at the contractor’s expense.

6.5 Light Test

The aim of this test is to verify alignment. A light shall be clearly visible between manholes and the visible image shall be a true circle with no more than a 2% or 10 mm (whichever is the greater) difference in image diameter from the actual pipe diameter.

6.6 Air and Water Tests

Pipe lines of 800 mm diameter and smaller shall be given an air test when the pipe is bedded and jointed but before backfilling and a water test after backfilling. Wherever possible, testing should be carried out from manhole to manhole.

6.7 Air Test

Air shall be pumped into the pipelines until a pressure of 100 mm head of water is indicated on a water manometer and the pressure shall not fall to less than 75 mm during a period of 5 minutes. The contractor will not be permitted to commence testing later than 4 hours after sunrise or earlier than 4 hours before sunset during the summer unless otherwise directed by the Engineer.
6.8 Water Test

The part of the pipe under test shall be filled with water under pressure to meet the following requirements:

<table>
<thead>
<tr>
<th>Depth to Invert</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 8 m</td>
<td>1.2 bar</td>
</tr>
<tr>
<td>8 m to 14 m</td>
<td>2.0 bar</td>
</tr>
<tr>
<td>Greater than 14 m</td>
<td>Greater of: 1 bar above ground water table or 2 bar</td>
</tr>
</tbody>
</table>

The test pressure shall be sustained for a period of 30 minutes and the volume of water required to maintain the test pressure shall be determined in an approved manner. The test will not be considered satisfactory unless it is maintained without leakage for at least 30 minutes. No leakage is allowed in this hydrostatic test. Any defects should be repaired and the pipeline should be retested.

All water required for testing and for cleaning the pipelines shall be potable water or irrigation water and shall be provided by the contractor, at his cost.

6.9 Infiltration and Exfiltration Tests

Pipes laid below the ground water table shall be subjected to an infiltration test. The measured infiltration shall not exceed 1 litre per hour per meter diameter per 30 m of length of pipeline under test. The infiltration test shall be conducted after dewatering activities have been suspended for at least 7 days. For any pipeline that fails, the contractor must propose measures to remedy the situation and execute such measures at his own cost to achieve compliance with the requirements. Infiltration and Exfiltration tests shall be done in presence of the Engineer or his representative.

6.10 Inspection of Pipelines by CCTV

Prior to commissioning or taking over, all pipelines shall be inspected by CCTV camera and a video recording survey. The contractor shall prepare a report of the pipelines in an approved format to the satisfaction of the Engineer. Both the report and the video recording shall become the property of the Ministry of Works. The contractor shall repair all defects identified by the CCTV inspection at his own cost. The engineer may require re-inspection of the pipe. Pipelines with internal diameter greater than 1,800 mm shall be inspected from inside by trolley. The contractor shall provide a suitable trolley, ventilation and safety equipment and any other plant and labour necessary for this purpose if required by the Engineer. CCTV inspection is not a substitute for the deflection test. The Engineer may require a combined CCTV and Sonar system unit to check the pipe wall and the surrounding soil.

Testing of pipelines shall in all cases be carried out in the presence of the Engineer or his representative. The contractor should note that 10% of the total installed cost (pipe, bedding, backfill, and testing) shall be withheld until the completion of all tests of the installed flexible pipe.

Upon completion of the pipelines, the Contractor shall, if instructed to do so, flush the line and undertake a CCTV inspection survey.

The following equipment is required as a minimum:

- A CCTV colour camera with integral lighting unit. The camera shall be capable of operating in 100% relative humidity, and shall be fitted with a rotating mirror for complete
circumferential viewing. The system shall be capable of producing a clear and high quality picture of the entire periphery of the pipe on the monitor screen and recording tape.

- The camera and lighting unit shall be mounted on a self-propelled crawler or on skis linked to a manual or power operated winch.
- A monitor screen which displays the camera view during inspection. The monitor screen shall be housed in covered accommodation with facilities for inspection by the Engineer and others.
- A screen writer which displays on the monitor screen, details of the inspection including date, location, pipe material, diameter of pipe, direction of view, and comments on the condition of the pipe.
- A measuring device which displays the camera location automatically on the screen. The device shall be capable of measuring the location to within an accuracy of 0.1% of the length of the pipeline or + 0.3 m whichever is the greater.
- A control unit which controls camera movement, lighting intensity, focusing and recording.
- A VHS video recording system to record the inspection and information displayed on the monitor screen.
- A 35 mm SLR camera capable of producing photographs from the monitor screen.

The procedure shall be as follows:

- The camera shall be moved through the pipeline in the direction instructed by the Engineer at a speed not exceeding 0.15 m/s. If the camera cannot pass through the complete pipeline in one operation, the inspection may be carried out from both ends of the pipeline.
- The camera shall be stopped whenever instructed by the Engineer to allow inspection by the Engineer.
- The video system shall be operated during the complete inspection to provide a continuous record of the inspection and information on the monitor screen.
- If necessary the Contractor shall remove any debris and/or carry out any remedial work identified during the survey. Further additional CCTV surveys resulting from the need to clean out/carry out remedial work shall be undertaken until the pipeline is approved for commissioning by the Engineer.
- Photographs of the monitor screen shall be taken whenever instructed by the Engineer.
- A record of the inspections shall be kept by the Contractor on site, and a report (two copies) shall be submitted to the Engineer within 3 days of completion of the inspection. The report shall contain a summary only of the condition of the pipeline.

The following items shall be submitted at the same time as the report:

- Final video film providing a continuous record of the last inspection and information on the monitor screen. The format of the film shall be confirmed by the Engineer.
- Photographs of the monitor screen, including date and chainage. The photographs shall be colour, 3R size, and mounted in photograph albums.

### 6.11 Manhole Testing

The contractor shall test 10 percent of all the manholes, to be selected by Engineer. Manholes shall be hydrostatically tested to at least one meter above the crown of the highest connection into the manhole being tested. The selected manholes shall be considered satisfactory if, there shall be no fall in level over a period of 24 hours and no visible leak. Should a manhole fail to pass, it shall be repaired and retested. All costs associated with testing and repairs shall be bared by the contractor.

The contractor should note also that neither the satisfactory testing of a pipeline, section of a pipeline or any other pipe work, nor the acceptance of any test by the engineer or his representative, shall in any way relieve the contractor of any of his responsibilities and obligations under the contract.
6.12 Testing of Pressure Pipelines

Before backfilling, pressure pipework shall be hydrostatically tested in accordance with BS EN 805. Cement lined pipes shall be kept at working pressure for a continuous period of 24 hours prior to carrying out of the test.

Sections for testing shall be in lengths approved by the Engineer. The Contractor shall submit his proposals for pressure testing prior to commencement of pipe laying. Road crossings and other short sections of pipe installed independently of main runs shall be tested separately. Testing shall follow immediately upon pipe laying and, upon satisfactory completion of the test, shall be backfilled so that tested lines are not left exposed.

Test pressure measurements shall be made at the lowest point of the pipeline section under test.

The Contractor shall completely fill the section of pipeline under test with potable water or where approved final effluent or raw water, expelling air from the pipe. Before applying the test pressure, air valves shall be isolated from the main to avoid damage to the floats. Testing against valves is not permitted unless directed by the Engineer.

During the test, water shall be added if the pressure drops, the test pressure restored, and the amount added shall be recorded. On each test length the acceptance criteria shall be that the amount of water added does not exceed 0.1 litre/mm of diameter/km of length/24 hours/30 m of head. Where pumping is required to maintain the pressure it shall be done at 30 minute intervals.

Following successful testing of all sections, the pipeline in its entirety shall be re-tested to the same test pressure as for the individual sections.

6.13 Test Pressure for Valves

Gate and check valves shall be tested to the test pressure of the main in which they are situated or to the maximum pressure rating of the valve, whichever is the greater. The test shall be sustained for 30 minutes. Valves shall be works tested and independently certified. Air release valves shall withstand a test pressure of 16 bar. They shall be works tested and independently certified. Test pressures may be lower where specified by the Engineer.

6.14 Flushing of Pipelines

Before the pipeline is put into service it shall be flushed at washouts and valves, and so on, to ensure complete freedom from obstructions and debris. Unless directed otherwise by the Engineer, the Contractor shall provide the water for flushing which shall be of potable quality.

6.15 Testing Water Retaining Structures

Concrete tanks to be tested shall be filled, to a test level about 75 mm below the overflow sill, and left to stand for at least 2 days to allow for absorption into the concrete. The water level shall then be measured and recorded using a hook gauge with vernier control, or other approved means of no less accuracy, and the water allowed to stand under test for 4 days. At least once each day during this period, the water level shall be measured and recorded. During the 4-day test period, evaporation from the water surface shall be established, if the tank is open then an evaporation pan is suitable.

Any inflows or outflows shall be measured and recorded throughout the test, from a time at least 24 hours before beginning to fill, until 24 hours after emptying or on completion of a final water level measurement.

If the tank leaks, any leaks identified should be repaired and then the tank refilled and tested again until it passes the test, all at the Contractors expense.
Notwithstanding the satisfactory completion of the above test, any leakage visible on the outside faces of the structure shall be stopped. Any caulking or making good of cracks in the wall section shall, where practicable, be carried out on the inside face.

The Contractor shall provide all measuring equipment and other items necessary for testing.

Steel tanks shall be filled with water and all leaks shall be repaired at the Contractor’s expense. Water for testing the storage tank the first time shall be supplied by the Employer, unless otherwise stated in the tender Documents. All other costs in connection with testing the tank shall be borne solely by the Contractor.

The testing shall be in accordance with the manufacturer’s guidelines and a test certificate shall be provided by the Engineer.

7. PART 7 DUCTING

7.1 Ducts

Pipes, joints and fittings for exposed ducts for building services shall comply with the relevant provisions of the appropriate British Standard, as set out below:

<table>
<thead>
<tr>
<th>Type</th>
<th>British Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unplasticized PVC pipe</td>
<td>BS 3506</td>
</tr>
<tr>
<td>Hollow steel sections</td>
<td>BS EN 10210: Part 2</td>
</tr>
<tr>
<td>(greater than 150 mm OD)</td>
<td></td>
</tr>
<tr>
<td>Steel tubes</td>
<td>BS EN 10296</td>
</tr>
<tr>
<td>(not greater than 150 mm OD)</td>
<td></td>
</tr>
</tbody>
</table>

Pipes, joints and fittings for buried ducts shall have flexible mechanical joints and comply with the relevant provisions of the appropriate British Standard, as set out below:

<table>
<thead>
<tr>
<th>Type</th>
<th>British Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unreinforced or reinforced concrete</td>
<td>BS 5911 and BS EN 1916</td>
</tr>
<tr>
<td>Unplasticized PVC</td>
<td>BS EN 1401</td>
</tr>
</tbody>
</table>

7.2 Trenches for Ducting

The bottom of the trench shall be leveled, backfilled and compacted in accordance with the specification for pipes. If the duct run is on varying gradients, the bottom of the trench shall rise or fall gradually, and the change in slope shall not be greater than that given by the maximum permissible deflections at joints as specified by the duct manufacturer. Joint spacing may be reduced to a minimum of 600 mm to achieve the required curves or changes in direction.

7.3 Bed, Surround and Backfill to Ducts

The bedding and surround for ducts shall be in accordance with this specification and the drawings.
The bedding material shall be tamped around the duct to a depth of 300 mm above the crown for rigid ducts or 150 mm for flexible ducts, unless detailed otherwise. Filling above this level shall be approved excavated material free from large stones or sharp objects, and shall be compacted in layers. In multiple duct runs, the spaces between the ducts shall be filled with Zone 1 or 2 sand and compacted and the specified depth shall be achieved over the uppermost ducts. Surplus excavated material shall be disposed of.

7.4 Depth of Cover to Cable Ducts

The minimum cover between the road surface and the crown of the uppermost duct shall be as stated on the Drawings. If this cover cannot be achieved, the ducts shall be encased in concrete.

7.5 Laying of Cable Ducts

Cable ducts shall be laid to straight lines and at the levels shown on the Drawings, or as directed, and laid and jointed in accordance with this Specification and the recommendations of the manufacturer.

If ducts are to be laid to deviating lines, curves and slopes, the deflection at the joint of each duct shall not be greater than two thirds of the maximum permissible deflection recommended by the manufacturer. Joint spacing may be reduced to a minimum of 600 mm to achieve the required deviations.

Where ducts are built into drawpits, joint boxes and other structures, short lengths of duct shall be installed immediately outside the structure as specified in Clause 4.4.

7.6 Multiple Runs of Cable Ducts

Cable ducts in multiple runs shall be laid at the centres shown on the Drawings. The final jointing of ducts shall be made in the trench; the ducts shall be lowered and jointed singly and not in groups, and joints shall be staggered by approximately half the duct length in alternative lines.

7.7 Bellmouths

Electrical duct entries to drawpits, cable trenches and the like shall be provided with an approved bellmouth.

7.8 Cutting of Cable Ducts

Ducts may be cut as required for the work. Except where ducts enter a cable pit at an angle, cuts shall be made at right angles, using a cutting guide. The inside edges of cuts shall be rounded off and dressed to prevent damage to cables.

7.9 Proving of Ducts

The Contractor shall notify his intention to carry out proving tests on ducts. Cable ducts shall be cleaned on completion by passing a mop or pig of appropriate size through twice in each direction. Any obstruction found shall be removed and defects remedied. Ducts for a particular service shall be proved in accordance with the requirements of that particular service authority.

7.10 Draw Ropes

Cable ducts exceeding 3 m in length shall be provided with draw ropes of 8 mm diameter 3-strand hauserlaid polypropylene complying with BS EN ISO 1346. The length of draw ropes shall be such that not less than two metres of rope protrudes from each duct end. After the ends of ducts have been sealed the free ends of the ropes shall be securely attached to stainless steel loops cast in to the underside of concrete slabs.
7.11 Sealing of Ducts

As soon as a duct or set of ducts has been proved and draw ropes installed, the ends and bellmouths shall be stopped with approved split tapered hardwood plugs. Spare ducts shall then be sealed to a depth of 50 mm with approved mastic sealant or by other approved method, and a coat of bitumastic paint shall be applied over the seal. Remaining ducts shall be sealed similarly after installation of cable.

Immediately after sealing, both ends of ducts shall be marked with suitable stakes until permanent markers are installed.

7.12 Duct Markers

The Contractor shall provide, and fix to the road surfacing, markers to indicate the line of each duct. Duct markers shall be of aluminium, and shall clearly indicate the name of the Service Authority. The method of fixing shall be as specified for reflective road studs.

8. PART 8 MISCELLANEOUS

8.1 Warning Tapes

The Contractor shall install approved warning tapes during backfilling work over buried pipes, cables, conduits and ducts, as required.

Warning tape shall be approved high quality, acid and alkali-resistant polyethylene film 250 mm wide, with a minimum thickness of 150 microns. Tape shall have minimum tensile strength of 125 kg/cm² longitudinally and 105 kg/cm² laterally with an elongation factor of 350%. Where the service is of a non-magnetically detectable nature, approved metal-backed tape shall be used.

Tape shall be printed with 50 mm high black lettering, alternately in Arabic and English. Wording shall be as directed. The complete wordings shall be repeated every 2 m along the tape. The colours shall be vivid, glossy and permanent with a life expectancy of 40 years.

Warning tapes shall be placed with the inscriptions facing upwards. The level of the tape relative to the top of the service shall be in accordance with the requirements of the relevant Authority or as indicated on the Drawings.

Warning tapes shall be coloured and inscribed for identification as follows:

<table>
<thead>
<tr>
<th>Service</th>
<th>Colour</th>
<th>Inscription (English and Arabic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Ducts/ Cables</td>
<td>Red</td>
<td>‘CAUTION–BURIED ELECTRIC CABLE’</td>
</tr>
<tr>
<td>Telephone Ducts/ Cables</td>
<td>Green</td>
<td>‘CAUTION–BURIED TELEPHONE CABLE’</td>
</tr>
<tr>
<td>Potable Water</td>
<td>Blue</td>
<td>‘CAUTION–BURIED WATERMAIN’</td>
</tr>
<tr>
<td>Foul/Surface Water Rising Main</td>
<td>Yellow</td>
<td>‘CAUTION–BURIED RISING MAIN SEWER’</td>
</tr>
<tr>
<td>Foul/Surface Water Sewer</td>
<td>Yellow</td>
<td>‘CAUTION–BURIED GRAVITY SEWER’</td>
</tr>
<tr>
<td>Effluent/Treated Effluent</td>
<td>Black with white lettering</td>
<td>EFFLUENT RE-USE PIPE BELOW. NOT FOR DRINKING.</td>
</tr>
</tbody>
</table>

Where required by the relevant utility or authority, tiles shall be provided to their approval.
8.2 Marker Domes and Posts

8.2.1 Beside Roadways in Non-built-up Areas

In non-built up areas, beside roadways which do not have made up footpaths, a standard pre-cast dome should be installed with standard marker plates clearly indicating the name of the Service Authority which should be set into the domes. In general the spacing of such monuments or domes should be every 200 m or at major changes in direction or to coincide with any duct crossing markers.

8.2.2 In Open Country

In open country away from roadways a standard vertical marker post should be installed with standard marker plates clearly indicating the name of the Service Authority which should be set into the post. In general the spacing of such monuments or posts should be every 200 m or at major changes in direction.

8.3 Boring and Drilling

8.3.1 General Requirements

All works related to pipe jacking or directional drilling shall follow “A guide to best practice for the installation of pipe jacks and microtunnels” published by the Pipe Jacking Association, June 1995.

The Contractor is to propose the method statement. Prior to beginning work, the Contractor is to submit to the Engineer a work plan detailing the procedure and schedule to be used to execute the project. The work plan should include a description of all equipment to be used, downhole tools, a list of personnel and their qualifications and experience (including back-up personnel in the event that an individual is unavailable), list of subcontractors, a schedule of work activity, project quality plan, method statement and a safety plan including procedures of handling potentially hazardous material.

The Contractor shall practice due diligence to safeguard all environmental issues, and shall execute all works in a manner that complies with all regulatory, municipality, and federal requirements. In this regard, the site shall be protected against pollutant leaks into the sea and all other surrounding areas of work. Controlled items pertaining to this requirement include bentonite, oils, waste, and all other liquids, solvents, solids, and so on, that may be harmful to marine life and/or agricultural outcrops.

8.3.2 Pipe Jacking

Excavation for pipe jacking shall be undertaken from within a shield equipped with steering jacks for adjusting the alignment. Face boards shall be available for boarding up the exposed excavation.

The Contractor shall limit the jacking load applied to the pipeline such that damage to the pipes is avoided, and in this connection, he shall be responsible for deciding whether an intermediate jacking station is needed.

The jacking load shall be transferred to the pipes through a thrust ring, which shall be sufficiently rigid to ensure even distribution of the load.

The pipe manufacturer’s described permitted draw or angular deflection in relation to Table 6 of BS 5911: Part 1 and BS EN 1916 shall not be exceeded at any individual joint.

The Contractor shall maintain up-to-date records of jacking loads and line and level measurements. A graphical relationship between the jacking force and the distance moved shall
be produced to ensure that the necessary measures are taken to avoid exceeding the maximum permitted jacking forces.

All lifting holes and grouting holes shall be sealed.

Unless otherwise required by the Contract, joint packing material designed to distribute the jacking load evenly shall be inserted at, and between, the pipe ends and at any intermediate jacking stations.

Before work may start on any thrust pit, the Contractor shall demonstrate that the design will withstand the maximum jacking force of which the jacks are capable.

Before a particular pipejack may commence, evidence shall be provided that the pipes necessary for completing the jack are on site or in storage elsewhere. The envisaged number of intermediate jacking stations shall be agreed in advance of commencement. At least one intermediate jacking station assembly shall be available at the start of the pipejack unless otherwise agreed.

Pipes including lead pipes, which have been jacked through a pipejack shall not be used elsewhere on the Works. Cut pipes shall not be jacked.

Installed joints shall be prevented from opening when the jacking loads are removed.

On completion of the drive, intermediate jacking stations shall be left fully closed. All jacks, props, thrust rings and packing shall be removed, the ends of the pipes cleaned, a new packing ring glued to the receiving face and the joint jacked partly closed. An "O" ring seal shall then be inserted into the sliding joint and the joint jacked fully closed. The order of closing the stations shall be from the tunnelling shield working back.

The annular space between the sides of the excavated tunnel and the jacking pipes shall be constantly filled with an approved lubricant at a pressure that will support the adjacent excavation. Daily records of the quantity of lubricant used for each length of pipe thrust and the point at which the lubricant was injected shall be submitted to the Engineer. The lubricant shall be thoroughly mixed prior to pumping or placing. On completion of the pipejack, the annulus shall be filled by displacing the liquid with grout.

Specifications on material to be used shall be submitted to the Engineer. Material shall include the pipe, fittings and any other item which is to be an installed component of the project.

8.3.3 Thrust Boring

The work specified in this section consists of furnishing and installing underground utilities using microtunnelling or thrust boring. This work shall include all services, equipment, materials, and labour for the complete and proper installation, testing, restoration of underground utilities and environmental protection and restoration.

The above specified conditions shall apply except as amended in this part.

All references to a shield equipped with steering jacks shall not apply. Unless otherwise approved, intermediate jacks are not permitted.

8.3.4 Directional Drilling

The work specified in this section consists of furnishing and installing underground utilities using directional drilling, directional boring or guided horizontal boring. This work shall include all services, equipment, materials, and labour for the complete and proper installation, testing, restoration of underground utilities and environmental protection and restoration. In addition to the requirements below, the general requirements specified above shall be followed.
The Contractor shall provide a comprehensive set of prequalification documents to the Client and Engineer, clearly indicating that he has executed similar works successfully in the Gulf region. The completed project details shall include project titles, Client, Engineer, and reference names.

The Contractor shall at all times keep accurate up to date records of all drilling operations, including all Pilot Holes, Reaming, and Pullback stages on the project.

Pilot hole drilling records shall include the following: project details including Client, Engineer, Contractor, date(s), drill pipe details, driller’s name, steering engineer’s name, mud motor details (if required), drill bit size, time of each drill pipe entry, azimuth, mud pressure, mud volumes, and depth. The Contractor will be free to add any other records as he sees beneficial for project quality records.

Reaming records shall include the following: project details including Client, Engineer, Contractor, date(s), reaming step size(s), times of reaming, mud pressure, mud volumes, and any other beneficial information the Contractor sees fit to suit the project quality records.

Pullback records shall include the following: project details including Client, Engineer, Contractor, date(s), pullback pressure(s), and time of each drill rod removed while pullback operation is in progress.

The Contractor shall submit specifications on directional drilling equipment, which shall include but not be limited to: drilling rig, mud system, mud motors (if applicable), downhole tools, guidance system, rig safety systems. Calibration records for guidance equipment shall be included. Specifications for any drilling fluid additives that the Contractor intends to use or might use will be submitted.

The directional drilling equipment shall consist of a directional drilling rig of sufficient capacity to perform the bore and pullback the pipe, a drilling fluid mixing, delivery and recovery system of sufficient capacity to successfully complete the crossing, a drilling fluid recycling system to remove solids from the drilling fluid so that the fluid can be re-used, a guidance system to accurately guide boring operations, a vacuum truck of sufficient capacity to handle the drilling fluid volume, and trained and competent personnel to operate the system. All equipment shall be in good, safe operating condition with sufficient supplies, materials and spare parts on hand to maintain the system in good working order for the duration of this project.

The drill head shall be steerable by changing the rotation of the head and shall provide the necessary cutting surfaces and drilling fluid jets.

A self-contained, closed, drilling fluid mixing system shall be of sufficient size to mix and deliver drilling fluid. The mixing system shall continually agitate the drilling fluid during drilling operations.

The drilling fluid shall be composed of clean potable water and appropriate bentonite mud. Water shall be from an authorized source with a pH of 8.5 to 10.0. Water of a lower pH or with excessive calcium shall be treated with the appropriate amount of sodium carbonate or equal. The water and additives shall be mixed thoroughly and be absent of any clumps or clods. No potentially hazardous material may be used in the drilling fluid.

The powder-form bentonite shall be thoroughly mixed and allowed to hydrate for a time long enough to avoid swelling while in the hole. The Contractor shall provide all mud mixing details in conformance with the bentonite manufacturer’s specifications and mixing guidelines, to the approval of the Engineer.

Mud motors shall be of adequate power to turn the required drilling tools without stalling. Should a mud motor not be required for completing the pilot hole drilling operation, then the Contractor shall provide the Engineer with other proposed downhole tools, including the proposed jetting and pilot head details.
Drill rods to be used on this project shall be minimum 90 mm diameter, Premium Grade, top quality S135, presented with up to date third party inspection reports, to the satisfaction and approval of the Engineer.

A guidance system, or proven gyroscopic system shall be used to provide a continuous and accurate determination of the location of the drill head during the drilling operation. The system shall be capable of tracking at all depths required for the crossing and in any soil condition, including hard rock. It shall enable the driller to guide the drill head by providing immediate information on the tool face, azimuth (horizontal direction), and inclination (vertical direction). The guidance system, unless otherwise specified or agreed with the Engineer, the guiding shall be accurate to ± 2% of the vertical depth of the borehole at sensing position at depths up to 30 m and accurate within 1.5 m horizontally.

The guidance system shall be of a proven type and shall be operated by personnel trained and experienced with this system. The Operator shall be aware of any magnetic anomalies on the surface of the drill path and shall consider such influences in the operation of the guidance system if using a magnetic system.

Pipe rollers or sand bags shall be used to prevent sagging of the pipe bundle while pipe pulling is in operation. The Contractor shall ensure that the duct pipes are never subjected to friction with abrasive materials, and that they are never dragged onto bare ground that may harm or severely scratch the pipe.

Other devices or utility placement systems for providing horizontal thrust other than those previously defined in the preceding sections shall not be used unless approved by the Engineer prior to commencement of the work. Consideration for approval will be made on an individual basis for each specified location. The proposed device or system will be evaluated prior to approval or rejection on its potential ability to complete the utility placement satisfactorily without undue stoppage and to maintain line and grade within the tolerances prescribed by the particular conditions of the project.

9. **PART 9 REFERENCE DOCUMENTS**

9.1 **Standards**

ASTM C321 Standard Test Method for Bond Strength of Chemical-Resistant Mortars

ASTM C413 Standard Test Method for Absorption of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes

ASTM D570 Standard Test Method for Water Absorption of Plastics

ASTM D4161 Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals

ASTM E154 Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover

BS 65 Specification for vitrified clay pipes, fittings and ducts, also flexible mechanical joints for use solely with surface water pipes and fittings

BS 1377 Methods of test for soils for civil engineering purposes

BS 2782 Methods of testing. Plastics

BS 2782: Part 3 Methods of testing plastics. Mechanical properties

BS 2782: Part 7 Methods of testing plastics. Rheological properties

BS 3506 Specification for unplasticized PVC pipe for industrial uses

BS 4211 Specification for permanently fixed ladders

BS 5150 Specification for cast iron gate valves

BS 5158 Specification for cast iron plug valves

BS 5163: Part 1 Valves for waterworks purposes. Predominantly key-operated cast iron gate valves. Code of practice
BS 5395: Part 1  Stairs, ladders and walkways. Code of practice for the design, construction and maintenance of straight stairs and winders
BS 5834: Part 2  Surface boxes, guards and underground chambers for gas and waterworks purposes. Specification for small surface boxes
BS 5911  Concrete pipes and ancillary concrete products
BS 5911: Part 1  Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete pipes (including jacking pipes) and fittings with flexible joints (complementary to BS EN 1916:2002)
BS 5493  Code of practice for protective coating of iron and steel structures against corrosion
BS 6014  Ethylene propylene rubber compounds. Specification
BS 6076  Specification for polymeric film for use as a protective sleeving for buried iron pipes and fittings (for site and factory application)
BS 6319  Testing of resin and polymer/cement compositions for use in construction
BS 7785  Shewhart control charts
BS EN 124  Gully tops and manhole tops for vehicular and pedestrian areas. Design requirements, type testing, marking, quality control
BS EN 131: Part 1  Ladders. Terms, types, functional sizes
BS EN 295  Vitrified clay pipes and fittings and pipe joints for drains and sewers
BS EN 295: Part 7  Vitrified clay pipes and fittings and pipe joints for drains and sewers. Requirements for vitrified clay pipes and joints for pipe jacking
BS EN 363  Personal fall protection equipment. Personal fall protection systems
BS EN 515  Aluminium and aluminium alloys. Wrought products. Temper designations
BS EN 545  Ductile iron pipes, fittings, accessories and their joints for water pipelines. Requirements and test methods
BS EN 573: Part 4  Aluminium and aluminium alloys. Chemical composition and form of wrought products. Forms of products
BS EN 598  Ductile iron pipes, fittings, accessories and their joints for sewerage applications. Requirements and test methods
BS EN 681  Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications
BS EN 681: Part 1  Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Vulcanized rubber
BS EN 755: Part 1  Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Technical conditions for inspection and delivery
BS EN 755: Part 2  Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Mechanical properties
BS EN 755: Part 3  Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Round bars, tolerances on dimensions and form
BS EN 755: Part 4  Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Square bars, tolerances on dimensions and form
BS EN 755: Part 5  Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Rectangular bars, tolerances on dimensions and form
BS EN 755: Part 6  Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Hexagonal bars, tolerances on dimensions and form
BS EN 755: Part 7  Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Seamless tubes, tolerances on dimensions and form
BS EN 755: Part 8  Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Porthole tubes, tolerances on dimensions and form
BS EN 755: Part 9  Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Profiles, tolerances on dimensions and form
BS EN 771  Specification for masonry units
BS EN 805 – Water supply. Requirements for systems and components outside buildings
BS EN 818 – Short link chain for lifting purposes. Safety
BS EN 1092: Part 1 – Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges
BS EN 1092: Part 2 – Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Cast iron flanges
BS EN 1171 – Industrial valves. Cast iron gate valves
BS EN 1401 – Plastic piping systems for non-pressure underground drainage and sewerage. Unplasticized poly(vinyl chloride) (PVC-U)
BS EN 1456: Part 1 – Plastic piping systems for buried and above-ground drainage and sewerage under pressure. Unplasticized poly(vinyl chloride) (PVC-U). Specifications for piping components and the system
BS EN 1514: Part 1 – Flanges and their joints. Dimensions of gaskets for PN-designated flanges. Non-metallic flat gaskets with or without inserts
BS EN 1916 – Concrete pipes and fittings, unreinforced, steel fibre and reinforced
BS EN 1917 – Concrete manholes and inspection chambers, unreinforced, steel fibre and reinforced
BS EN 10088 – Stainless steels
BS EN 10210: Part 2 – Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties
BS EN 10216 – Seamless steel tubes for pressure purposes
BS EN 10217 – Welded steel tubes for pressure purposes
BS EN 10224 – Non-alloy steel tubes and fittings for the conveyance of water and other aqueous liquids. Technical delivery conditions
BS EN 12020: Part 2 – Aluminium and aluminium alloys. Extruded precision profiles in alloys EN AW-6060 and EN AW-6063. Tolerances on dimensions and form
BS EN 10250: Part 4 – Open steel die forgings for general engineering purposes. Stainless steels
BS EN 10296 – Welded circular steel tubes for mechanical and general engineering purposes
BS EN 12334 – Industrial valves. Cast iron check valves
BS EN 13101 – Steps for underground man entry chambers. Requirements, marking, testing and evaluation of conformity
BS EN 13244: Part 1 – Plastic piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage. Polyethylene (PE). General
BS EN 13244: Part 2 – Plastic piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage. Polyethylene (PE). Pipes
BS EN 13244: Part 3 – Plastic piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage. Polyethylene (PE). Fittings
BS EN 13244: Part 4 – Plastic piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage. Polyethylene (PE). Valves
BS EN 13244: Part 5 – Plastic piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage. Polyethylene (PE). Fitness for purpose of the system
BS EN 13397 – Industrial valves. Diaphragm valves made of metallic materials
BS EN 14364 – Plastic piping systems for drainage and sewerage with or without
pressure. Glass reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP). Specifications for pipes, fittings and joints

BS EN ISO 1346  Fibre ropes. Polypropylene split film, monofilament and multifilament (PP2) and polypropylene high tenacity (PP3). 3-, 4- and 8-strand ropes

BS EN ISO 1461  Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods

BS ISO 4659  Styrene-butadiene rubber (carbon black or carbon black and oil master batches). Evaluation procedure

DIN 1229  Masses per unit area for gully tops and manhole tops for vehicular and pedestrian areas

ISO 2531  Ductile iron pipes, fittings, accessories and their joints for water or gas applications
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACB</td>
<td>Air Circuit Breakers</td>
</tr>
<tr>
<td>ACOP</td>
<td>Approved Code of Practice</td>
</tr>
<tr>
<td>ACRIB</td>
<td>Air Conditioning and Refrigeration Industry Board</td>
</tr>
<tr>
<td>ADCM</td>
<td>Acoustic Doppler Current Meters</td>
</tr>
<tr>
<td>AFMA</td>
<td>Australian Fisheries Management Authority</td>
</tr>
<tr>
<td>AGMA</td>
<td>American Gear Manufacturers’ Association</td>
</tr>
<tr>
<td>AISI</td>
<td>American Iron and Steel Institute</td>
</tr>
<tr>
<td>AS</td>
<td>Acceptance Strength</td>
</tr>
<tr>
<td>ASTA</td>
<td>Association of Short-circuit Testing Authorities</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing Materials</td>
</tr>
<tr>
<td>ATS</td>
<td>Automatic Transfer Switch</td>
</tr>
<tr>
<td>AWS</td>
<td>American Society for Testing Materials</td>
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<tr>
<td>BASEC</td>
<td>British Approval Service for Electric Cables</td>
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<tr>
<td>BOCA</td>
<td>Building Officials and Code Administrators</td>
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<td>BRE</td>
<td>Building Research Establishment Ltd.</td>
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<td>British Standards</td>
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<td>Building Service Research and Information Association</td>
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<td>CBR</td>
<td>California Bearing Ratio</td>
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<tr>
<td>CCTV</td>
<td>Close Circuit Television</td>
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<tr>
<td>CECELEC</td>
<td>Comité Européen de Normalisation</td>
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<tr>
<td>CECOMAF</td>
<td>Comité Européen des Constructeurs de Matériel Frigorifique</td>
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<tr>
<td>CIBSE</td>
<td>Chartered Institution of Building Services Engineers</td>
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<tr>
<td>CHW</td>
<td>Chilled Water</td>
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<td>Cl</td>
<td>Cast Iron</td>
</tr>
<tr>
<td>CLW</td>
<td>Cooling Water</td>
</tr>
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<td>CM</td>
<td>Current Margin / Communication cable</td>
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<tr>
<td>CMP</td>
<td>Communication cable (Plenum)</td>
</tr>
<tr>
<td>CP</td>
<td>Code of Practice</td>
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<td>Circuit Protection Conductor</td>
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<td>Current Transformer</td>
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<td>EMC</td>
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