4 PIPELINE INSTALLATION

4.1 GENERAL

4.1.1 Scope of Work

1 This Part includes the installation of pipelines.

2 Related Sections and Parts are as follows:

This Section
Part 1,..... General
Part 2,..... Earthworks
Part 3,..... Pipes and Fittings Materials
Part 5,..... Valves, Penstocks and Appurtenances
Part 6,..... Miscellaneous Metal Works
Part 7,..... Miscellaneous GRP Works
Part 8,..... Protective Coatings and Painting

Section 1, General
Section 3, Ground Investigation
Section 5, Concrete.

4.1.2 References

1 The following standards are referred to in this Part:

EN 12620 .....Aggregates for concrete

BS 4872 .....Approval testing of welders when welding procedure approval is not required

BS 6072 .....Tubular polyethylene film for use as a protective sleeving for buried iron pipes and fittings

EN 752 .....Drain and sewer systems outside buildings

EN 1092 .....Flanges and their joints

EN 12007 .....Gas supply systems - Pipelines for maximum operating pressure up to and including 16 bar, Part 2: Specific functional recommendations for PE

ISO 12176 .....Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems, Parts 1 and 2

ISO 21307 .....Plastics pipes and fittings — Butt fusion jointing procedures for polyethylene (PE) pipes and fittings used in the construction of gas and water distribution systems

ISO 13953 .....Polyethylene (PE) pipes and fittings - Determination of the tensile strength and failure mode of test pieces from a butt fused joint

ISO 13954 .....Plastics pipes and fittings - Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm

SFS 3115:E .....Plastics Pipes Water Tightness Test for Pressure Pipelines (English version of Finnish Standard)

WIS-4-08-02 .....Specification for bedding and sidefill materials for buried pipelines

AWWA C200 .....Steel Water Pipe 150 mm and Larger

AWWA C600 .....Installation of Ductile-Iron Water Mains and Their Appurtenances.

4.1.3 Guidelines

1 The following Guidelines are applicable to the installation and testing of HDPE pipes and fittings:

DVGW GW330.....Installation & Welding of High Density Polyethylene (HDPE) Pipes for Gas & Water Applications

DVGW GW331.....Supervision of Installation & Welding of High Density Polyethylene (HDPE) Pipes for Gas & Water Applications

DVS 2202-1.....Imperfections in thermoplastic welded joints: Features, description, evaluation

DVS 2203-1.....Testing of welded joints of thermoplastic sheets and pipes: Test methods – Requirements

DVS 2207-1.....Welding of thermoplastics: Heated tool welding of pipes, pipeline components and sheets made of HDPE

DVS 2208-1.....Welding of thermoplastics: Machines and devises for the heated tool welding of pipes, pipe parts and panels

4.1.4 Definitions

1 Pipes: circular tubes through which fluid can flow including manufactured lengths of pipes, bends, fittings, junctions and other specials, joints and jointing parts.

2 Valves: manufactured devices for controlling the passage of fluids through pipes including sluice gates, reflux valves, and air valves including associated joints, jointing parts, operating gear and fittings.

3 Installation: material transport and handling, pipelaying including the complete operation of laying jointing and testing pipes in trenches or elsewhere, and the construction of pipeline ancillaries

4 Pipeline: long, continuous line of pipes and fittings including valves and ancillary structures and equipment used for transporting fluids; specifically, sewers and ancillary works for the transport of sewage and surface water and similar pipelines for the transport of treated sewage effluent.

4.1.5 Submittals

1 The Contractor shall submit the documents described in the following paragraphs.

2 Working drawings: Before commencing work the Contractor shall prepare working drawings necessary for the construction and installation of facilities. The drawings shall be prepared to A1 size or a size and scale as directed by the Engineer. The drawings shall be submitted to the Engineer in an orderly manner and at periods which will permit adequate time for review and approval by the Engineer. Five copies of drawings shall be submitted.

3 Detailed work programme with schedule for the delivery of pipes and fittings

4 Methods statements to supplement the working drawings, as follows:

(a) installation

(i) joints and couplings

(ii) measures to ensure integrity of interior pipe lining and exterior protective coating at joints and couplings

(iii) installation and adjustment of pipe bedding and other supports

(iv) fitting of pipelines to valves.

(b) testing of sewer pipelines and pressure pipelines to the requirements described in Subpart 4.5

(c) welding procedures and electrodes with drawings and schedules as may be necessary

(d) safety procedures and protective equipment

5 Quality assurance and control documents including

(a) certified copies of reports of required tests including:

(i) pipe pressure tests

(ii) dielectric joint tests

(b) copies of certificates relating to welder's tests shall be made available to the Engineers on request

4.1.6 Quality Assurance

1 A suitably qualified and experienced safety officer shall be employed to ensure that all Contractor's employees follow safety procedures and are provided with appropriate safety and protective equipment.

2 Welders employed on the fabrication and site welding shall have passed the welder approval tests of BS 4872, Part 1 or other standard approved by the Engineer.

4.1.7 Delivery, Storage and Handling

1 Delivery, storage, and handling shall be as specified in Part 3 of this Section.

2 The Contractor shall replace or repair pipe damaged during handling and installation, to the approval of the Engineer.

4.1.8 Specialists, Inspection and Testing

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

2 Such independent tests may be carried out at any stage during the execution and maintenance of the Works, but they shall not relieve the Contractor of his obligations under the Contract.

3 To the extent ordered by the Engineer, the Contractor shall provide labour, plant, tools and materials (but not special testing equipment) for direct assistance to the specialist firm in their inspection and independent testing and for any further work, investigations, and repairs which the Engineer considers necessary as a result of such inspection or testing.

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

4.1.9 Soil Corrosivity Study

1 Where designated in the Project Specification, the Contractor shall carry out a soil corrosivity study along the route of proposed ferrous pipelines as directed by the Engineer and mark the results on the pipeline layout plans.

2 Soil resistivities shall be undertaken using a low resistance, null-balance earth tester and a four pin array, or any other equipment approved by the Engineer. Readings shall be recorded in ohm-cm and shall be taken at 1.0 m incremental depths to a depth 1 m below the pipeline invert levels. Readings shall be taken at a spacing along the route of the proposed pipelines as required to reflect the changing soil conditions, but in no case shall the spacing exceed 500 m.

3 Soil samples shall be taken as directed by the Engineer along the route of the proposed pipelines at a maximum spacing of 500 m. Soil samples shall be tested for sulphates, sulphides, chlorides, pH, moisture content, and carbonates.

4.1.10 Setting Out and Pipeline Alignment

1 All sewers shall be laid accurately to the lines, and levels gradients shown on the approved drawings so that the pipeline is straight between successive manholes in the vertical and horizontal planes.

2 Pressure pipelines shall be laid accurately to the lines levels and depths shown on the approved drawings. Where changes of direction are required, deflections shall be made in accordance with the manufacturer's recommendations.

3 Manufactured bends shall only be used where shown on the Drawings or where otherwise permitted by the Engineer's Representative.

4 Where pipelines of constant gradient are to be laid, the Contractor shall provide, fix and maintain at such points as may be directed by the Engineer's Representative properly painted sight rails and boning rods of pre-determined measurement for the boning in of individual pipes to correct alignment. The sight rails shall be situated vertically over the line of pipes or immediately adjacent thereto and there shall at no time be less than three sight rails in position on each length of pipeline under construction to any one gradient

5 If the Contractor wishes to propose an alternative method of controlling pipeline alignment, he shall submit his proposed method to the Engineer's Representative for approval

4.1.11 Tools for Installation and Testing

1 The Contractor shall supply all necessary tools for cutting, chamfering, jointing, testing and for any other requirement for satisfactory installing the pipelines.

4.1.12 Inspection During Installation

1 Pipes and fittings including any sheathing, inside linings and outside coatings, shall be inspected by the Contractor immediately before and after installation, and damage or other imperfection shall be repaired by the Contractor as directed by the Engineer before installation and in accordance with the following:

(a) Material required for the repair of pipe, sheathing, linings and coatings shall be obtained by the Contractor and shall be used in accordance with the manufacturers recommendations.

(b) Without relieving the Contractor of any of his obligations, the Engineer may inspect and test the pipe and appurtenances by any appropriate means, and damage discovered by such inspection shall be repaired by the Contractor.

(c) The Contractor shall remove from Site any pipe or appurtenance which in the opinion of the Engineer is so damaged as to be unfit for incorporation in the Works. The obtaining of replacements for damaged pipes and fittings to the approval of the Engineer shall be an obligation of the Contractor.

4.1.13 Dewatering

1 All pipeline installation work shall be carried out in the dry.

2 Dewatering shall be carried out as specified in Part 2 of this Section.

4.1.14 Closures and Short Sections

1 For the purpose of reducing the angular deflections at pipe joints, and for closure sections, the Contractor will be permitted to install pipe sections of less than standard length. Closing lengths and short sections of pipes of all types shall be fabricated and installed by the Contractor as found necessary at Site. Where closing pieces are required, the Contractor shall make all necessary measurements and shall be responsible for the correctness thereof. The Contractor shall be responsible for taking the measurements required to determine the lengths of cut portions of pipes for insertion as closing lengths in pipelines.

4.1.15 Cutting of Pipes

1 Where pipes are required to be cut on the Site the cutting shall be done by the Contractor in accordance with the manufacturer's recommendations and in a manner approved by the Engineer.

2 The pipe and methods of jointing shall be such that the locations of fittings and lengths of pipe can be adjusted to suit Site conditions.

3 Cutting of reinforced concrete pipes will not be allowed. Special lengths of pipes shall be manufactured for closures as required. Other pipes such as GRP, ductile iron, vitrified clay, MDPE, HDPE, PVC-U and cast iron pipes shall only be cut if approved by the Engineer.

4 The cutting of vitrified clay pipes, MDPE, HDPE, PVC-U, and ductile iron pipes for inserting specials, fittings or closure pieces shall be carried out as follows:

(a) Cutting shall be carried out in a neat and workmanlike manner with an approved cutting machine without damage to the pipe and so as to leave a smooth end at right angles to the axis of the pipe.

(b) Cutting by hacksaw shall not be permitted unless approved by the Engineer.

(c) Only experienced men shall be employed by the Contractor on this work.

(d) The Contractor shall take every precaution to ensure that both the measurement tolerances and the cutting of pipes are to the accuracy required. Should any errors occur the Contractor shall correct the defects to the approval of the Engineer.

4.1.16 Stringing of Pipes

1 Pipes shall be distributed to installation site only in such quantities as can be installed in one working day or as allowed by the Engineer.

2 The Contractor shall take pipes from the storage areas, unload and string along the route of the proposed pipeline. Pipes shall be so strung as to cause the least practicable interference with the use of the land.

3 After a pipe has been strung and immediately before being laid, it shall be cleaned out and inspected for defects. Cast or ductile iron pipes shall be rung with a light hammer while the pipe is suspended clear of the ground to detect cracks. Other pipes shall be visually inspected. Any defective, damaged or unsound pipe shall be rejected. Any damage to the lining or coating of the pipe shall be repaired or the pipe rejected as directed by the Engineer.

4 Plastic pipes shall not be strung along the pipe route but shall be stored in accordance with Part 3 of this Section until required for laying and jointing.

4.1.17 Inspection of Trench Formation

1 After excavations have been completed to the designated levels and, trench formation compacted, the Contractor shall issue a formal notice to the Engineer that the trench formation is ready between designated points for inspection. The Engineer will without unreasonable delay inspect the said trench formation, unless he considers it unnecessary and advises the Contractor accordingly. Any rejection of trench formation will be confirmed in writing by the Engineer.

2 The formation will be re-inspected by the Engineer after replacement of any unsound material with material as specified under Clause 2.2.3 of Part 2 of Section 8.

3 No bedding shall be placed until the Engineer's Representative has given his approval to the trench formation.

4.1.18 Overpumping and Flow Diversions

1 Flow diversions shall be in accordance with Clause 10.4 of the Section.

4.1.19 Other Services

1 Where the Works requires the seeking, protection, diversion or relocation of existing services the procedures set out in Section 6 Part 11 shall be followed.

4.2 DUTILE IRON, PVC, CONCRETE, VITREOUS CLAY, ABS AND GRP PIPELINE JOINTING

4.2.1 Push-fit Joints

1 Immediately before assembling each joint incorporating a rubber ring seal, the rubber shall be inspected for cracks, every part of the ring being deformed by hand to about 150 mm radius. If under this deformation any cracks are either revealed or initiated then the ring shall be rejected, cut through completely to prevent inadvertent use, and the matter reported forthwith to the Engineer. If more than three successive rings inspected in this way are rejected the Contractor shall on the instruction of the Engineer stop all pipe jointing until the cause of the defect has been proved and remedied to his satisfaction.

2 The rubber ring shall be placed in the groove on the socket or spigot ring. The groove shall be free of deleterious material; e.g., dirt, moisture, oil, and grease. The inside surface of the socket shall be lubricated with a compound recommended by the manufacturer which will facilitate the telescoping of the joint. The spigot end of the pipe shall then be inserted into the socket of the adjoining pipe using a suitable tool to push the spigot into the socket. The position of the pipe and the gasket in the joint shall then be checked using a feeler gauge to demonstrate proper jointing. When joints are not properly made, pipes shall be adjusted, or removed and rejointed as necessary to ensure proper jointing. Care shall be taken to avoid twisting or cutting the ring when jointing the pipe.

3 For pipes up to and including 700 millimetres nominal bore the joints shall be capable of withstanding a deflection of not less than 1.5 degrees in any direction and for pipes over 700 millimetres nominal bore 0.5 degrees in any direction. All pipe joints shall be capable of withstanding a “draw” of 13 millimetres over and above the initial jointing allowance. The initial jointing allowance is the gap between the spigot and the shoulder of socket measured parallel to the centre line of the pipeline and shall not be less than 6 millimetres or greater than 13 millimetres.

4.2.2 Mechanical Joints

1 Where mechanical joints are approved, installation shall be in accordance with the manufacturer’s recommendations. The Contractor shall render the end of each pipe perfectly smooth so as to allow the joint sleeve to slide freely and where necessary shall coat the pipe ends with two coats of an approved quick drying sealing and protective compound. Buried joints shall be wrapped using protective tape as specified in Clause 3.8.5 and applied as clause 4.3.5.

4.2.3 Flanged Joints

1 Flanged joints for ductile iron and cast iron pipes and specials shall be made with rubber joint gaskets and steel bolts and nuts which shall include two washers per bolt. The use of jointing paste or grease shall not be permitted. The gasket may be fastened to the bolts with cotton thread. The bores of abutting pipes or fittings shall be concentric and no jointing material is to be left protruding into the bore.

2 All nuts shall first be tightened by hand and nuts on opposite sides of the joint circumference shall then be alternately and progressively tightened with a spanner so as to ensure even pressure all around the joint.

3 Buried joints shall be wrapped using protective tape as specified in Clause 3.8.5 and applied as clause 4.3.5.

4.2.4 GRP Joints

1 Joints shall be of the “O” ring or rolling type, and shall incorporate a soft or flexible control register to help to locate the joint.

2 GRP pipe joints shall be assembled in accordance with manufacturer's instructions for the type of flexible joint provided.

3 Joints shall be capable of withstanding the various tests specified for the appropriate class of pipe. Joints shall withstand, while maintaining the specified test pressure, a deflection of not less than 1.5 ° in any direction or for pipes up to and including 600 mm nominal bore, and 0.5 ° in any direction for pipes over 600 mm diameter.

4 Rubber joint rings shall be made of EPDM SBR or nitrile rubber (NBR) and shall comply with the relevant requirements of EN 681-1 for Type WG rings.

5 Flanged pipes, if required, shall incorporate an annular gasket and these gaskets shall cover the full face of the flange and shall have holes cut in correspondence to the bolt holes in the flanges. Flanges shall be drilled to EN 1092 type PN 16. Alternatively jointing system for flanged pipes, incorporating rubber rings, may be approved by the Engineer. Stainless steel backing rings shall be inserted between the bolt head / nut and the GRP flange to spread the load.

4.3 MDPE AND HDPE PIPELINE JOINTING

4.3.1 General

1 The Contractor shall abide by the following guidelines with regards to jointing MDPE and HDPE (PE) pipes and fittings unless otherwise approved by the Engineer.

(a) PE pipes and fittings of 90 mm OD and above shall joined by butt fusion whenever possible.

(b) PE pipes and fittings of less than 90 mm OD shall be joined together using electro-fusion couplings and fittings.

(c) Electro-fusion fittings may also be used to undertake repairs and install off-takes or connections on existing pipelines. They may also be used for the joining together of pipe strings where it is not practical to use a butt fusion welding machine.

(d) To join PE pipes to metal pipes and fittings such as valves, restrained mechanical transition fittings and stub flanges shall be used.

(e) Restrained mechanical fittings may, with the permission of the Engineer, to undertake repairs and install off-takes or connections on existing pipelines.

4.3.2 PE Welding Technicians

1 All PE electro and butt fusion jointing, PE jointing to GRP and metallic valves and fittings shall only be undertaken by a certified HDPE Welding Technician holding a valid Welder Licence.

2 The PE Welding Technician shall have attended a comprehensive course on the Installation and Welding of High Density Polyethylene (HDPE) Pipes. The minimum course length shall be 5 days and the Technician shall have sat and passed an exam in accordance with the GW330 standard of the German Technical and Scientific Association for Gas and Water (DVGW) or an equivalent national body approved by the Engineer.

3 The PE Welding Technician shall hold a valid GW330 Welder License or equivalent issued by a national body approved by the Engineer, which shall be subject to annual renewal by attending a re-examination course.

4.3.3 PE Welding Inspectors

1 A specialist PE Welding Inspector shall observe and supervise the handling, welding, jointing to other materials and testing on site of all HDPE pipes and fittings.

2 The PE Welding Inspector shall have attended a comprehensive course on the Installation and Welding of High Density Polyethylene (HDPE) Pipes. The minimum course length shall be 5 days and the Inspector shall have sat and passed an exam in accordance with the GW331 standard of the German Technical and Scientific Association for Gas and Water (DVGW) or an equivalent national body approved by the Engineer.

4.3.4 PE Welding Equipment

1 All welding machines and welding equipment shall fulfil the requirements of DVS 2208-1 or the relevant part of ISO 12176. All welding machines shall be of an automatic or semi-automatic design where the welding machine determines and controls the welding parameters based on the pipe and fitting details entered by the operator. They shall also be equipped with a data logging function that measures and records information listed in DVS 2208-1.

2 All machines shall undergo a yearly calibration and function test, carried out by a service centre authorised by the machine manufacturer.

4.3.5 Method Statements

1 A detailed method statement for PE pipe jointing shall be prepared by the Contractor and submitted to the Engineer for approval. The method statement shall include details of which equipment shall be used and how the work will be performed to ensure compliance with the recommendations of the pipe manufacturer and of this specification. It shall include, but not be limited to:

(a) Details of the equipment to be employed by the Contractor, together with procedures for its operation, maintenance, periodic inspection and testing.

(b) Details of the experience and certification of the pipe and fitting jointers that shall be employed by the Contractor.

(c) Procedures for joint preparation, indicating method and degree of cutting, cleaning, drying, scraping, alignment, support, etc. of the pipe ends to be joined.

(d) Jointing procedures, specifying the equipment and tools to be employed, together with all relevant parameters such as voltage, temperature, pressure, heating time and cooling down time and the means by which jointing operations shall be controlled.

(e) Inspection and testing procedures together with proposals for the independent and on site inspection and testing on welds on a regular basis.

(f) QA/QC procedures

(g) All safety precautions and procedures.

4.3.6 Electrofusion Jointing

1 All electrofusion jointing shall be undertaken in accordance with this specification and the guidance given in DVS 2207-1

2 Only barcode labelled electro-fusion fittings incorporating fusion indicators and complying with the requirements of ISO4427, Part 3 shall be used. The electrofusion control unit shall incorporate data input through the use of a bar code reader pen and a data retrieval facility to allow historical fusion data to be read on the unit's screen and to be exported to an external computer or memory stick.

3 The electro-fusion control box shall deliver the correct fusion parameters to the electro-fusion fitting. The power generator shall provide the power requirements of the control box, taking into account the electrical characteristics of the control box.

4 Positioning tools including suitable alignment clamps shall at all times be used to minimise misalignment and prevent movement during the fusion and cooling cycle of the joint. A suitable shelter shall be used in cold, windy, dusty or wet weather conditions.

5 Prior to commencing the welding process the Contractor shall measure and ensure that the ovality of the pipe or spigot end is within the limits given in Table 3 of ISO 4427, Part 3.

6 All pipework shall be cleaned with disposable alcohol impregnated wipes prior to undertaking the pipe scraping, in order to remove any contamination. Prior to scraping the Contractor shall measure and mark the area of the pipe or spigot end to be scraped in order to remove the oxidized surface to a depth between 0.2 and 0.4 mm. The length of the pipe or spigot end to be scraped shall be equivalent to the insertion depth of the electro-fusion joint plus a distance of between 10 and 20 mm.

7 Only rotating mechanical scrapers or peelers, which are capable of cutting a continuous strip or ribbon over the insertion length of the coupler or fitting, shall be used.

8 Only after preparation and scraping of the pipe end shall the fitting be removed from its packaging and immediately inserted over the pipe end.

9 Each pipe or spigot end shall penetrate completely its relevant part of the electro-fusion socket.

10 Alignment clamps shall not be removed before the appropriate cooling time has elapsed. Abnormal displacement of the electric wire coils shall not occur. This shall be checked prior to commencement of the fusion process.

4.3.7 Electro-fusion Joint Inspection

1 All completed electro-fusion joints shall be inspected in accordance with the requirements of Appendix B of EN 12007 Part 2. Should the joint contain any of the faults described in the standard then the electro-fusion fitting shall be cut out and replaced.

2 After completion of the fusion process, all fusion indicators shall be checked to ensure that they are in the position indicated in the Manufacturer's instructions. If any fusion indicators are not in the required position the electro-fusion fitting shall be cut out and replaced.

3 The Contractor shall, on a regular basis allow the Engineer to download the historical data relating to the welds made by the unit through the data retrieval facility.

4.3.8 Butt Fusion Jointing

1 All butt fusion jointing shall be undertaken in accordance with this specification, the single low pressure jointing procedure given in ISO 21307 and the guidance given in DVS 2207-1.

2 Assign a unique joint number to each joint and have a data retrieval facility to allow historical fusion parameters to be read on the unit’s screen and to be exported to an external computer or memory stick

3 In the case of large diameter pipes having a high wall thickness in excess of 35 mm the Contractor may propose to instead follow the single high pressure fusion jointing procedure described in ISO 21307. Such a deviation from DVS2207-1 shall only be allowed with the written approval of the Engineer.

4 Only pipes and fittings of the same size, SDR and material are to be butt fusion jointed.

5 A dummy joint shall be made at the start of each welding session using pipe off cuts of the same size, material and SDR as the pipe being installed. The normal trimming, bead up and full heat soak cycles will be adhered to.

6 If the pipe size is changed during the day, if the heater plate is allowed to cool below 180°C or if maintenance of the butt fusion equipment is carried out then a new dummy weld shall be performed.

4.3.9 Butt Fusion Joint Inspection

1 All butt fusion joints shall be inspected in accordance with the requirements of Appendix B of EN 12007 Part 2. Should the joint contain any of the faults described in the standard then the joint shall be cut out and replaced. The inspection shall include the following points:

(a) The gap between the two single beads shall not be below the fusion surface.

(b) The displacement between the fused pipes must not exceed 10% of the pipe wall thickness.

(c) The difference between two single bead widths shall not exceed 10% of the double bead width.

(d) The weld beads shall be free from all contamination and have a smooth even surface with no evidence of distortion, holes or bubbles

(e) At the direction of the Engineer external beads shall be removed with an approved tool and inspected for contamination and defects. They shall also undergo bend back testing. Beads should be solid and rounded with a broad root as hollow beads with thin root and curled appearance can be indicative of excessive pressure or no heat soak.

(f) Each removed bead shall be numbered with its corresponding joint number clearly displayed and removed beads shall be retained for inspection by the Engineer.

(g) The width of each external bead width shall be measured using bead gauges and the width of the bead shall be within the range given by the pipe and / or welding equipment manufacturer.

(h) No signs of damage (such as scratches or deep impressions caused by clamps) shall be visible on either side of the joint.

(i) Any joints the do not comply with the above requirements shall be cut out and a new joint made; the failed joint shall be handed over to the Engineer.

(j) Records of all tests and inspections shall be maintained by the Contractor and made available for review and approval by the Engineer.

4.3.10 Testing of Fusion Joints

1 A minimum, 1 % of all butt fusion joints shall be cut out and destructively tested under laboratory conditions in accordance with ISO 13953 by an approved testing organisation. The joints to be tested shall be selected by the Engineer immediately upon completion of the welding process, whereupon they shall be cut out and delivered for testing.

2 A minimum of 1 % of all electro-fusion fittings shall be cut out and destructively tested under laboratory conditions in accordance with ISO 13954 by an approved testing organisation. The fittings to be tested shall be selected by the Engineer immediately upon completion of the welding process, whereupon they shall be cut out and delivered for testing. They shall comprise at least 1 of each type of electro-fusion fitting even if this requires more than 1 % of all electro-fusion fittings to be tested. Note that the minimum test requirement is for one fitting of each type i.e. bend, coupling, tapping saddle, tee etc. not one of each size and type.

3 All costs associated with the testing, together with any consequent rectification of faults and retesting shall be borne by the contractor.

4.3.11 Anchorage

1 Anchorage lugs shall be provided for socket and spigot fittings and socket clamps and tie rods used where there is a possibility of pulling the joint under pressure. Concrete thrust blocks shall be used in lieu of the above where socket and spigot pipe is used below ground. The Contractor shall submit, for the Engineer's approval, working drawings and information demonstrating the adequacy of anchorage systems other than thrust blocks or other systems shown on the Contract Drawings.

4.4 PIPE LAYING

4.4.1 General

1 Except as otherwise specified in this Clause, pipe bedding shall conform with the requirements specified in Part 2 of this Section.

2 The Contractor shall, after excavating the trench and preparing the proper bedding, furnish all necessary facilities for properly lowering and placing sections of the pipe in the trench without damage and shall properly install the pipe.

3 Each pipe shall be carefully lowered onto its prepared bed by means of appropriate slings and tackle. A recess shall be left in the prepared bed to permit the sling to be withdrawn. If the prepared bed is damaged, the pipe shall be raised and the bed made good before pipe laying is continued.

4 No pipe shall be rolled into place for lowering into the trench except over suitable timber planking free from roughness likely to damage any coatings.

5 The section of pipe shall be fitted together correctly and shall be laid true to line and grade in accordance with the bench marks established by the Contractor. The bench marks shall be approved by the Engineer.

6 The full length of the barrel of the pipe shall have a uniform bearing upon the bedding material and if the pipe has a projecting socket, suitable excavation shall be made to receive the socket which shall not bear on the subgrade.

7 Pipes shall be laid with the class identification marks or the jointing marks shown by the manufacturer in the uppermost position. Pipe sections shall be so laid and fitted together that the pipeline will have a smooth and uniform interior. The pipeline shall be clean and unobstructed at the time of its installation and shall be true to the required line and levels.

8 Spigot and socket pipes shall generally be laid upgrade without break from structure to structure and with the socket end upgrade. Backlaying may be permitted as deemed necessary and approved by the Engineer.

9 Whenever work ceases on any pipeline the unfinished end of the pipeline shall be securely closed with tight fitting plug or cover.

10 Before any pipe is lowered into place, the bedding shall be prepared and well compacted so that each length of pipe shall have a firm and uniform bearing over the entire length of the barrel.

11 Pipes shall be laid in straight lines, both in the horizontal and vertical planes, between manholes or, where directed in the case of pressure pipelines and larger diameter sewers to regular curves. The placement of pipes shall comply with the following requirements:

(a) each pipe shall be plumbed to its correct line and directly and accurately sighted by means of a laser positioning system or boning rods and sight rails fixed to secure posts which shall be set up and maintained at each end of the sewer to be laid and not more than 20 m apart. Sight rails shall be clearly painted in contrasting colours and be not less than 150 mm deep, straight and level

(b) boning rods shall be of robust construction clearly painted and accurately made to the various lengths required, the lower end being provided with a flat edged shoe of sufficient projection to rest on the invert of the pipes as laid. The boning rod shall be complete with a vertical spirit level

(c) boning rods and sight rails shall not be removed until the pipeline has been checked and approved by the Engineer

(d) alternative methods of locating and levelling pipelines may be allowed subject to the approval of the Engineer

(e) any pipe which is not in true alignment, both vertically and horizontally, or shows any undue settlement after laying, shall be taken up and relaid correctly by the Contractor

(f) all adjustments in line and grade shall be made by scraping away or filling and tamping in under the barrel of the pipe and not by wedging or blocking

(g) the trench shall be kept completely dry

(h) in no case shall pipes be jointed before being lowered into position

(i) the gasket should be positioned and lubricated.

12 Pipelines shall be tested in accordance with Subpart 4.5.

4.4.2 Laying of Rigid and Semi-Rigid Pipes

1 Each pipe immediately before being laid shall be carefully brushed out and inspected for defects. In trench pipes with flexible joints except where concrete bed, bed and surround or protection is required shall be laid on a well compacted bed of granular material extending for the full width of the trench and with sufficient material at the sides to permit the pipes to be worked into the granular material and firmly supported to true line and level. Sufficient space should be left to enable the joints to be made tested and inspected but the Contractor shall ensure that at least three quarters of the pipe length is fully supported. After the pipeline has been tested and approved by the Engineer the trench shall be carefully filled to 300 mm above the crown of the pipe with granular material in accordance with the bedding requirements specified in Part 2 of this Section and as shown on the Drawings.

2 Vitrified clay pipes shall be installed in trenches which shall not exceed the maximum trench width at 300mm above crown of pipe as shown in Table 2.1 of Part 3 of this Section.

3 Should the Contractor exceed the trench widths given in Table 2.1 he shall provide calculations to show the loading on the pipe and bedding requirements and where required he shall provide plain or reinforced concrete cradle or surround, to the approval of the Engineer, at no additional cost. The same type of pipe bedding/surround shall be used for the full sewer length between adjacent manholes.

4 Unless otherwise specified, pipe bedding shall be as shown on the Contract Drawings. Notwithstanding the above, for Vitrified Clay pipe the special pipe bedding requirements as Table 4.2 are to be provided in all cases whether or not shown on the drawings or indicated in the bills of quantity.

Table 4.2 - Special Bedding Requirements for VC Pipes

Nominal bore mm	Depth to Invert (D) m	Bedding Type*
700-800	D>9.0	1. Plain concrete cradle
>900	4.0<D<5.0	2. Plain concrete cradle
>900	5.0<D<9.0	Reinforced concrete cradle with minimum 0.4% transverse steel
>900	D>9.0	Reinforced concrete surround with minimum of 1% transverse steel.

(* as shown on drawings)

4.4.3 Laying of Flexible MDPE and HDPE Pipes

1 This clause does not apply to GRP pipes for which laying requirements are given in Clause 4.3.4 of this Section.

2 All operations involving the laying, bedding, jointing, backfilling etc. of pipes of plastic materials shall be strictly in accordance with the manufacturer's recommendations subject to the approval of the Engineer.

3 The pipeline shall be laid on a well compacted sand or granular material that shall extend across the full width of the trench bottom. The pipe bed shall have a minimum thickness of 100 mm and be compacted to a minimum modified Proctor (AASHTO) density of 90% prior to the laying of the pipeline.

4 After laying of the pipeline the Contractor shall place pipe surround material on both sides of the pipe, ensuring that no cavities are left between the underside of the pipe and the trench bottom or pipe bed. The pipe surround material shall be placed in layers of no more than 150 mm thick and compacted with hand tools across the width of the trench to achieve a minimum Modified Proctor (AASHTO) density of 90%. The pipe surround shall extend to a minimum of 200 mm above the crown of the pipe.

5 Where pipes are laid in good quality ground conditions such as those native soils comprising granular, sandy or rocky materials, the pipe bed and surround shall comprise clean dry sand free from silty and foreign materials and particles of larger than 10 mm diameter.

6 The maximum particle size of the granular material shall also not exceed 10% of the pipe outside diameter.

7 Should the excavated native soil fail to meet the above requirements it shall be graded on site in order to do so or be replaced with an imported sand or granular material complying with the requirements of the UK WIS 4-08-02 or this specification.

8 Where pipes are laid in poor quality ground conditions such as those native soils comprising soft or silty materials, the pipe bed and surround shall comprise an imported granular material complying with one of the grades given in the UK WIS 4-08-02 or this specification.

9 Single sized aggregate shall not be used for the pipe bed and surround in conditions where the native soil comprises of sandy, silty or soft material unless it is wrapped in a geotextile filter fabric to prevent migration of fine material from the surrounding soil in to the bed and surround

10 When the grade at which the pipeline laid exceeds 10° trench breakers or clay dams shall be installed to prevent the migration of bed and surround material due to the flow of water along the trench.

4.4.4 Laying of GRP Pipes

1 During the mobilisation period the Contractor shall submit for the Engineer's approval the pipe manufacturer's complete and detailed specification for the handling and installation of pipe and fittings in open trench and such other methods of construction of pipeline specified or proposed by the Contractor. This specification shall be submitted during the mobilisation period irrespective of whether the data was submitted with the Tender.

2 The Contractor shall transport, store, handle and lay pipes in accordance with the approved manufacturer's handling and installation specification as approved by the Engineer.

3 The manufacturer's handling and installation specification shall include details of the manufacturer's technical expert to be assigned to the Contract. The technical expert shall have extensive experience of handling and installation of GRP and shall be fully familiar with the manufacturer's handling and installation specification.

4 The manufacturer's technical expert shall provide comprehensive technical assistance to the Contractor throughout the Contract and shall regularly monitor the Contractor's handling and installation operations.

5 Any instructions or advice given by the manufacturer's technical expert to the Contract shall be copied to the Engineer. In the event that the Contractor deviates from the approved handling and installation specification, the manufacturer's technical expert shall immediately inform the Contractor and the Engineer.

6 All costs associated with the provision of a technical expert by the manufacturer shall be borne by the Contractor.

7 GRP pipes shall, unless otherwise directed by the Engineer, be laid on a special bedding material. The space below the barrel of the pipes shall be filled with special bedding material to the full width of the trench in layers not exceeding 150 mm in thickness. After pipe laying, further special bedding shall be placed and thoroughly compacted to fill the entire space between the pipe and the undisturbed sides of the trench up to a depth of 150 mm above the top of the pipe. The minimum thickness of the special bedding below the barrel of the pipe shall be 250 mm or as directed by the Engineer. Where a manufacturer requires greater thickness of special bedding below, around and over the pipes than those specified they shall be deemed to have been allowed for in the rates for bedding.

8 Where GRP pipes are built into a rigid structure; e.g., manhole or a pumping station, the first 100 mm of pipe at entry to the structure shall be surrounded by an approved flexible material. Flexible joints shall be incorporated adjacent to structures, in accordance with Clause 4.2.4.

9 Where short GRP pipes are detailed these shall be factory made. Cut ends shall be sealed with two layers of resin, the second layer being paraffin wax filled to ensure full cure.

10 Where GRP pipes are required to be surrounded with concrete, all necessary precautions shall be taken to ensure that maximum allowable deflections are not exceeded. Adequate precautions are to be taken to ensure that the pipe does not float during placing of the concrete surround.

11 At all times, backfilling shall be carefully carried out to ensure no voids or pockets of unconsolidated material are present. The Contractor shall monitor the vertical deflection of the pipes throughout the backfilling operation. No pipe shall exhibit more than 1.5% deflection after placing and compaction of the granular bed and surround. In addition, after completion of the trench backfilling, the average deflection of a length of pipe shall not exceed 1.5%, and every pipe shall be demonstrated to exhibit no more than the manufacture's calculated allowable 'Initial Deflection', or 3.5% deflection, whichever is smaller. If any of these values are exceeded, the affected pipes shall be exhumed and re-laid.

12 The deflection shall also be checked on each length between manholes or chambers before commissioning to determine whether longer term deflections are within permissible limits. The average deflection of a length of pipe shall not exceed 3%, and every pipe shall be shown to exhibit a deflection no greater than 5%, or the calculated allowable deflection consistent with the achievement of a long term deflection not exceeding 5%, whichever is smaller, at any point. Pipes exhibiting greater deflections shall be exhumed and re-laid.

13 Pipes exhibiting a deflection greater than 8% or 1.6 times the calculated allowable long term deflection, shall be exhumed, indelibly marked 'REJECTED', removed from the site and not reused.

4.4.5 Corrosion Protection of Ferrous Pipelines

1 Where tape wrapping is wrapped at site it shall be applied by machine under factory controlled conditions in accordance with Clause 3.7.6 of this Part.

2 Pipe joints shall be protected by continuing the tape wrapping, or by heat shrink polyethylene tubes coated internally with thermoplastic adhesive. The profile of the pipe joint shall be smoothed using bituminous mastic or preformed plastic foam sections taped in position. Heat shrink sleeves shall be on pipes with extruded polythene coatings, and in all cases shall be applied in accordance with the sleeve manufacturer's and pipe coating manufacturer's instructions.

3 Joints within in-situ concrete chambers do not require heat shrinkable sleeve protection.

4 Damaged areas of protective coating or wrapping shall be repaired in a manner to be approved by the Engineer's Representative.

5 Ferrous pipelines shall be supplied with one of the following corrosion protection systems:

(a) Cold applied self-adhesive laminate tape wrapping

(b) Extruded polyethylene coating

(c) Loose polyethylene coating

6 Extruded polyethylene coating shall be as Clause 3.7.7. Heat shrink sleeves shall be used over joints in polyethylene coated buried pipes.

7 Spigot ends of pipes coated in either of the approved manners shall not be coated over the depth of engagement within the socket or flexible coupling, but shall be coated with epoxy, polyethylene or polyurethane for pipes internally lined with these materials.

8 Where ductile iron buried pipe is designated to be encased in loose polythene sleeving, installation shall be in accordance with BS 6076.

9 The pipe shall be supported by a central sling and a length of sleeving pulled over the spigot end and bunched up to the sling.

10 The pipe shall then be rested on blocks placed at its extremities and the sleeving pulled up to the socket and folded and taped or tied in position. The sling shall then be replaced to enable jointing to be carried out. A wide sling shall be used to distribute the weight and thus obviate intense pressure on the sleeving. Care shall be taken to avoid damage when removing the sling from the trench.

11 The sleeve shall not be drawn up over the pipe joints until the completion of the hydrostatic testing. Immediately after making the pipe joint, the pipe trench shall be backfilled as described hereinbefore in readiness for the hydraulic testing and to prevent damage to the sleeving.

12 After completion of the hydraulic testing, the sleeving shall be drawn up over and fixed around the pipe joints. A pad of sleeving shall first be placed around the joint to prevent damage to the joint sleeve by the edges of the socket or by bolts. A length of sleeving shall then be drawn over joint overlapping itself either side of the joint for a minimum of 300 mm and this shall be tied or taped tightly in position.

13 Any pipe sleeving perforated during fitting shall be repaired by overlaying with a short sleeve folded and secured with tape. Torn or damaged sleeving which is considered by the Engineer as not repairable by this method shall be replaced by the Contractor.

14 Immediately after fitting the pipe sleeving the pipe trench shall be partly backfilled to prevent damage to the sleeving.

4.4.6 Concrete Protection to Pipe

1 Where concrete protection to pipelines is specified or ordered by the Engineer's Representative a 75 mm thick Grade 20 concrete layer shall be laid over the full width of the trench and never less than 150mm wider on each side than the barrel of the pipe and with its top surface positioned as shown on the drawings.

2 This concrete shall be allowed to set and be thoroughly washed down before pipe laying is started.

3 The length of pipeline laid in any one operation before concreting the pipeline shall be that which in the opinion of the Engineer's Representative permits accurate laying of the pipeline and proper compaction of the fill.

4 Pipes up to 1200mm diameter shall be firmly supported on precast concrete blocks and separated from them by 25mm thick saturated softwood packing.

5 Pipes greater than 1200mm diameter shall be firmly supported on precast concrete blocks and separated from them by saturated softwood packing 38mm thick.

6 Alternatively for pipes up to 300mm diameter a layer of concrete Grade 20 of minimum water content can be laid on the 75mm concrete layer and the pipes worked into this concrete to true line and level before it sets. Sufficient space shall be left to enable joints to be made, tested and inspected but the Contractor shall ensure that the barrel of the pipe is fully supported for at least two thirds of the pipe length.

7 After the pipeline has been tested, and approved by the Engineer's Representative, the concrete shall be thoroughly washed down and additional concrete Grade 20 shall be carefully placed and compacted thereon to avoid disturbing the pipes or joints until the appropriate profile for the type of protection required has been reached.

Nominal bore of pipe mm	Minimum thickness of surround mm
Up to and including 500	150
500 – 900	250
1000 – 1100	300
1200 - 1400	350
>1400	400

8 Concrete protection to the pipelines shall be concrete cradle or concrete surround as detailed on the Drawings and shall be of concrete Grade 20. The thickness of the concrete surround below, to the sides and above pipes shall be as follows:

9 When support of excavation is provided building paper shall be placed against that support before concreting to facilitate withdrawal of support.

10 In the case of spigot and socket pipes with flexible joints the concrete protection at each joint shall be interrupted in a vertical plane at the edge of the socket by a strip of fibreboard or other material approved by the Engineer's Representative and of the following thickness:

Up to 300mm nominal bore - 13mm

Over 300 and up to 600mm nominal bore - 25mm

Over 600 and up to 1200mm nominal bore - 38mm

Over1200 and up to 2000mm nominal bore - 50mm

11 The protection and filling of headings shall be of mass concrete Grade 20 and may be carried out in one operation.

4.4.7 Deflection Criteria for Flexible Pipelines

1 All flexible pipelines will be subjected to deflection measurements at Site. Sections of pipe failing to meet the specified deflection criteria shall be removed from the trench and relaid, provided the pipe is not damaged. This procedure shall be repeated until the pipeline is found to be satisfactory. Removal from the trench and relaying shall be an obligation of the Contractor. If the permanent set or deflection, after removal, exceeds the limits set out below, the pipes shall be deemed to be damaged and will therefore be condemned. Pipes so condemned shall be indelibly marked, removed from the Site, and replaced by the Contractor.

2 At all times, backfilling shall be carefully carried out to ensure that no voids or pockets of unconsolidated material are present. The Contractor shall monitor the vertical deflection of the pipes throughout the backfilling operation. No pipe shall exhibit more than 3.0 % deflection after placing and compaction of the granular bed and surround. In addition, after completion of trench backfilling, the average deflection of a length of pipes shall not exceed 3.0 %, and every pipe shall be demonstrated to exhibit no more than the manufacturer's calculated allowable initial deflection, or 5.0 % deflection, whichever is the smaller. If any of these values is exceeded, the affected pipes shall be dismantled and relaid.

3 MDPE and HDPE (PE) pipes may be bent or curved on site down to a minimum radius as recommended by the manufacturer. In the event of the manufacturer providing no recommendation, the minimum bend radius shall not be less than 25 times the pipe OD, Where there are space restrictions the bend radius may be reduced down to 20 times the pipe OD, but only with the written permission of the Engineer.

4 No electro-fusion or mechanical joints should be incorporated in the sections of PE pipework which are to be bent. Instead a formed bend or elbow should be welded in the pipeline in order to prevent excessive stress.

5 The deflection shall also be checked on each length between manholes before commissioning to determine whether longer-term deflections are within the specified limits. The average deflection of a length of pipes shall not exceed 3 %, and every pipe shall be shown to exhibit a deflection no greater than 5 %, whichever is the smaller, at any point. Pipes exhibiting greater deflections shall be exhumed and relaid.

6 Pipes exhibiting a deflection greater than 8 % or 1.6 times the calculated allowable long term deflection, shall be exhumed, indelibly marked "REJECTED", removed from site and not reused.

4.4.8 Backfilling

1 The requirements of Part 2 of this Section shall apply, except as otherwise specified in this Clause.

2 After the pipeline has been tested and approved by the Engineer, the trench shall be carefully backfilled to 300 mm above the crown of the pipe for rigid pipes with granular material. Backfilling of the pipe trench should be carried out as designated, or shown on the Contract Drawings.

3 Where concrete bedding or surround is required, the backfill shall not be placed before the compressive strength of the site concrete has reached 15 MPa.

4 Where concreting to pipeline is specified, a blinding layer of Grade 20 SRC concrete shall be placed over the full width of the trench or heading.

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

6 Concreting to the pipeline shall be either bed or bed and surround as shown on the Drawings and shall be of Grade 20 SRC concrete along such lengths as are shown on the Drawings or ordered by the Engineer.

7 The pipe shall be prevented from moving during concreting.

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

9 When support of excavations is provided, building paper shall be placed against that support before concreting to facilitate withdrawal of the support. Building paper shall comply with BS 1521 Class 'A2'.

10 In the case of pipes with flexible joints, the concrete at each joint shall be interrupted in a vertical plane at the edge of the socket by a strip of fibreboard or other material approved by the Engineer and of the following thicknesses:

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

11 The protection and filling of headings shall be of Grade 20 SRC concrete.

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

4.4.9 Deflection at Joints

1 Where the Engineer orders or allows a change of direction to deflect pressure pipelines from a straight line, either in the vertical or horizontal planes to avoid obstruction or where long radius curves are permitted, the amount of deflection allowed shall not exceed that required for satisfactory connection of the joint and shall be approved by the Engineer. Where a change of direction cannot be made by deflection at the joints of ordinary straight pipes, bends shall be used. The locations of such bends and other specials are shown on the Contract Drawings and their exact positions will be determined by the Engineer on the Site.

4.4.10 Wadi Crossings

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

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

3 The Contractor shall fill the trench in both banks with rock fill or concrete up to the designated levels. The extent of this work may be varied to suit each individual crossing. Unless otherwise ordered, the concrete encasement of the pipe shall extend at least to a section vertically below the tops of the banks. Protection against erosion to the banks shall be provided by means of stone pitching or riprap.

4.4.11 Pipe Supports

1 Pipe hangers and saddle supports shall be of standard manufacture as shown on the Drawings and in compliance with the following general requirements:

(a) piping shall be supported independently from appurtenances to which it is affixed.

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

(c) a support shall be provided for each pipe at or near the point where it is connected to machinery or valves. A support shall be provided for each valve and special fitting.

(d) flexible joints shall be required at either ends of the support system.

(e) where necessary, expansion joints shall also be provided.

(f) pipe hangers and supports shall generally be fabricated in Mild Steel. These shall be galvanised and painted with coal tar epoxy.

2 For pipelines to be fixed in culverts, the Contractor shall prepare proposals for thrust and anchor support and submit them to the Engineer for approval. Such approval shall not relieve the Contractor from his responsibility for the adequacy of his proposal. Additional requirements for both location and details of supports may be shown on the Drawings or directed by the Engineer as the work proceeds to suit the actual conditions encountered.

4.4.12 Building-in Pipes to Structures

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

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

3 Any over-excavation adjacent to a structure or beneath the formation level of a pipeline, either to be constructed under the Contract or in a future contract, shall be backfilled with Grade 20 SRC concrete.

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

5 Where it is impracticable to cast pipes and specials in the concrete, boxouts shall be provided in the formwork. The box shall have six or eight sides, depending on the pipe diameter, and shall be no larger in size than will give adequate clearance for the subsequent positioning and grouting in of the pipe. The sides of the boxout shall be provided with a tapered central annular recess to provide a positive key. The boxout shall be provided with a grout hole and, at the top of the central annular recess a vent hole. The boxhole shall be stripped with the main formwork and the concrete surface thoroughly cleaned and roughened.

6 Unless otherwise shown on the Contract Drawings, where pipes pass through a concrete wall or structure they shall be protected with a surround of Grade 20 SRC concrete integral with the external face of the structure. For pipes of less than 500 mm diameter, the surround shall extend from the wall or structure by 300 mm and the width and depth of the surround beyond the outside face of the pipe at its horizontal and vertical diameters shall be a minimum of 300 mm or as otherwise indicated on the Drawings. For pipes of 500 mm diameter or greater the surround shall extend from the wall or structure by 500 mm and the width and depth of the surround beyond the outside face of the pipe at its horizontal and vertical diameters shall be 500 mm or as otherwise indicated on the Drawings.

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

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

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

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

11 Where the structure is tanked, Grade 20 OPC concrete shall be used and the tanking shall extend to the concrete surround.

4.4.13 Cleanliness of Pipelines

1 Pipelines and manholes shall at all times be kept free of all silt, mortar, debris and other obstructions. When work is not in progress the open ends of the pipeline shall be securely plugged with an approved watertight plug or stopper firmly fixed to resist unauthorised removal. Claw type plugs or any type liable to damage the pipe shall not be used. All such stoppers, plugs or caps shall be provided with a vent incorporating a valve for the purpose of testing whether the pipeline is under pressure or vacuum and to enable pressures to be equalised before its removal.

2 The Contractor shall clear the inside of each fitting and pipe length immediately before jointing and shall swab all fittings and pipe lengths to remove all dirt, sand or other matter that may clog the pipeline or contaminate the fluid to be transported in the pipeline. After jointing, the interior of the pipes shall be freed from any dirt, stones or other matter that may have entered them. For this purpose, a rubber disc, brush, or other suitable implement that will not harm the internal lining of the pipe shall be pulled through the pipe after jointing.

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

4.4.14 Marker Tape

1 All trenches for pressure pipelines, shall be marked with a high quality acid and alkali-resistant red non bio-degradable plastic tape with a minimum width of 150 mm placed during backfilling 300 mm below finished surface or as directed by the Engineer. These tapes shall have a minimum strength of 125 kg/cm^2 in the longitudinal direction and 105 kg/cm^2 transversely with an elongation factor in the longitudinal direction of 350 percent. The text on the tape shall be permanent black ink bonded to resist prolonged chemical attack by corrosive acids and alkaline with message repeated at a maximum interval of two metres. Tapes over non-ferrous pipes shall be detectable by electro-magnetic means using low output generator equipment.

2 The tape wording and colour shall be as follows:

WORDING	COLOUR
DANGER : FOUL SEWAGE	RED
CAUTION TREATED SEWAGE EFFLUENT	GREEN
SURFACE WATER	GREY
WATER MAIN	BLUE
DANGER : FUEL PIPELINE	BROWN

3 The tape shall be laid continuous over pipelines and at joints there shall be a minimum of one metre overlapping. Tape shall be terminated inside valve boxes to allow clipping of detector equipment to the tape.

4.4.15 Pressure Pipeline Marker Posts

1 Pipeline marker posts shall be provided at all points where the pipeline crosses boundaries or changes direction and elsewhere at maximum intervals of 100m. Each marker post shall be set over the centreline of the pipelines with concrete Grade 20 SRC concrete base surround in accordance with the Contract Drawings. Marker posts shall incorporate a description of the pipeline and its service in Arabic and English to the approval of the Engineer. Offset marker posts may also be used in areas where the post could not be installed over the centreline of the pipelines.

2 Coloured marker plates shall be made from multi-layered plastic, green for TSE and orange for foul sewage.

4.4.16 Valve Chamber Marker Posts

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

2 Where the pipeline is in a footpath or verge, the marker post shall be installed against the wall or property boundary and facing the chamber cover, with Grade 20 SRC concrete base surround.

4.4.17 Abandonment of Pipelines

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

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

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

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

5 Upon completion of the above procedure, the Contractor shall undertake abandonment of manholes inspection chambers and other structures. Where a pipeline or service connection to be abandoned connects into a manhole or chamber to be retained, the connection shall be plugged at the chamber wall and the associated channel in the benching of the manhole or chamber shall be cleaned and filled with concrete Grade 20 SRC. The benching shall then be covered with the appropriate protective lining to match the existing manhole lining.

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

4.4.18 Abandonment of Structures

1 Where manholes, septic tanks, cesspits, soakpits and other structures are to be abandoned, they shall be emptied of their contents to the approval of the Engineer. The contents including sludge from these structures, whether undiluted or mixed with sand, shall be disposed of off the Site by the Contractor to a location approved by the Engineer. The Contractor shall submit in writing his proposals for emptying the contents and disposal. No work shall begin on demolition until the structure has been completely emptied.

2 After desludging, the roof slabs and tops of walls of the structure shall be demolished to an elevation not less than 500 mm below existing ground level. The fragments of demolished structures may be used to partially fill the void. Voids shall be filled up with sand, watered and well compacted up to the elevation of the underside of the cover slab. The frames and covers of manholes and chambers shall be removed by the Contractor and delivered to the designated Employers' stores and placed into storage.

3 If an existing service is found within a structure to be abandoned, the Contractor shall inform the Engineer and carry out the Engineer's instructions for ensuring that the service pipeline is retained or restored. If a sleeve is to be provided, the sleeve shall extend for 100 mm on either side of the structure. When backfilling or working around an existing service or sleeve, the Contractor shall take all precautions to ensure that no damage occurs and that there is no interruption of service.

4.4.19 Corrosion Protection of Flexible Couplings and Ferrous Fittings

1 Buried flexible couplings, including flange adaptors shall be protected as follows:

(a) Mastic paste filling (Denso paste or similar)

(b) Mastic tape wrapping (Denso tape or similar)

(c) and finished with cold applied self-adhesive laminate tape wrapping (or heat shrink sleeving) in accordance with Clause 8.4.3.5

2 Couplings, including all associated nuts and bolts, within chambers or pumping stations shall be polyamide powder coated ("Rilsan" or similar).

4.5 PIPELINE STRUCTURES AND APPURTENANCES

4.5.1 Manholes for Foul Sewerage

1 The Contractor shall prepare a standard record sheet for every manhole and structure and shall submit to the Engineer for information only.

2 Manholes shall be constructed as shown on the Contract Drawings and at the locations indicated thereon or at other locations directed by the Engineer.

3 The blinding concrete shall be mass concrete Grade 25 SRC concrete and the manhole base slab, benching and insitu concrete walls shall be Grade C40 SRC concrete.

4 Precast concrete manhole rings shall be manufactured using Grade C50 SRC concrete. The joint surfaces and outer face of the precast concrete rings shall have factory applied epoxy coating in accordance with Part 8 Clause 8.3.15. The inner face of the precast manhole ring shall be a prefabricated GRP liner at least 6mm thick bonded by lugs to the concrete. The completed joints between precast concrete rings shall have an insitu applied sealing strip at least 6mm thick overlapping the GRP liner by a minimum of 150mm each side. The sealing strip shall be capable of withstanding the full hydrostatic head of external ground water to ground level and the maximum internal hydrostatic head, whichever is the greater.

5 The underside of the base and the external faces of insitu concrete bases and walls shall be protected with a membrane tanking system. The necessary period for setting, as recommended by the manufacturer, shall be allowed before beginning other works to complete the construction of the manhole.

6 The cover slab shall be surmounted by ductile-iron manhole cover and frame of the quality specified. The covers in road and paved areas shall be accurately set on precast concrete segments to the level and slopes of the roads or pavements.

7 In the case of shallow manholes, the cover and frame may be cast directly monolithic with the reinforced concrete cover slab and projecting up by 50 mm as shown on the Contract Drawings.

8 The interior face of manholes and access shafts shall be prefabricated GRP liners at least 6 mm thick permanent lining.

9 Prefabricated GRP benchings and channels shall be preformed, inverted and filled with Grade C40 SRC concrete. Alternatively, the GRP lining may be applied to the in-situ concrete benching after constructing the benching.

10 GRP lining to walls shall incorporate lugs moulded onto the outside face at 500 mm centres to allow bonding to the concrete surround. The lining shall have adequate strength to withstand handling, and shall not buckle or distort during pouring of the concrete surround. Internal bracing may be used during pouring of the concrete surround. Internal bracing may be used during pouring to maintain circularity and verticality.

11 Cover slabs shall be precast using Grade C50 SRC concrete and shall incorporate a preformed flat sheet of GRP on the soffit, bonded to a GRP tube to form the access opening. Both linings shall incorporate lugs moulded onto the surface to allow bonding to the concrete. The overall size of the lining to the soffit of the slab shall be 150mm greater than the internal diameter of the manhole onto which the slab is to be placed.

12 In all cases, the outer surface of the GRP, exposed to the sewage atmosphere, shall consist of a chemically resistant layer comprising vinyl ester resin suitably reinforced with a 'C' glass or synthetic tissue veil. This layer shall be no less than 2mm thick, and shall have a resin content by weight of approximately 90% at the exposed surface, reducing to 65% - 75% at the inner surface. The remainder of the liner shall consist of vinyl ester or isophthalic resins and "E" or "ECR" glass chopped strand mat. Fillers, such as silica sand and calcium carbonate shall not be used. Loss of Ignition Test to BS 2782 (method 1002) shall be conducted on random samples of GRP manhole liner to detect percentage of glass and the presence of any silica sand filler.

13 Joints in the lining tubes of insitu concrete manholes shall not normally be permitted.

14 Joints between preformed GRP benchings and lining tubes shall be made using an external sleeve 200 mm long bonded onto both units, and then bandaged using suitable resin and chopped strand mat prior to casting the insitu concrete walls. Such bandaging shall extend 75 mm either side of the edge of the sleeve. On the inside face of the manhole, the joint between the benching and liner tube shall be filled with vinyl ester paste to produce a smooth finish.

15 If GRP linings to benchings are to be formed in situ the surface of the wall lining tube shall be lightly abraded over a height of 150 mm from benching level. A fillet of 50 mm radius shall then be formed of vinyl ester paste at the junction of benching and wall. The GRP lining to the channels and benchings shall then be built up by applying isophthalic or vinyl ester resin to the whole of the benching, fillet and abraded wall lining. A layer of "E" or "ECR" mat shall than be rolled into the resin using a suitable steel roller to exclude all air and provide complete immersion of the glass fibre in the resin. After a period to allow pre-gel to a tacky state a second coat of resin shall be applied followed by a further layer of glass fibre mat. This process shall be repeated until the total thickness of lining is approximately 4 mm. Vinyl ester resin and "C" glass or synthetic tissue veil shall then be used to complete the lining.

16 Top surfaces of benchings shall incorporate silica sand to form a non-slip surface.

17 The precast cover slab shall be seated on the walls using sand/cement mortar. The joint shall be raked out 15 mm deep on the inside face and pointed with an approved pitch extended polyurethane sealant.

18 No fixed ladder is required into manholes on foul sewers. Where ladders in structures are specifically instructed and are shown on the drawings, they shall be fabricated in stainless steel Grade S31 or GRP. All ladders shall comply with BS 5395: Part 3. All fixings shall be stainless steel.

19 Intermediate the Contractor shall provide the Engineer with a 10 year unconditional guarantee against failure of all GRP linings whether caused by defective materials or workmanship. The guarantee shall be valid from the date of completion of the installation and must be handed to the Engineer before the issue of the Final Completion Certificate.

20 All manholes shall be watertight on completion and where leakage is discovered the Contractor shall perform such work and provide all materials as are necessary to render such faulty work watertight. The Contractor is warned that he should expect rubbish and debris to be deposited in the manholes during the course of construction and he should take the necessary measures to ensure that the manholes clean.

21 Backfilling around manholes in roads shall be carried out using granular material as approved by the Engineer.

4.5.2 Manholes for Surface Water Sewerage

1 Bases and mass concrete manholes shall be cast using Grade 40 SRC concrete. Where reinforced concrete manholes are specified they shall be constructed in accordance with the drawings and have a GRP liner complying to Clause 4.4.1. The GRP liner shall extend to 300mm above the soffit of the outlet pipe of the manhole. The inner surface above the GRP liner shall have an epoxy protective coating.

2 The benching and channels shall be GRP lined as Clause 4.4.1.

3 The underside of the base and the sides of insitu concrete bases and walls shall be protected with a membrane tanking system as Clause 4.4.1.

4 Precast Grade C50 SRC concrete manhole rings may be used above the level of the GRP inner liner. The precast rings shall have a factory applied epoxy protective coating to all surfaces.

5 Cover slabs shall be precast using Grade 50 SRC concrete and shall have a factory applied epoxy coating to all surfaces.

6 The Contractor shall provide the Engineer with a 10 year unconditional guarantee against failure of all GRP linings whether caused by defective materials or workmanship. The guarantee shall be valid from the date of completion of the installation and must be handed over to the Engineer before the issue of the Final Completion Certificate.

7 No fixed ladder is required into manholes on surface water sewers. Where ladders in structures are specifically instructed and are shown on the drawings, they shall be fabricated in stainless steel Grade S31 or GRP. All ladders shall comply with BS 5395: Part 3. All fixings shall be stainless steel.

4.5.3 Chambers

1 The Contractor shall prepare a standard record sheet for every chamber for valves, meters, inspection, washouts and other similar purposes for the approval of the Engineer.

2 Chambers shall be constructed in accordance with the Contract Drawings and at the locations or at other locations directed by the Engineer.

3 The Contractor shall ensure that there is a minimum clearance of 300mm around all flanges and parts of valves built into chambers, including the handwheel.

4.5.4 Connections to Existing Pipelines

1 At locations shown on the Contract Drawings or as instructed by the Engineer, the Contractor shall connect the new pipelines to the existing pipelines or structures but not until the said pipelines have passed the final tests.

2 The Contractor shall co-ordinate with Drainage Affairs, Maintenance Department staff to make connections onto existing foul sewers and other drainage pipelines.

3 The Contractor shall be responsible for dealing with all flows while making connections to existing sewers or drainage pipework by over-pumping the entire flow between manholes or other approved bypassing methods. The Contractor shall retain a standby pump and fulltime operator on site during pumping operations.

4.5.5 Anchor and Thrust Blocks

1 The Contractor shall construct anchor and thrust blocks at every bend and junction on pressure pipelines and where otherwise shown on the Contract Drawings or instructed by the Engineer. Each thrust block shall to have a sufficient bearing area and shall be placed to safely transmit thrust to the surrounding original ground. If soft, spongy, unstable or similar material is encountered upon which the thrust block is to bear this unsuitable material shall be removed and replaced with Grade 20 SRC mass concrete as directed by the Engineer.

2 The excavation for the thrust block shall be carried out prior to laying the pipes except that a trimming margin of not less than 150mm shall be left to be removed by hand excavation in order to obtain a firm thrust face against undisturbed ground. This trimming margin shall only be removed after laying and jointing of the pipes and the concrete for the thrust block shall be placed on the same day as the removal of the trimming margin.

3 No pressure shall be applied to thrust blocks until the concrete has matured for at least seven days.

4 "Rocker" pipes shall be installed adjacent to all concrete thrust blocks.

4.5.6 Property Connections Survey

1 The Contractor shall complete and submit to the Engineer for approval a standard record sheet of every property connection. The information shall be recorded on forms provided by the Engineer.

2 The Contractor shall survey and prepare individual plans for each property at a scale of 1:500 (or such other scale as may be agreed by the Engineer's Representative). These shall show existing plot boundaries, location of all buildings, location of all visible services and location and level of all drainage services, including septic tanks. The plans shall indicate the nature of each building, clearly identifying kitchen, mess areas, toilets, washrooms and the drains serving these areas and gullies elsewhere. The plans shall identify the drains serving. The plan shall be submitted on paper and AutoCAD compatible .dwg file. As a separate layer on the dwg file the Contractor shall mark his proposals for the property connection, including a cross-section and this shall be submitted to the Engineer's Representative for approval. No property connection work shall commence before approval to the proposed layout has been received in writing from the Engineer's Representative.

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

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

4.5.7 Future House Connections

1 During the course of the Contract the Engineer's Representative and the Contractor shall agree on a programme regarding the positions and other details of the junctions to be left for future house connections. Such branches and junctions shall in all cases terminate in an approved stopper obtained from the pipe manufacturer.

2 The Contractor shall survey and prepare individual plans for each plot at a scale of 1:500 (or such other scale as may be agreed by the Engineer's Representative). These shall show existing boundary walls or fences and ground level at each corner of the plot. The plan shall be submitted on paper and AutoCAD compatible dwg file. As a separate layer on the dwg file the Contractor shall mark his proposals for the property connection and this shall be submitted to the Engineer's Representative for approval. No property connection work shall commence before approval to the proposed layout has been received in writing from the Engineer's Representative.

3 The Contractor shall produce accurate records of the exact location of all service connections and shall include for these in his rates.

4.6 TESTING OF PIPELINES

4.6.1 General

1 The Contractor shall submit for the Engineer's approval details of his proposed methods and programme for testing (including details of test equipment) and shall arrange for all test to be witnessed by the Engineer or other person appointed by the Engineer. Test equipment shall be approved by the Engineer and calibration certificates when requested by the Engineer shall be submitted. The Contractor shall provide all equipment necessary for carrying out testing and cleaning including pumps, gauges, piped connections, stop ends, and all other temporary works. All water required for testing and cleaning the pipelines shall be from a source approved by the Engineer.

2 Pipelines shall be adequately restrained before being put under test except as hereinafter detailed. No testing will be permitted until seven days after thrust blocks and other holding down works have been completed. Trenches may not be left open at joints before testing pipelines except as permitted by the Engineer who may lay down certain restricting conditions. In addition to any tests of individual joints or other interim tests which may be designated elsewhere, the Contractor shall submit all parts of the pipelines to a final test.

3 This and the following Clauses on testing pipelines do not apply to GRP pipes for which testing requirements are given in the Project Specification where appropriate.

4 Pipelines shall be tested in lengths between manholes or valve pits with lengths not exceeding 400 metres except by agreement with the Engineer's Representative. Testing shall not be against closed valves, and pipes of different diameters shall not be tested together in the same test. The arrangements for testing a pipeline shall include provision for purging the air from the pipeline during the test.

5 In all pipelines which are constructed with mechanical joints or with joints which permit axial movement, the joints shall be left open so that they may be inspected during hydraulic testing. In such cases only the barrels of the pipes shall be backfilled prior to hydraulic testing taking great care to avoid the joints and leaving sufficient space all round the joints to permit inspection and to undertake remedial measures should the joint be found to leak under hydraulic testing. After the successful completion of hydraulic testing, the joints shall, if specified, be wrapped, coated or sleeved as appropriate, and then backfilled in the manner specified elsewhere in this specification.

6 The final test shall be applied in the presence of the Engineer's Representative.

7 The Contractor shall keep a record of all tests in a book which shall be available for inspection and handed over to the Engineer's Representative on demand. The Contractor shall complete standard test record sheets as provided by the Engineer.

8 The section under test shall be properly sealed off with blank flanges or special stop end caps held securely in position by adequate temporary anchorages, and filled with water. All peak points of the pipeline shall be adequately vented during the filling operation using temporary bleed valves. All air valves shall be removed and all other valves shall be set in the open position.

9 Pipe joints, valves and fittings shall be checked carefully for loose bolts or connections which might cause leakage and delay the execution of the tests.

10 Should any section fail to pass the tests, the Contractor shall determine the cause of the failure and shall locate, excavate and repair any damage or leakage sustained by the pipeline before or during the tests and retest the section. The cost of such repair work, additional backfilling and reinstatement and abortive tests shall be borne by the Contractor.

11 Water for the test shall be disposed of in a manner to be approved by the Engineer. Pumping water onto the site shall not be permitted.

12 The Contractor shall be responsible for ensuring that all test methods and procedures comply with his Health and Safety Plan.

13 The Contractor shall provide detailed method statements for his methods of testing access shafts, manholes and pipelines.

4.6.2 Gravity Sewer Pipelines

1 Each pipeline 600 mm or less in diameter shall be tested by air test. Should any pipe fail the air test, the Engineer may order a water test to be carried out. Acceptance of the pipeline will then be based on the results of the water test. All pipelines up to and including 1200 mm shall be tested by air test in accordance with the requirements of EN 752.

2 The Contractor shall, at his own expense, furnish all equipment and materials for making the tests. Each pipeline shall be tested before backfilling and also after backfilling before carrying out road reinstatement or laying new road surfacing. Where the pipeline is located under a new road alignment, the pipeline will be tested after sub-base compaction in complete. All pipelines shall be subjected to pass infiltration tests as specified herein. All pipes are to be clean and empty at the time of testing. Tests shall be performed in the presence of the Engineer.

(a) Air Test:

(i) the Contractor shall plug all pipe outlets with suitable plugs, and brace each plug securely where needed

(ii) air shall be pumped in slowly to the pipe until a pressure of 100 mm water gauge is indicated on a manometer connected to the system. After the internal pressure of 100 mm water gauge is obtained, 5 min shall be allowed for the air temperature to stabilise within the pipe.

(iii) Air may be added to restore the pressure to 100 mm water gauge. During a further period of 5 min, the pressure shall not fall below 75 mm water gauge without further pumping.

(b) Water Test

(i) all the joints of the pipeline shall be able to withstand a pressure of a minimum 5m head of water, above the crown of pipe at the highest point of pipeline without leakage. A layer of embedding soil equal to the diameter of pipe shall be laid over the pipe to prevent the lifting of pipe while applying test pressure. However, all the joints shall be left open for the purpose of inspection for leakage if any. All branches and open ends shall be closed with stoppers, secured with longitudinal braces/thrust block, before testing begins

(ii) water shall be filled from the lowest point and air allowed to escape through an air vent fixed for the purpose at the high points of the pipeline section under test. The diameter of air vent shall be about one and half times the diameter of water inlet pipe to allow easy escape of air. No entrapped air shall remain in the pipeline while testing

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

(c) Infiltration Test

(i) the upper ends of the sewer and service connections shall be closed sufficiently to prevent the entry of water and pumping of groundwater shall be discontinued until the groundwater surface reaches its natural level before beginning the infiltration test the dewatering system shall be stopped, but not be removed until the infiltration test has been successfully completed or as otherwise permitted by the Engineer the infiltration shall not exceed 6 litres per millimetre diameter per kilometre per day of the portion of sewer being tested, including the length of service connection entering that section.

(ii) the total length tested in one section shall not exceed 400 m in length. This length is dependent upon the type of deflection measuring equipment proposed by the Contractor if flexible pipes are used.

(iii) no gravity pipeline will be accepted if the total infiltration exceeds the above mentioned limit and joints will not be accepted if during an internal inspection, any infiltration is visible.

3 Prior to issue of a Certificate of Completion a CCTV survey shall, on the instruction of the Engineer's Representative, be carried out on a representative sample of no more than 12% of the length of constructed pipelines. Should this survey indicate sections of pipeline which fail to meet the specification requirements, the Contractor will be required to carry out remedial works and undertake additional CCTV surveys at his expense.

4.6.3 Pressure Pipelines

1 The pipeline shall be tested between valve chambers or into sections not exceeding 400 m in length unless approved otherwise by the Engineer. The section tests shall be carried out as follows:

(a) each pipeline or section thereof shall be filled with water and all air removed as far as possible

(b) the pressure shall then be raised by pumping in water until the test pressure is reached and shall be maintained at this level by further pumping until it is steady

(c) pumping shall then be stopped and the time taken for the observed pressure to fall by 1.0 m shall be recorded

(d) pumping shall then be resumed and the quantity of water pumped in order to restore the test pressure shall be recorded

(e) if after three hours the test pressure has not fallen by 1.0 m, pumping shall be resumed at that stage, the time being recorded as three hours

(f) the rates of loss shall then be calculated as the recorded quantity divided by the recorded time

(g) the test pump and gauge shall be connected to the pipeline at a location other than the highest point in the pipeline to facilitate release of air from the highest point

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

(i) the loss shall not exceed 0.02 litres per mm diameter per kilometre per 24 hours for each 0.1 MPa of head applied

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

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

(a) all joints between individual test sections shall be left uncovered during this final test

(b) the final test shall be carried out using the same procedure as the section test

(c) in all cases of water tests, where the measured leakage rate exceeds the allowable, the Contractor shall, at his own expense, make all necessary repairs and carryout additional testing until a satisfactory result is obtained

(d) before pressure testing is started the Contractor shall recheck pipes and valves for cleanliness and shall recheck the operation of all valves. The "open" ends of the pipeline or sections thereof) shall normally be stopped off by blank flanges or cap ends additionally secured where necessary by temporary struts and wedges. All anchor and thrust blocks shall have been completed and all pipe straps and other devices intended to prevent the movement of pipes shall have been securely fastened

(e) since valves cannot be guaranteed to be perfectly drop-tight, testing against closed valves which are connected to an existing system shall be prohibited; testing against other closed valves (including air valves) not so connected, may be attempted if desired, provided the valves are suitably anchored against thrust. No claims whatsoever will be entertained on account of leaking valves, or any other difficulties in closing off lengths of pipework for testing, which shall be entirely an obligation of the Contractor

(f) on successful completion of the final test, the exposed joints shall be covered and the trench backfilled as specified in the appropriate Clause 2.3 of this Section.

3 The pipeline shall be tested for a period of at least 24 hours after which the test pressure shall be restored by pumping and the quantity of water lost during the test measured.

4 Plastic irrigation drip pipe work shall be completely filled with water and visually inspected for leakage. No section showing signs of leakage will be accepted. In addition, any length of pipe which in the opinion of the Engineer or his designated representative is showing signs of degradation through contact with sunlight shall be cut out and replaced.

4.6.4 Other Pressure Pipelines

1 Water Pipelines and Other Pressure Piping Carrying Liquids

(a) water pipelines and other pressure piping carrying surface water ground water and treated sewage effluent excluding raw sewage pressure pipelines having socket and spigot gasket joints shall be given a pressure and leakage test. Ductile iron or PVC-U pipe shall be tested to AWWA C600 ; steel pipe to AWWA C200

(b) PVC-U treated sewage effluent pipework shall completely filled with water and visually inspected for leakage. No section showing signs of leakage shall be accepted.

2 Pressure Pipe, Flanged or Welded Joints

(a) PVC-U, steel, cast iron, ductile iron or other pipe material, with solvent welded, welded, threaded, flanged, grooved end or flexible couplings and joints shall be pressure tested. No leakage shall be permitted.

3 Pressure Air and Gas Piping:

(a) All piping carrying air or other gasses under pressure shall be given a pressure test. No leakage is permitted. Low pressure air piping shall be tested pneumatically. Air pressure of 140 kPa shall be applied to piping and fittings. High pressure air piping shall be tested to 1400 kPa. There shall be no drop in pressure in a 24-hour period

(b) Leaks shall be located and repaired to the satisfaction of the Engineer. Pressure drops due to thermal contraction are acceptable if the pressure returns to the original test pressure after 24 hours.

4 All piping, including valves, shall be field tested at the specified pressure with duration of two hours minimum, for each pressure test. Piping conveying liquids between process tankage, not subject to pumping, shall be tested to the maximum possible pressure that can be obtained under static conditions. Air piping shall be tested using air or nitrogen.

5 All exposed pipe, fittings, valves, hydrants, and joints shall be carefully inspected before either being cast in concrete or during the open trench tests, or both. All defects discovered shall be corrected by removal and replacement, as approved by the Engineer, and the work then retested to demonstrate satisfactory performance.

6 Where practical, no concrete encasement or backfilling of pipe joints will be permitted before the satisfactory completion of the tests in any given section.

4.6.5 MDPE and HDPE Pressure Pipelines

1 Upon substantial completion of the pipeline or major sections, the line shall be cleaned and hydrostatically tested to prove integrity of the pipeline section and to detect any leakage prior to commissioning. Testing shall be performed in accordance with the Finnish Standard SFS 3115:E and the procedure described below. The Contractor shall supply all necessary fittings, equipment and facilities required to undertake the testing.

2 The Contractor shall prepare a detailed Method Statement for the pressure test that shall follow the outline test procedure described below and be subject to the approval of the Engineer.

(a) Seal the pipeline. Fix all blank flanges. Remove air valves. Remove all on line equipment that may be damaged by high pressure.

(b) Only test against blank flanges, do not attempt to test against closed valves.

(c) Cover the pipe with sufficient backfill to protect it from direct sunlight, leaving joints exposed where practical.

(d) If backfilling is not practicable schedule the tests for early morning or evening.

(e) Fill the pipeline from the lowest point. Bleed the air from all high points and flange points where it is possible and tighten once water begins to spill.

(f) When the line is full, close off the filling valve and check all flanges and the small diameter test pipework for leaks.

(g) **Phase1**
Commence raising the pressure at the filling point to the operating pressure or a pressure of 5 bar, whichever is higher. Hold this pressure for a period of 2 hours and add water whenever the pressure drops by 0.2 bar in order to maintain a steady pressure.

(h) Visually inspect the pipe length for leakage.

(i) **Phase2**
After two hours raise the pressure to 1.3 times the operating pressure or 6.5 bar, whichever is higher, as quickly as is practical. Again maintain this pressure for two hours by adding water whenever the pressure drops by 0.2 bar.

(j) Visually inspect the pipe length for leakage.

(k) **Phase3**
At the end of the second two hours release the pressure back down to the phase I level i.e. the operating pressure or 5 bar, within a period of no more than 30 minutes and as quickly as is practical, in a controlled manner.

(l) **Phase3–Case1**
If after one hour the pressure in the pipelines remains at or above the operational pressure, the test is considered to be completed with the pipeline passing the hydrostatic test.

(m) **Phase3–Case2**
If after one hour the pressure in the pipeline has fallen below the operational pressure, water shall be added to raise the pressure back to the operating pressure level, having first noted the low pressure before adding any water.

(n) **Phase3–Case2**
Measure the added water by draining it off into a measuring cylinder. (i.e. reduce pressure to the previously recorded low value and save the water bled off). The measured quantity is then compared against the allowable quantity to determine if the pipeline passes the hydrostatic pressure test.

Figure 1 Graphical Representation of the Hydrostatic Test Process
Case 1 – Pipeline passes test without adding any make up water

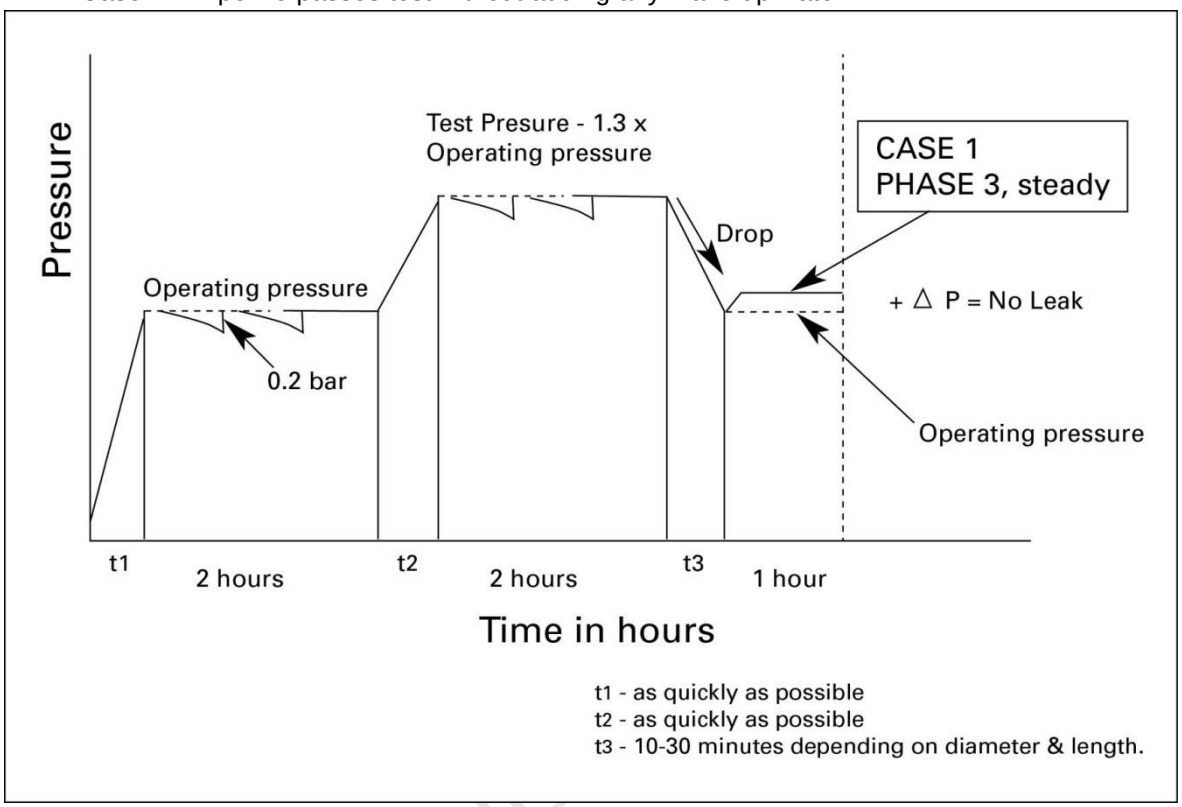
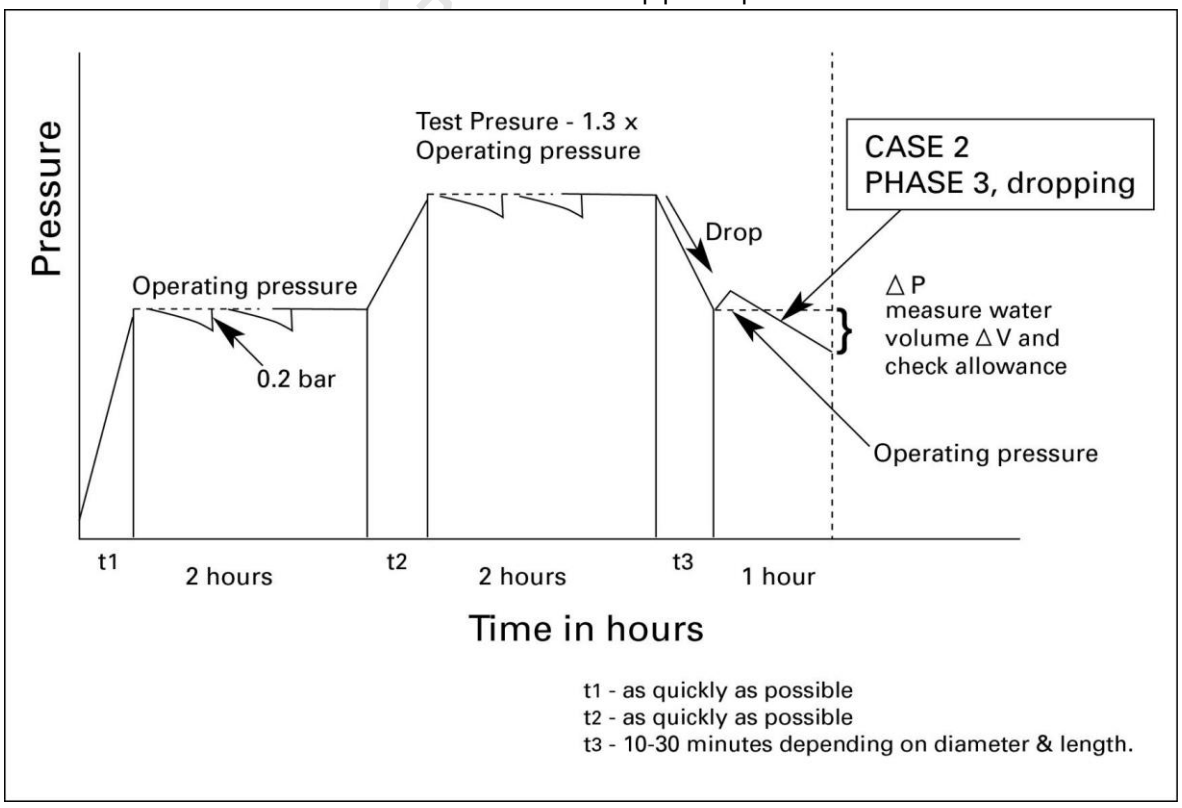


Figure 2 Graphical Representation of the Hydrostatic Test Process
Case 2 – Water to be added to determine if the pipeline passes or fails



3 If during Phase 3 the pressure within the pipeline remains at or above the operational pressure of the pipeline for a period of at least one hour, the pipeline is considered to have passed the hydrostatic test.

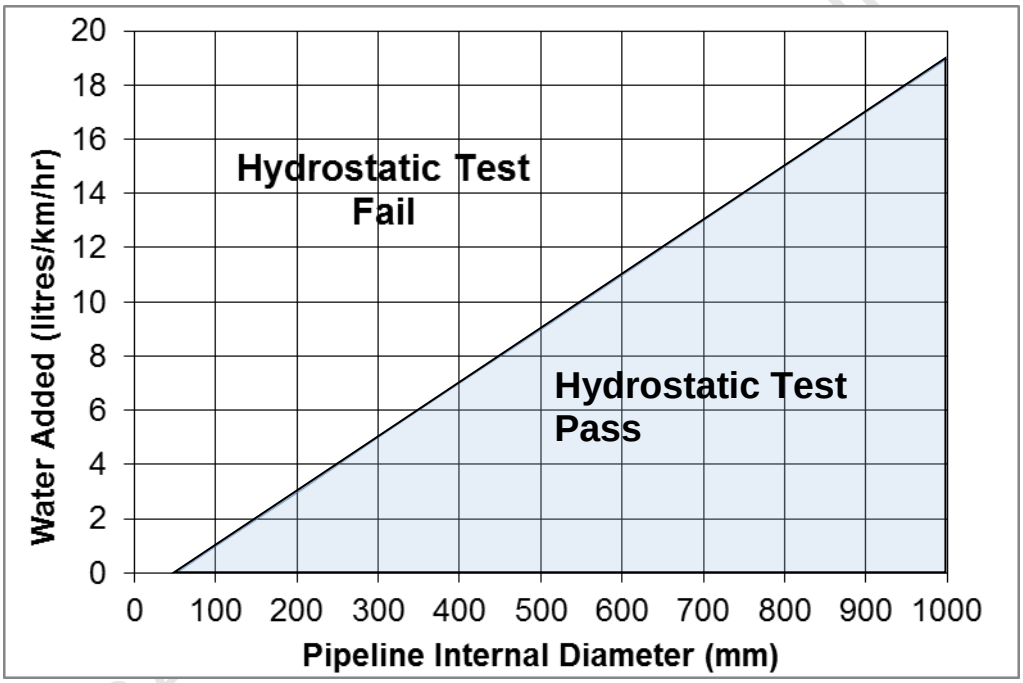
4 If water needs to be added the pipeline is considered to have passed the hydrostatic test if the quantity of water added in terms of litres of water per km of pipeline length per hour of the phase 3 period is less than that given in the following expression and in Figure 3.

$Q \leq Di/50 - 1$ (litres / km/ hour)

Q = added water in litres.

Di = internal diameter for the pipeline in mm.

Figure 3. Hydrostatic Test – Allowable Quantities of 'Make Up' Water



5 The pressure gauge shall be calibrated, certified and to accurate to 0.1 bar. It shall be connected to the feed pipework.

6 The small diameter test pipework shall include a bleed valve at upper end of the pipeline and at all high points together with feed pipework and valve at the lower end of the pipeline. The feed pipework shall include a means of draining off the water in to a measuring cylinder that shall have a capacity of at least 2 litres capacity, graduated to 100 mls.

7 The Contractor shall also have a thermometer for air and water temperature measurement.

8 Care should be taken not to over pressure the lower end of the system during testing. Gauges should always be placed at the lower end of the length under test. As far as possible the difference between the lower and upper end should be kept to one bar. It is recognized that this may not always be possible when longer lengths are being tested, or where the slope of the pipeline makes it impractical.

9 Where the phase II pressure is within the pressure rating of the pipe and test temperatures are 30 ^{O}C or less no adjustment of test pressure is necessary.

10 When ambient temperatures at the time of test are over 30ºC and test pressures are over the pressure rating of the pipe then it may be necessary to modify the test pressure according to the table below or as agreed with the pipe manufacturer.

Test Temp. (ºC)	32	38	43	49	54	60
Multiplier	0.9	0.8	0.75	0.65	0.6	0.5

11 When undertaking the testing the Contractor shall also take in to account the following points.

(a) Care should be taken that any mechanical elements on the system are protected from elevated pressure or completely removed from the pipeline.

(b) Do not subject the line to prolonged over-pressure. Always aim to complete the procedure within one working day.

(c) During the summer make sure that the pipe is not subject to direct sunlight during testing.

(d) During pressure testing pay full attention to the HSE aspects of the procedure. In particular keep the general public away from high pressure test areas.

(e) The test equipment must be capable of pressurizing the test length within a reasonable time. If the procedure becomes protracted (beyond one working day) the test length may be modified or reviewed. Extremely long test lengths may be subject to special procedures.

4.7 MISCELLANEOUS ITEMS

4.7.1 Manhole Covers and Frames

1 Manhole covers shall be made from ductile iron and comply with EN 124 which shall include:

(a) Documentation confirming EN 29002 certification; or

(b) Documentation identified under Annex A to EN 124, concerning Independent Third Party Inspection.

(c) Independent random sample testing at an approved testing facility to demonstrate full compliance with all aspects of the code i.e. load testing and dimensional tolerances.

(d) Production facilities shall be quality assessed in accordance with ISO 9000 or EN 29002 (BS 5750).

2 Where manholes are located in road carriageway, the covers shall be non-rock double triangular Class D400 unless otherwise designated. The double triangular cover shall be loosely coupled with stainless steel bolts. The frames for sewer and surface / ground water manholes shall provide a minimum access opening of 750mm square. The frames for TSE chambers shall provide a minimum access opening of 675mm square.

3 Manhole covers in paved areas, car parks, verges, roads within property boundaries, and other areas accessible to pedestrians and light vehicles, shall be non-rock double triangular Class B125 unless otherwise designated. The double triangular covers shall be loosely coupled with stainless steel bolts plate. The frames for sewer and surface / ground water manholes shall provide a minimum access opening of 750mm square. The frames for TSE chambers shall provide a minimum access opening of 675mm square.

4 All castings shall be grit blasted and coated on all exposed faces with a zinc primer and coal-tar epoxy paint finish in accordance with Part 8 of this Section which shall result in a smooth coating, tough and tenacious when cold, and neither tacky nor brittle.

5 The covers and frames on foul sewers shall incorporate a removable self-sealing GRP or similar corrosion resistant plate meeting the requirements of Part 7 of this Section. The plate shall fit between the cover and the frame such that no surface area of the frame shall be exposed to the atmosphere within the manhole. This shall be achieved by the inclusion of a neoprene sealing ring or by a similar approved method. The plate shall be complete with a lifting handle on the upper surface. The design of the frame and cover and plate shall be subject to the approval of the Engineer. A heavy grease seal is to be formed in all cases between the cover and frame to prevent the ingress of sand.

6 Manhole covers for sewerage, surface water and treated sewage effluent systems shall have the following words embossed in both English and Arabic, respectively:

(a)	Sewerage:	Drainage
		Foul Sewer
(b)	Surface water:	Drainage
		Surface Water
(c)	Treated sewage effluent:	Drainage
		Treated Sewage Effluent.

7 The size of lettering shall be approved by the Engineer.

8 The Contractor shall supply one pair of manhole keys or prying and lifting bar, as appropriate with each 30 covers provided with a minimum of one tool for each type cover. Keys and prying and lifting bars shall be of approved appropriate design to match the different cover configurations. Keyways in manhole covers shall be of the closed type.

9 Any manhole covers and frames on sewer or surface / ground water manholes that are damaged or otherwise disturbed during the execution of the Works shall be replaced with covers and frames with a minimum clear opening of 750mm square and incorporate a GRP sealing plate. If the opening through the concrete cover slab is less than 750mm square, then the concrete slab shall also be replaced.

10 Manhole covers for foul sewerage, surface water and treated sewerage effluent shall be provided with inscriptions both in Arabic and English cast into the top surface of the cover. The lettering shall conform to the details given elsewhere in these documents or to the current details available from Drainage Affairs.

2. Duct Covers and Frames

11 Duct covers and frames shall be of cast iron, ~~galvanised mild steel~~ or aluminium as shown on the Drawings, and shall be waterproof, non-rocking and recessed for filling with concrete.

12 Cast iron duct covers and frames shall be obtained from an approved experienced manufacturer, shall have machined seating faces and sloping mating faces to facilitate sliding out of covers. The covers shall be capable of withstanding a 5 tonne wheel load when the recesses are filled with Grade SRC 25 concrete, or such other load as may be shown elsewhere in the Contract Document.

13 Galvanised steel covers and frames shall be obtained from an approved experienced manufacturer. Covers shall have solid bases fitted with reinforcing rods and where detailed on the drawings shall incorporate locking bolts. Covers shall be capable of withstanding a 5 tonne wheel load when filled with Grade SCR 25 concrete, or such other load as may be shown elsewhere in the Contract Document. Covers shall generally be filled with concrete, but finished with tiling to match the surrounding floor finish.

14 Aluminium duct covers and frames shall be fabricated from aluminium alloy Grade 6063-T6 or other such chemically resistant alloy which the manufacturer can demonstrate will withstand aggressive atmospheres likely to be encountered. Covers shall have solid bases, and shall incorporate reinforcing bars held in place in plastic clips. Those faces of the frame which will come into contract with cement mortar or concrete shall be painted with two coats of bituminous paint before installation of the frame.

15 All covers shall be installed strictly in accordance with the manufacturer's instructions.

16 Two complete sets of lifting keys including any necessary spanners shall be provided in each room in which ducts covers are installed.

17 A heavy grease seal is to be formed between the cover and frame to prevent the ingress of sand.

18 Multiple covers shall have removable intermediate beams.

4.7.2 Hinged Aluminium Access Covers

1 Hinged aluminium access covers shall be fabricated from chequer or ribbed plate. The covers shall be designed to carry a uniformly distributed load of 7.5 kN/m^2, and deflection under this loading shall not exceed one percent of the span.

2 The frame shall be made from aluminium alloy complying with BS 1474 Grades 6063-T6 or 6082-T6.

3 Where a cover is to be located within tiled areas, the frame shall be made from channel sections. The outer vertical arm of the channel frame shall be set flush with the top of the adjacent floor finishes. The inner vertical arm shall be shorter to allow the chequer plate to sit the inner arm, while allowing the chequer plate cover to be flush with adjacent floor finishes. The edges of the chequer plate cover shall be turned down into the channel section. Hinges shall not stand proud of the cover and sealed lifting eyes shall be provided complete with two lifting keys for each cover.

4 Where a cover is to be located on concrete upstands or flat concrete surfaces, the frame shall be made from angle sections. The edges of the chequer plate cover shall be turned down over the angle frame to provide a weatherproof cover. A lifting handle shall be provided on the edge opposite the hinges and a hasp provided for locking the cover with a padlock. The frame shall be bolted down to the concrete below using a minimum of four 10 mm diameter stainless steel acrylic resin anchors.

5 Fixings shall be of stainless steel. Gaskets shall be provided to isolate aluminium alloy from other material.

4.7.3 Drainage Channels for Vehicle and Pedestrian Areas

1 Drainage channels for Vehicle and Pedestrian Areas shall comply with the requirements of EN 1433.

4.8 FUTURE SEWER CONNECTION

4.8.1 General

1 All stub pipes and pipes built into manholes for future connections are to be sealed with an approved stopper, obtained from the same manufacturer as the pipe.

2 Marker posts shall be provided at the ends of all pipes left for future connection except where a single stub pipe is built into a manhole and are to be located as directed by the Engineer's Representative.

4.9 INSITU LINING OF EXISTING MANHOLES

4.9.1 General

1 Where directed by the Engineer, the Contractor shall apply a GRP lining to all internal surfaces of an existing manhole. The lining shall generally comply with the requirements of Specification Clause 4.4.1.

2 The cover slab and manhole cover shall be removed. The slab shall be disposed to an approved tip. The manhole cover and frame shall be thoroughly cleaned, treated with two coats of bituminous paint and submitted to Drainage Affairs Store.

3 All surfaces to be lined shall be clean and dry, step irons and any unsound materials shall be removed to the satisfaction of the Engineer prior to the commencement of any lining or sealing work.

4 For walls a preformed liner sized to fit in the existing manhole may be used. The joint between the base of the liners and existing benching shall be sealed into a chase cut into the existing benching by a heavy duty epoxy resin based sealant approved by the Engineer, which must be applied strictly in accordance with the manufacturer's instructions. The space between the existing internal concrete wall of the manhole and the liner shall be filled using an approved non-shrink cementitious grout.

5 Alternatively an in situ wall lining may be used. The walls shall first be made good with 3:1 sand cement mortar and the surfaces to be lined shall be lightly abraded. An in-situ lining 6mm deep in compliance with Specification Clause 4.4.1.9 shall then be formed.

6 On completion of the lining a new GRP ladder shall be installed in accordance with Specification Clause 4.4.1.15, if shown on the Contract Drawings.

7 A new cover slab and manhole cover shall be provided. The cover slab shall comply with Specification Clause 4.4.1.9. The manhole cover and frame shall comply with Specification Clause 4.6.1.

8 The Contractor shall provide the Employer with a 7-year unconditional guarantee against failure of all GRP linings whether caused by defective materials or workmanship. The guarantee shall be valid from the date of completion of the installation and must be handed to the Engineer before the issue of the Certificate of Completion.

END OF PART