11 SEWER REHABILITATION

11.1 GENERAL

11.1.1 Scope

1 This Part includes the specifications for all work necessary to rehabilitate sewers, manholes and chambers including, but not limited to:

(a) sealing of sewers and manholes
(b) manhole rehabilitation
(c) manhole lining
(d) sliplining of sewers
(e) deformed pipe lining
(f) cured-in-place pipe (inversion method)
(g) spiral wound profile liner
(h) pipe cracking or bursting.

2 Related Sections and Parts are as follows:

This Section

Part 1..... General
Part 2..... Earthworks
Part 4..... Pipeline Installation
Part 6..... Metal Works
Part 7..... Miscellaneous GRP Works
Part 8..... Painting and Protective Coatings
Part 10..... Sewer Cleaning and Inspection Survey

11.1.2 References

1 The following standards and other documents are referred to in this Part:

ASTM C923 M.....Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures Pipes and Laterals [Metric]
ASTM D543.....Resistance of Plastics to Chemical Reagents
ASTM D618.....Methods of Conditioning Plastics and Electrical Insulating Materials
ASTM D638.....Standard test method for tensile properties of plastics.
ASTM D746.....Standard test method for brittleness temperature of plastics and elastomers by impact.
ASTM D790.....Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D883.....Definition of Terms Relating to Plastics
ASTM D991.....Standard test method for rubber property-volume resistivity of electrically conductive and antistatic products.
ASTM D1238.....Standard test method for melt flow rates of thermoplastics by extrusion plastometer.
ASTM D1248.....Specification for Polyethylene Plastics Moulding and Extrusion Materials
ASTM D1505 .....Standard test method for density of plastics by the density gradient technique.

ASTM D1525.....Standard test method for Vicat softening temperature of plastics.

ASTM D1600.....Abbreviations of Terms Relating to Plastic Pipes

ASTM D1693.....Test for Environmental Stress-Cracking of Ethylene Plastics

ASTM D1784.....Specification for Rigid PVC Compounds and Chlorinated PVC (CPVC) Compounds

ASTM D2122.....Method for Determining Dimensions of Thermosetting Pipe and Fittings by Acetone Immersion

ASTM D2152.....Test Method for Degree of Fusion of Extruded PVC Pipe and Moulded Fittings by Acetone Immersion

ASTM D2240.....Standard test method for rubber property-Durometer hardness.

ASTM D2412.....Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

ASTM D2444.....Test Method for Impact Resistance of Thermoplastic Pipe and Fittings by means of a Tup (Falling Weight)

ASTM D2657.....Practice for Heat-Joining Polyolefin Pipe and Fittings

ASTM D2837.....Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials

ASTM D3035.....Specification for Polyethylene (PE) Plastics Pipe (SDR-PR) Based on Controlled Outside Diameter

ASTM D3350.....Specification for Polyethylene Plastics Pipe and Fittings Materials

ASTM D3753.....Specification for Glass-Fiber-Reinforced Polyester Manholes

ASTM D4703.....Standard practice for compression moulding thermoplastic materials into test specimens, plaques or sheets.

ASTM F412 .....Definitions of Terms Relating to Plastic Piping Systems

ASTM F477 .....Specification for Elastomeric Seals for Joining Plastic Pipe

ASTM F585 .....Practice for Insertion of Flexible Polyethylene Pipe into Existing Sewers

ASTM F714 .....Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

ASTM F1216 .....Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

ASTM F1248 .....Standard test method for determination of environmental stress crack resistance (ESCR)of polyethylene pipe.

ASTM F1533 .....Standard specification for polyethylene (PE) pipe

ASTM F1606 .....Standard practice for rehabilitation of existing sewers and conduits with deformed polyethylene (PE) liner.

ASTM F1697 .....Standard specification for poly (vinyl chloride) (PVC) profile strip for machine spiral-wound liner pipe rehabilitation of existing sewers and conduits

ASTM F1698 .....Installation of Poly (Vinyl Chloride) (PVC) Profile Strip Liner and Cementitious Grout of Rehabilitation of Existing Man-Entry Sewers and Conduits

ASTM F1741 .....Standard practice for installation of machine spiral wound poly (vinyl chloride) (PVC) liner pipe for rehabilitation of existing sewers and conduits.

ASTM F794 .....PVC Large Diameter Ribbed Gravity Sewer Pipe and Fittings based on Controlled Inside Diameter

BS 4346 .....Joints and fittings with unplasticized PVC pressure pipes

BS 5556 .....Specifications for general requirements for dimensions and pressure ratings for pipes of thermoplastic materials

BS 5955 .....Code of practice for plastic pipe work

BS 8010 .....Pipelines

EN 681-2 .....Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Thermoplastic elastomers

EN 681-1 .....Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Vulcanized rubber

EN 752 .....Drain and sewer systems outside buildings - Sewer system management

EN 1401 .....Plastics piping systems for non-pressure underground drainage and sewerage - Unplasticized poly(vinyl chloride) (PVC-U)

EN 12201-3 .....Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE)

EN 1852-1 .....Plastics piping systems for non-pressure underground drainage and sewerage - Polypropylene (PP)

CP 312, ...Plastic pipe work

ISO 161 .....Thermoplastic Pipes for the Transport of Fluids Nominal Outside Diameters and Nominal Pressures

ISO 9000 .....Quality Systems

ISO 9967 .....Method for Determination of Long Term Ring Stiffness

WRc.....Sewer Rehabilitation Manual

11.1.3 Definitions

1 The following terms have the meanings hereby assigned to them except where the Contract clearly renders these meanings inapplicable:

(a) Sliplining: insertion of a new liner pipe into an existing pipeline of larger diameter followed by grouting of the annulus.

(b) Cured-in-place, inversion, in-situ or soft lining: the creation of a new pipe within an existing pipeline by insertion of a resin impregrated polyester felt liner by inversion under pressure lining inversion under pressure, the liner then being cured in-situ.

(c) Spiral wound profile lining: insertion of helically wound, profile walled thermoplastic sections to form a liner, followed by grouting of the annulus.

(d) Deformed pipe lining: a continuous deformed pipe which reverts to its predeformed shape after installation.

(e) Pipe cracking or bursting: replacement of an existing pipeline between manholes or inspection chambers or a combination thereof with a new pipe of equivalent or greater size whereby the new pipe is inserted behind the pipe breaking machine as fragments of the existing pipe are displaced to the sides.

(f) Length of sewer: length of sewer pipe between two consecutive manholes or inspection chambers.

(g) Service connection: the connection of the property sewer with the main sewer pipeline.

11.1.4 Submittals

1 The Contractor shall submit complete data and details of sewer rehabilitation for the Engineer's approval as follows:

(a) name and experience of specialist subcontractor

(b) a programme of work, detailed method statement, and schedule of plant to be used in the Works, detailing the working practices, and specialist equipment.

(c) proposed method of overpumping or flow diversion as applicable to undertake sewer rehabilitation.

(d) specific data for proposed materials and equipment for the Engineer's approval 14 days prior to commencement of any sewer rehabilitation works as follows:

(i) test certificates and technical literature to show that the sealants, liners, and lining systems materials proposed meet the requirements stated in the specifications.

(ii) original catalogues specific to the requirement for all proposed equipment. All equipment shall be suitable and made of such materials to withstand the prevailing climatic conditions of Qatar and the corrosive environment.

(e) Specific data to be submitted while carrying out and at the completion of the work:

(i) records of sealing of sewers in each length of sewer, including joint sealing verification results

(ii) CCTV video tapes, pictures in digital format (TIFF) and site coding sheets prepared in accordance with Part 10 of this Section showing the initial condition and the completed work including the restored condition.

(f) The Contractor shall submit to the Engineer following data for 15 sewer rehabilitation projects carried out by the proposed subcontractor during the last five years:

(i) project location

(ii) name and address of client

(iii) start and completion dates.

(iv) cost of the works

(v) length, diameter and material of pre-rehabilitated sewers

(vi) length, diameter and liner material for each type of rehabilitation system

(vii) reference letter from the client or the engineer.

2 The Contractor shall submit the following data to supplement (d) of this sub-clause:

(a) Sewer Liner
- (i) Manufacturers name.
- (ii) Suppliers name.
- (iii) Installers name (Subcontractor)
- (iv) Product name (if applicable).
- (v) Product description.
- (vi) Manufacturers technical data.
- (vii) Test results or certificates.
- (viii) Checked and approved liner pipe thickness design and stiffness calculations.
- (ix) Storage instructions.
- (x) Installation instructions.
- (xi) Installation records in the same project area
- (xii) Proposed grout mixture where applicable.

(b) Manhole and joint sealing materials and manhole rehabilitation materials
- (i) Manufacturers name.
- (ii) Suppliers name.
- (iii) Installer name (Subcontractor)
- (iv) Product name (if applicable).
- (v) Product description.
- (vi) Manufacturers technical data.
- (vii) Test results or certificates.
- (viii) Storage instructions.
- (ix) Application instructions.

3 The Contractor shall submit method statements to the Engineer for approval 4 weeks in advance of commencing the site activity. These shall comprise but not necessarily be limited to:

(a) Sewage bypass pumping and/or diversion plan which shall include an emergency response plan to be followed in the event of a failure of the bypass pumping and/or diversion plan.

(b) Detailed construction plan including:
- (i) Equipment set-up and locations of proposed access points.
- (ii) Anticipated cut off periods for services.
- (iii) Procedures for verification of active service connections.
- (iv) Procedures for notifying affected residences and businesses.
- (v) Procedures for complying with traffic control.
- (vi) Procedures to be adopted to obtain permits to work from the Drainage Affairs.
- (vii) Safety procedures in particular working with scaffolding, entering confined spaces and operations with hot media.
- (viii) Sewer cleaning procedures.
- (ix) Liner installation procedures.
- (x) Procedures for sealing annular space between liner pipe and host pipe where applicable.

(xi) Methods of sealing any annular space between liner pipe and host pipe at manholes.

(xii) Procedures for manhole liner-pipe liner joint sealing.

(xiii) Procedures for manhole rehabilitation.

(xiv) Procedure for any required modifications (temporary or permanent) to existing manholes (such as widening of access opening, removal of cover slabs, removal of intermediate landings, ladders, removal of manholes benching etc).

4 The Contractor shall submit drawings to the Engineer for approval in advance of commencing the site activity. These shall comprise but not necessarily be limited to:

(a) Liner insertion locations.

(b) Sewage bypass pumping and/or diversion locations.

(c) Liner end sealing at manholes and GRP lamination to manhole wall and benching liners.

(d) Any required modification to existing manholes.

5 Representative samples, as agreed with the Engineer, must be submitted for at least the following items before work commences.

(a) Proposed liner system.

(b) Liner to host pipe sealing materials.

(c) Manhole rehabilitation materials.

(d) Manhole liner to pipe liner sealing materials.

11.1.5 Quality Assurance

1 The system shall be design to comply with the appropriate provisions of BS 2782, BS 3412, BS 5556, EN 752 and BS 8010.

2 The Contractor shall employ approved prequalified specialist subcontractors designated in the Project Specification.

3 The specialist subcontractor shall conduct this work in accordance with the quality management procedures conforming to ISO 9000.

4 Key operators employed of the subcontractor shall be competent in the relevant sewer rehabilitation methods and techniques.

11.1.6 Warranty

1 The Contractor shall provide the Engineer with a seven year unconditional warranty against failure of all GRP manhole linings whether caused by defective materials or workmanship. The warranty shall be valid from the date of completion of the installation and submitted to the Engineer as a precondition to the issuance of the Certificate of Completion.

11.2 GENERAL REQUIREMENTS

11.2.1 Work Programme Review, Cleaning, Inspection

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

2 The Contractor shall provide methods statements for each of the rehabilitation methods and systems he proposes to use for each of the functional requirements designated in the Project Specification.

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

4 The Engineer and the Contractor shall agree on the locations and systems to be used for rehabilitation if necessary, and if necessary, the Contractor shall review and revise his programme of work and submit to the Engineer for approval. The Engineer's approval shall not relieve the Contractor of his obligations under the Contract.

5 Sewer cleaning, inspection and overpumping work shall be satisfactorily completed before undertaking sewer rehabilitation.

11.2.2 Safety

1 The Contractor shall carry out all operations in accordance with the safety requirements specified in Section 1 and Part 10 of this Section.

11.2.3 Preparation for Installation of Linings

1 The following installation procedures shall be adhered to unless approved otherwise by the Engineer:

(a) before installing lining in sewers the Contractor shall ensure that the sewers are clean of debris in accordance with Part 10 of this Section. Sewers shall also be gauged to ensure that they can accommodate the liners.

(b) the Contractor shall inspect by CCTV the section or sections to be lined and shall record salient features including any obstructions and service connections, in accordance with Part 10 of this Section.

(c) the Contractor shall overpump the sewage flow around the section or sections of the pipeline that are to be lined. The overpumping shall be carried at in accordance with Part 10 of this Section. Leaks in the pipes due to groundwater infiltration shall be stopped by grouting or other appropriate methods approved by the Engineer.

(d) the Contractor shall clear the pipeline of obstructions, solids, dropped joints, or tree roots or collapsed pipe that will prevent the insertion of the liner. Where inspection or gauging reveals an obstruction that is not at the location of the entry shaft, the Contractor shall remove the obstruction by means of a cutting machine inserted into the sewer line. Where this is not possible, the Contractor shall make an excavation to expose and remove or repair the obstruction as directed by the Engineer.

(e) a temporary tie-in shall be made between the relined section and the existing system and the bypass plug removed at the end of each working day.

(f) Prior to dispatch of any product and/or material from source the Contractor shall notify the Engineer in writing in sufficient time to allow the Engineer the opportunity to inspect and test the product and/or material prior to delivery.

(g) To allow the Engineer to inspect the Works the Contractor shall give the Engineer a minimum of 24 hours notice of carrying out the following activities on site.

(i) Sewer cleaning.

(ii) CCTV survey.

(iii) Sewage bypass pumping and/or diversion.

(iv) Liner installation.

(v) Manhole rehabilitation.

(h) No lining work shall be permitted until the prepared sewer has been inspected and approved by the Engineer.

(i) Where it is necessary to carry out any modification to existing manholes to enable manhole and/or sewer cleansing, CCTV survey or sewer rehabilitation, the Contractor shall carry out any such modification to the Engineer's approval. Following completion of the works in a manhole, the Contractor shall return the manhole to its original or better condition to the approval of the Engineer including reinstatement to surfaces disturbed as a result of manhole modification/sewer rehabilitation. Modification to manhole may include removal of manhole cover slab, intermediate landing slabs, platforms and manhole benching. Removal of intermediate landing slabs/platforms may be considered as permanent (i.e. may not necessarily be reinstated) provided the GRP wall liner is extended to cover the exposed area due to slab removal and welded to the existing liner, and the GRP ladder is adjusted and re-installed as a continuous ladder throughout the manhole height.

(j) Unless specifically itemised and listed in the BOQ, modifications to manholes which may be necessary to carry out the sewer rehabilitation and associated works shall be deemed to be included in the sewer rehabilitation rates.

11.2.4 Delivery, Storage and Handling

1 Delivery, storage and handling of products and materials shall be in accordance with the manufacturers' recommendations and the following provisions.

(a) Delivery storage and handling shall at all times be performed in a manner to avoid product damage.

(b) The liner shall not come in contact with any sharp projections that may cause damage during transportation loading and unloading. Cover liner during transportation.

(c) Store materials on a flat level area and raised above the ground on timber bearers.

(d) Store materials under opaque cover and out of direct sunlight at all times. Maintain a free flow of air around materials at all times.

(e) The Contractor shall visually inspect all products upon delivery to site and report any damage to the Engineer.

2 Any products damaged during delivery, storage and handling shall be marked by the Contractor and set aside.

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

4 Any damaged products deemed unsuitable for repair by the Engineer shall be removed from site and replaced.

11.2.5 Annulus Grout

1 Low strength grout filling the annular space between the host pipe and the liner (where applicable) shall be a cementitious mixture incorporating suitable admixtures as approved by the Engineer and shall have a minimum compressive strength of 12N/mm^2.

2 Generally, the equipment shall be capable of performing the specified operations in lines where flows do not exceed the maximum line flows for joint testing/sealing.

11.3 SEALING OF PIPES AND MANHOLES

11.3.1 Scope

1 Complete ~~or~~ an initial step of rehabilitation by the remote sealing of sewer pipe joints using a sealing packer. The materials specified herein shall also be applicable in sealing of man-access sewers and manholes.

11.3.2 Sealing Compounds

1 The sealing material shall comply with EN 681 and shall perform effectively in the intended application and under expected field conditions.

2 Mixing and handling of sealing materials shall be in accordance with the manufacturer's recommendations.

3 Chemical sealing compounds shall have the following properties and characteristics:

(a) while being injected, the chemical sealant shall be able to react/perform in the presence of either, or both, surface water or groundwater, if present

(b) the cured material shall withstand submergence in either, or any combination of, surface water, groundwater, sea water or sewage without degradation

(c) the resultant sealant formation shall prevent the passage of water through the sewer pipe joint

(d) the sealant material, after curing, shall be flexible

(e) in place, the formed sealant shall be able to withstand wet/dry cycles without adversely affecting the seal

(f) the formed sealant shall be non-biodegradable

(g) the cured sealant shall be chemically stable and resistant to the chemical constituents sewage and the sewer environment

(h) packaging of component materials shall

(i) be compatible with site storage and handling requirements

(ii) ensure worker safety

(iii) cause minimal spillage during handling

(i) mixing of the component materials shall be compatible with field operations

(j) cleanup shall be effected without inordinate use of flammable or hazardous chemicals

(k) residual sealing materials shall be removed from the sewer to prevent any blockage of the sewage flow.

4 Chemical resin for sealing pipe joints and manholes shall be a hydrophilic polyurethane compound suitable for injection.

5 The material must be "salt-water" grade, able to react with saline ground water to form a flexible seal.

11.3.3 Joint Sealing of Pipes

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

2 The sealing equipment shall comprise a CCTV survey system, chemical sealant containers, pumps, regulators, injection sealing packers, hoses, valves and all other necessary apparatus and tools required for sealing sewers of the various diameters. The packer shall be cylindrical and shall be so sized and have cables attached at each end to enable it to be pulled freely through the pipeline. The packer device shall be constructed in a manner to allow an amount of sewage to flow as designated in the Project Specification.

3 Joint shall be sealed by injecting chemical sealing compound into or through faulty joints using a system of pumps, hoses, and sealing packers. Jetting or driving pipes from the surface that could damage the pipelines or impair their structural integrity will not be permitted. Uncovering the pipe by excavation of pavement and soil will not be allowed. The packer shall be positioned over the faulty joint by means of a measuring device and the CCTV camera in the pipeline. The Contractor shall ensure that the packer is accurately positioned over the joint. The packer ends shall be expanded using controlled pressure. The expanded ends shall seal against the inside periphery of the pipe to form a void area at the faulty joint which shall be completely isolated from the remainder of the pipeline. Sealant compound shall be pumped into the isolated area through the hose system at controlled pressures in excess of groundwater pressure, if any.

4 Upon completing sealing of each joint, the packer shall be completely deflated then reinflated and the joint retested. Should the void pressure meter not read zero after deflation, the Contractor shall clean his equipment of residual grout material or make the necessary equipment repairs/adjustments to produce accurate void pressure readings. Joints that fail to meet the specified test criteria shall be resealed and retested until the test criteria can be met.

5 Residual sealing materials protruding into the pipe shall be removed. The sealed joints shall be left flush with the pipe surface. Excessive residual sealing materials which accumulate in the pipeline shall be removed.

6 Records shall be kept of joints sealing performed in each length of sewer to identify the length of sewer in which joints were, the location of each joint sealed, and the joint sealing verification test results.

7 Not more than one month before the expiration of the Period of Maintenance and as a precondition to the Engineer's issuance of the Maintenance Certificate for the Contract, sewers shall be retested as follows:

(a) an initial retest area consisting of specific lengths of sewers will be selected by the Engineer. Length of sewers to be retested shall be randomly selected throughout the project area and shall be representative of the majority of the sealing work originally performed. The initial retest area shall consist of at least 5 %, but not exceed 10 %, of the length contained in the Contract

(b) within the initial retest area, the Contractor shall retest all previously sealed joints as specified. Any joints failing the retest shall be resealed at no extra cost to the Employer

(c) if the failure rate of the joints exceeds 5 % of the retested joints, an additional retest area of equivalent size will be selected by the Engineer and all previously sealed joints shall be retested. The additional testing and sealing, where necessary, shall continue until a failure rate of less than 5 % is achieved

(d) additional testing or sealing required beyond the initial retest area shall be accomplished at the Contractor's expense. The Contractor shall provide adequate number of crews at Site so that the retesting will proceed at a rapid rate.

8 The pumping unit, metering equipment and the packer device shall be designed so that proportions and quantities of materials can be regulated in accordance with the type and size of the leak being sealed.

11.3.4 Sealing of Manholes

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

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

3 Sealing equipment shall consist of chemical sealant containers, pumps, regulators, injection packers, hoses, valves, and all other necessary apparatus and tools. The chemical injection pumps shall be equipped with pressure meters for monitoring pressure during the injection of the chemical sealants. Where necessary, fluid bypass lines equipped with pressure-regulated bypass valves shall be incorporated into the pumping system.

4 Structural cracks shall be repaired out as follows:

(a) holes shall be carefully drilled close to the damaged section from within the manhole and shall extend through the entire manhole wall

(b) if leakage is occurring through cracks due to high groundwater table, fewer holes shall be drilled provided all leakage is stopped from these holes. A watertight seal between the holes and the injection device shall be provided. Hoses, shall be attached to the injection device from an injection pump. Chemical sealing materials shall then be pumped through the hose until material refusal is recorded on the pressure gauge mounted on the pumping unit or a predetermined quantity of sealant has been injected

(c) care shall be exercised during the pumping operation to ensure that excessive pressures do not develop and causing damage to the manhole structure

(d) upon completion of the injection, the packers shall be removed and the remaining holes filled with mortar and trowelled flush with the surface of the manhole walls or other surfaces

(e) the mortar used shall be of the quick-setting type with non-shrinking characteristics

(f) any GRP internal lining which has been disturbed shall be repaired in accordance with Part 7 of this Section.

5 Not more than one month before the expiration of the Period of Maintenance and as a precondition to the Engineer's issuance of the Maintenance Certificate for the Contract, manholes shall be visually inspected by the Contractor in the presence of the Engineer. Sealing work that has become defective shall be repaired at no additional cost to the Employer.

6 All manhole sealing shall be done during high groundwater conditions, unless the points of leakage have been previously identified.

11.4 SLIPLINING OF SEWERS

11.4.1 General

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

2 Procedures set out in ASTM F 585 shall be followed, except as otherwise specified in this Part.

3 The Contractor is not constrained on the type of lining method he puts forward, but the Contractor will have to demonstrate, through previous project documentation, that the proposed method has a proven track record and that it is fully applicable to the conditions to be found in the Gulf region.

4 The Contractor shall design the liner to support all combinations of imposed loads including earth, traffic, hydrostatic etc and have a minimum service life of 50 years. For the purpose of calculations, it shall be assumed the ground water table is at ground level. Host pipes shall be considered to be fully deteriorated. The liner shall have a minimum allowable long term stiffness of 2500N/m^2 and be designed to have a factor of safety of 2.

5 The normal requirement will be that the liner shall provide the least possible thickness or decrease in diameter to meet the requirements of this section and consequently it is preferable to be of the close fit type.

6 Liner shall be of a light colour to enhance Closed Circuit Television (CCTV) clarity for inspection purposes.

7 Leak repair shall be carried out when required to create an environment to enable the rehabilitation works to be executed successfully. If the rehabilitation method adopted can be successfully implemented under wet conditions, the Contractor is not obliged to repair the leaks.

8 The finished liner shall be continuous over the entire length of an insertion run between two manholes or access points and shall be free from visual defects.

9 The beginning and end of the liner pipe shall be sealed to the rehabilitated pipeline and to manhole liner using a material that is compatible with the liner.

11.4.2 Materials

1 The sewer liner pipe and fittings shall be manufactured from a polyethylene compound conforming to ASTM D1248 and meeting the requirements for Type II or III, Class B or C, Grades P23 or P34, Category 5. Pipe made from this compound shall have a minimum long-term hydrostatic strength rating of 8.6 MPa in accordance with ASTM D2837. When the environmental stress crack resistance (ESCR) of the compound is measured in accordance with ASTM D1693, Condition C, the compound shall withstand not less than 192h in 100 % solution Igepal CO-630 at 38 °C before reaching a 20 % failure point (F20).

2 The standard dimension ration (SDR), defined as the specified outside diameter (OD) divided by the minimum wall thickness, shall be demonstrated by calculation to be sufficient to support the worst combination of internal and external loads. The wall thickness tolerance shall be within plus 12 %.

3 Liner pipe shall be provided with joints designed so that neither the outside diameter of the pipe is increased nor the internal diameter of the pipe is decreased at the joint.

4 Liner pipes shall be suitable for use in ambient air temperatures up to 55^0C and with sewage up to 45^0C.

11.4.3 Installation of Sliplining

1 Where excavations for insertion of liner are made, the Contractor shall locate the excavations on the basis of the location of the sewers to be sliplined, pulling distances, and traffic conditions subject to Engineer's approval. Excavation locations shall be such as to minimise traffic disruption, and the number of excavations reduced by inserting the pipe in both directions from a single opening. Insertion shafts shall be designed to avoid imposing a bending radius of less than 35 times the outside diameter of the liner. Insertion shafts shall be sloped gradually from the ground surface to the soffit of the sewer. The Contractor shall provide sufficient sheeting and bracing to the excavation as required. The soffit of the existing sewer shall be exposed and the crown of the pipe shall be removed as necessary for insertion of the liner. Care shall be taken not to disturb the bottom portion of the existing pipe.

2 Jointing shall be by thermal butt-fusion welding in accordance with the manufacturer's recommendations. All fusion jointing shall be carried out by trained personnel with equipment designed for butt-fusion welding of thermoplastic pipe.

3 Sections of liner shall be jointed above ground either at the Site or at a remote location.

4 Where the insertion shaft is not at a manhole the jointing shall be accomplished using a stainless steel full-encirclement clamp. If such jointing cannot be achieved, then a new manhole shall be constructed. Recommended minimum lengths of clamps to afford adequate pullout protection are given in Table 11.1.

Table 11.1
Minimum Length of Clamps

OD of Liner Pipe	Minimum Length of Clamp
(mm)	(mm)
90	190
115	250
135	250
170	380
180	380
220	380
270	500
325	500
340	500
405	760
455	760
475	760
560	760
661	760

5 Alternative pipe jointing methods shall be subject to the approval of the Engineer.

6 The liner shall be inserted with a power winch and steel cable connected to the end of the liner using of an appropriate pulling head. Where necessary a second pulling head may be attached to the other end of the liner for attachment of a tag line to pull the liner back out of the sewer.

7 Pulling shall be continued form start to completion without interruption, and precautions shall be taken during insertion to protect the liner pipe so that any ragged edges of a broken sewer pipe will not score the outside of the liner.

8 The manufacturer's recommendations regarding relaxation of the liner shall be followed before sealing the annular space between the liner and existing sewer pipe. The annular space between the polyethylene liner and the existing sewer shall be sealed using a method approved by the Engineer.

9 Where an existing manhole is used as an entrance shaft the manhole shall be reinstated to good condition or it shall be replaced with a new manhole in accordance with Part 4 of this Section.

10 Foam sealant shall not protrude into the manhole and the sealant shall be finished over with a quick-setting, non-shrinking type of cement grout. Finishing inside the manhole shall be accomplished using a quick-setting cement type grout to raise the manhole trough to the invert of the liner pipe and reform the manhole benching as required. Exposed cement type grout surfaces shall be protected against corrosion by lining with GRP in accordance with Clause 4.4.1 of this Section.

11 Precautions shall be taken to prevent collapsing of the liner owing to excessive grouting pressure.

12 The liner shall be secured in the upstream manhole. Each existing service connection shall be excavated and reconnected to the new liner pipe using either polyethylene heat fusion saddles or strap-on saddles as conditions require. A neoprene gasket shall be inserted between the liner and the strap-on saddle. Saddles shall be secured to the liner pipe using stainless steel bands. Connections of saddle fittings to existing service connections shall be made using elastomeric boots, full-encirclement clamps, or other methods approved by the Engineer.

13 Before backfilling any existing sewers that had been broken to open, the pipe shall be repaired and the annular space between the existing sewer and the new liner sealed using cement or expandable foam to the approval of the Engineer.

14 At locations where the liner pipe has been exposed, the pipe and fittings shall be encased in Grade 20 SRC concrete.

11.5 DEFORMED PIPE LINER INSTALLATION

11.5.1 Scope

1 The scope of the work consists of rehabilitating sewers by the insertion of a deformed thermoplastic pipe into existing sewers. The deformed pipe on the application of pressure and temperature or on release of deforming stress induced by swaging reverts to its pre-deformed shape to form a tight fit inside the host pipe without the formation of an annulus.

11.5.2 Materials

1 The HDPE liner material shall be designed for use in gravity sewers and shall be in strict conformance with all applicable sections of ASTM F1533.

2 The liner shall be made from High Density Polyethylene resins complying with ASTM D1248, Type III, Grade P34 and Cell Classification PE 345434C, D or E per ASTM D3350. The Contractor shall submit to the Engineer for approval certified test results from the liner pipe manufacturer to verify that the resin material used for extrusions of the liner meets the specified requirements, including the quality control records during the liner extrusion process.

3 At the time of manufacture, each lot of liner shall be inspected for defects with samples being taken in accordance with ASTM D4703 and tested in accordance with ASTM D1693, ASTM D2837 and ASTM F714.

4 For testing purposes a production lot shall consist of all liner having the same marking number. It shall include all items produced during any given work shift and must be identified accordingly to differentiate it from previous or following production.

5 Each deformed liner coil in compliance with ASTM F1533 shall be clearly marked by the manufacturer with the following information:

(a) ASTM F1533 designation.
(b) Nominal outside diameter.
(c) SDR.
(d) Approximate coil length.
(e) Standard material designation code.
(f) Manufacturer's name.
(g) Manufacturer's production code from which plant location, machine and date of manufacture can be identified.
(h) The project or contract number.

6 Liner minimum wall thickness shall be determined by strength and minimum stiffness requirements.

7 The liner shall be fabricated from materials which will be resistant to internal exposure to sewage, sewage gases and reagents listed in Table 1 above, when tested in accordance with the provisions of ASTM D543, to a temperature of 40°C.

8 The HDPE material used in the production of the liner shall meet, or exceed, the physical properties given in Table 11.5 below.

Table 11.5
Deformed Pipe Liner Properties

Property	Test Method	Value
Density	ASTM D1505	950kg/m^3
Flow rate	ASTM D1238	8.0g/10min
Tensile strength @ ultimate	ASTM D638	30N/mm^2
Tensile strength @yield	ASTM D638	20N/mm^2
Ultimate elongation	ASTM D638	600%
Flexural modulus	ASTM D790	1000N/mm^2
Environmental stress crack resistance	ASTM D1693	10,000 hrs

F_0, hours condition C Compressed ring ESCR F_0	ASTM F1248	10,000 hrs
Brittleness temperature	ASTM D746	-117^0C
Vicat softening temperature	ASTM D1525	125^0C
Hardness, Shore D	ASTM D2240	50
Volume resistivity	ASTM D991	10^{15} ohm-cm
Thermal expansion		0.20mm/m/^{0}C

9 At the time of installation the liner shall be homogeneous throughout, uniform in colour, free of cracks, holes, foreign materials, blisters and deleterious faults.

11.5.3 Installation

1 The Contractor's method statement shall be submitted to the Engineer for approval. In the method statement the Contractor shall describe the means of deforming the liner in-situ and of providing, maintaining, monitoring, and controlling the reforming environment until the liner has reverted to its original circular shape and the temperature returns to the normal sewer ambient temperature.

2 Calculations demonstrating the adequacy of the pulling capacity of the winch shall be prepared and submitted by the Contractor for the Engineer's approval.

3 The liner shall be positioned at the upstream manhole without excavation and shall be winched directly from the coil through the upstream manhole and the host pipe.

4 Due care shall be exercised during winching to avoid damage to manholes and snagging. Guides or rollers shall be used within the manholes to avoid the risk of snagging.

5 The pulling winch shall be equipped with a tension gauge capable of controlled operation at variable speed.

6 The pipe shall be cut flush at manhole inlet and outlet points using a rotary cutter and the joints sealed.

7 The Contractor shall adopt working practices for plastic pipes accordance with BS 5955.

8 The Contractor shall obtain detailed installation instructions and procedures from the manufacturer for the actual installation of the deformed and reformed system. The requirements of ASTM F1606 shall also be satisfied.

9 When the deformed pipe liner is in place it shall be cut and the pipe end closing assembly used for heat and pressure control within the liner shall be attached and secured at both pipe ends. Temperature and pressure measuring instruments shall be attached to both ends of the deformed HDPE liner to provide a continuous monitor of the temperature and pressure being applied to the liner.

10 Through the use of steam and air pressure the deformed pipe shall be reformed to conform to the existing pipe wall.

11 The reformed HDPE liner shall be cooled in accordance with the manufacturer' recommendations.

12 Temperatures and pressures shall be monitored and recorded throughout the installation process to ensure that each phase of the process is achieved at the manufacturer's recommended temperature and pressure limits

13 For each length of liner two samples shall be taken at locations determined by the Engineer. The sampling method shall include the use of a former to replicate the host pipe. The samples shall be clearly labelled with date taken and location. The samples shall be tested for average inside diameter, average outside diameter and minimum wall thickness in accordance with ASTM D2122, pipe stiffness at 5% deflection in accordance with ASTM D2412 and for the properties given in Table 3. The stiffness so measured shall meet, or exceed the stiffness requirements determined by calculation for that section of sewer line or the minimum specified stiffness whichever is greater. Any material may be rejected for failing to meet any of the requirements of this specification.

14 The water tightness of the liner shall be gauged throughout the forming process.

11.6 CURED-IN-PLACE LINER INSTALLATION (INVERSION METHOD)

11.6.1 Scope

1 The scope of work consists of rehabilitating sewers by the installation of a resin impregnated flexible felt tube inverted into existing sewers. When cured, the new material shall extend over the length of the inversion as a continuous, tight-fitting, watertight lining.

11.6.2 Materials

1 The liner material shall be designed for use in gravity sewers and shall be in strict conformance with all applicable sections of ASTM F1216.

2 The felt liner tube shall be a thermoplastic polyester tube consisting of one or more layers of flexible needled felt or an equivalent woven and/or non/woven material capable of carrying resin, and with sufficient needling and crosslapping and strength to withstand the installation pressures and curing temperatures.

3 The felt tube shall be compatible with the resin and catalyst systems to be utilised.

4 The finished liner shall consist of a felt layer (or layers) impregnated with a thermosetting resin and fabricated to fit tight against the host pipe. An allowance shall be made for circumferential stretching during installation where applicable.

5 Each felt liner tube shall be clearly marked by the manufacturer with the following information:

(a) Manufacturer's name.

(b) Manufacturer's production code from which plant location, machine and date of manufacture can be identified.

(c) The project or contract number.

6 The lining technique shall comprise using a suitable preliner to prevent loss of resin.

7 The resin used shall be a general purpose, unsaturated, thermosetting, vinylester resin able to cure in the presence or absence of water and a catalyst system compatible with the insertion process that provides physical properties given in Table 11.6.

Table 11.6
Cured in Place Liner Properties

Property	Test Method	Value
Flexural strength	ASTM D790	31N/mm^2
Short term flexural modulus	ASTM D790	1724N/mm^2
Long term flexural modulus	ASTM D790	862N/mm^2
Tensile strength	ASTM D638	21N/mm^2

8 The installed and cured liner shall be chemically resistant to exposure to sewage and sewage gases as experienced with the high temperatures in Qatar.

9 At the time of installation the liner shall be free of all visible tears, holes, cuts, foreign materials and other defects.

10 The liner shall be fabricated to a size that when installed will neatly fit the internal circumference of the sewer being renovated. Allowance shall be made for circumferential stretching during insertion. The minimum length shall be that deemed necessary by the Contractor to effectively span the distance from inlet to outlet of the respective manholes unless otherwise designated in the contract specification. The Contractor shall verify the lengths on Site before impregnation. Individual inversion runs may be made over one or more lengths of sewer as determined on Site by the Contractor and approved by the Engineer.

11.6.3 Installation of Cured-In-Place Liner

1 The following installation procedure shall be adhered to unless otherwise proposed in the Contractor's method statement and approved by the Engineer:

(a) the Contractor shall designate a location or locations where the reconstruction tube will be vacuum impregnated before installation. The Contractor shall allow the Engineer to inspect the materials and wet-out procedure. A catalyst system compatible with the resin and reconstruction tube shall be used

(b) the Contractor shall provide facilities to control the temperature of the wet-out reconstruction tube to prevent premature setting of the resin

(c) the wet-out reconstruction tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of an inversion medium of sufficient pressure and volume sufficient to fully extend it to the designated or termination point

(d) the inversion pressure shall be adjusted to be sufficient to cause the impregnated tube to invert from manhole to manhole and hold the tube tight to the pipe wall and to produce dimples at side connections and flared ends at the manholes. Care shall be taken during the elevated curing temperature so as not to overstress the felt fibre

(e) after inversion is complete, the Contractor shall provide a suitable curing environment. Monitoring and control equipment shall be provided to permit observation and maintenance of the curing environment. Temperature and other factors of the curing environment shall be those recommended by the resin manufacturer

(f) should excessive infiltration into the sewer be present, a preliner shall be inserted into the sewer line to prevent washout of the resin.

2 Initial curing shall be deemed to be completed when inspection of the exposed portions of cured pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realise an exotherm. The curing period shall be that recommended by the resin manufacturer, as modified for the cured-in-place inversion process, during which time the Contractor shall maintain the quality of the curing environment to the levels recommended by the resin manufacturer.

3 The Contractor shall cool the hardened liner to a temperature below 38 °C before relieving the pressure. Cooling may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Care shall be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed liner.

4 Where the new liner fails to make a tight seal due to broken or misaligned host pipe at the manhole wall, the Contractor shall apply a seal at that point. The seal shall be of a resin mixture compatible with the liner and the host pipe.

5 After the new liner has been cured in place, the Contractor shall reconnect existing active service connections as directed by the Engineer. Unless otherwise designated in the contract specific documentation, shall be done without excavation. In the case of non -man-entry pipes from the interior of the system by means of CCTV cameras and a cutting devices that re-establish the service connection and seal the joint at the point of entry of the service connection.

6 The Contractor shall obtain detailed installation instructions and procedures from the manufacturer for the actual installation of the cured in place liner system. The requirements of ASTM F1216 shall also be satisfied.

7 The section of pipeline to be lined shall have been cleaned, surveyed and repaired to the requirements of this section of the standard specification prior to liner installation.

8 For each length of liner two samples shall be taken at locations determined by the Engineer. Sampling method shall include the use of a former to replicate the host pipe. The samples shall be clearly labelled with date taken and location. The samples shall be tested for average inside diameter, average outside diameter and minimum wall thickness in accordance with ASTM D2122, pipe stiffness at 5% deflection in accordance with ASTM D2412 and for the properties given in Table 2. The stiffness so measured shall meet, or exceed the stiffness requirements determined by calculation for that section of sewer line or the minimum specified stiffness whichever is greater. Any material may be rejected for failing to meet any of the requirements of this specification.

9 The watertightness of the pipe shall be gauged while curing and under a positive head.

10 The beginning and end of the liner pipe shall be sealed to the rehabilitated pipeline and to the manhole liner using a material that is compatible with the liner.

11 Wrinkles in the finished pipe which exceed 5% of the pipe diameter are unacceptable and the liner shall be removed and a replacement liner installed to the approval of the Engineer.

11.7 SPIRAL WOUND PROFILE LINER

11.7.1 Scope

1 The scope of work consists of rehabilitation of sewers by the installation of helically wound, profile walled thermoplastic pipe.

11.7.2 Materials

1 The physical properties of the PVC-U material used in the production of the liner shall conform to the cell classifications 12454C or 1236C, as defined by ASTM D1784. Notwithstanding this requirement, the material shall meet or exceed the following physical properties, as given in Table 11.2:

Table 11.2
Physical Properties of PVC-U Material

Property	Value
Flexural Modulus (Short Term)	2400 MPa
Flexural Modulus (Long Term)	800 MPa
Tensile Strength (Short Term)	45 MPa
Tensile Strength (Long Term)	20 MPa
Heat Distortion Temperature	70 °C
Specific Gravity	1.4
Allowable Long-term Strain	2 %
Hardness (Shore D)	80

2 The base material for the liner shall consist of a profile walled strip, extruded from PVC-U or other thermoplastic material, approved by the Engineer in accordance with ASTM F 1697. All materials shall be resistant to internal exposure to potable water, sea water, sewage, sewer gases, and reagents listed in Table 11.3, when tested in accordance with the provisions of ASTM D543, to a temperature of 35 °C:

Table 11.3
Resistance of Liner Material

Reagent	Concentration
Nitric Acid	5 %
Phosphoric Acid	10 %
Sulphuric Acid	10 %
Detergent	0.1 %
Soap	0.1 %

3 Where high liner stiffness is required to resist external loads, the strength of the liner may be enhanced by the provision of plastic-coated stainless steel reinforcement wound into the liner at the time of installation. The steel reinforcement shall consist of stainless steel type 316L and shall be coated with a low density polyethylene coating or other material approved by the Engineer, not less than 1 mm thick. The steel shall meet or exceed the following physical properties given in Table 11.4:

Table 11.4
Physical Properties of Steel

Property	Value
Tensile Strength	250 MPa
Modulus of Elasticity	195 GPa
Coefficient of thermal expansion	9 x 10^{-6}/ °C

4 For each length of liner a sample shall be prepared prior to the winding machine being placed into the manhole. A length of pipe shall be formed from the same batch of material to be used in the installation. The length of sample shall be such that three lengths may be cut and tested in accordance with ASTM D2412 for pipe stiffness at 5% deflection and for the properties given in Table 4. The stiffness so measured shall meet, or exceed the stiffness requirements determined by calculation for that section of sewer line or the minimum specified stiffness whichever is greater. Any material may be rejected for failure to meet any of the requirements of this specification.

5 Each liner shall be clearly marked by the manufacturer with the following information:

Manufacturer's name

Manufacturer's production code from which plant location, machine and date of manufacture can be identified

The project or contract number

6 At the time of installation the liner shall be homogenous throughout, uniform in colour, free of cracks, holes, foreign materials, blisters and deleterious faults.

7 This method may only be used for pipes of 250mm diameter or greater.

11.7.3 Installation of Spiral Wound Profile Liner

1 The installation of spiral wound liner shall follow the recommendations of ASTM F-1698.

2 Spirally wound profile liners shall be installed using a winding machine placed at the bottom of the manhole, with the liner being introduced at a diameter of approximately 25 mm less than the minimum diameter of the pipeline to be rehabilitated. After the liner has been installed, the annular gap shall be filled with a cementitious grout or the liner shall be expanded until it comes into intimate contact with the host pipe.

3 Jointing of the liner shall be accomplished by the use of an adhesive material suitable for use with the liner material. The adhesive shall be fully resistant to the corrosive sewer environment and shall be applied to the strips at temperatures of 35 to 50 °C. Alternatively the liner shall be joined using a mechanical locking strip. The strip shall have mechanical and chemical resistance properties that are not less than those of the liner material. The joint shall be continuous and watertight for the full length of the sewer. The interface between the liner and manhole shall be sealed with material specified in Clause 11.10.3.

4 Grouting of the annulus shall be carried out using the differential pressure method. The liner shall be filled with water and maintained at a constant pressure that is greater than the grouting pressure. Failure to maintain pressure in the pipeline will indicate that a defect exists. The water pressure shall be monitored via a gauge fitted to the grout plug, whereas the grouting pressure shall be monitored via a gauge fitted at the end of the grout hose. When water direct from a potable supply is used, an anti-siphon device shall be used to prevent contamination. Grouting shall be continued until there is a consistent flow of grout at the upstream manhole. Should grout pressure build up, before a show of grout is observed, the injection shall be stopped immediately to prevent damage to the liner. A sample of the grout shall be taken during grouting and its curing time monitored.

5 Alternative grouting methods that are specific to a particular lining system will be allowed only with the approval of the Engineer.

11.8 PIPE CRACKING OR BURSTING

11.8.1 Scope

1 Rehabilitation of sewers by the replacement of existing pipes with polyethylene (PE) or polypropylene (PP) pipes by breaking the existing pipes, expanding the hole size and inserting the replacement pipes in one operation with a minimum of disturbance to the surrounding ground and no surface disruption.

11.8.2 General

1 The Contractor shall satisfy the Engineer that the pipe bursting procedures will not have detrimental effects on adjacent utilities or structures, particularly from vibration arising from use of pneumatic bursters. The Contractor shall be responsible for such damage and shall bear the cost of rectification.

2 The Contractor shall comply with the requirements of service authorities and shall be deemed to have identified the location of services which may be affected by the Works. Unless otherwise required by the service authorities, where services are known to be located within one meter of the pipe to be burst, the Contractor shall expose the service in advance of pipe bursting. A minimum free space of 500 mm shall be created beneath the service over a length to be agreed between the Contractor and the service authorities.

11.8.3 Materials

1 The materials used for replacement of the existing pipes shall be polyethylene or polypropylene unless otherwise specified in the contract documents.

2 The method of jointing the pipes shall be as the manufacturer's recommendations for the application. Unless otherwise specified or approved by the Engineer pipe joints shall be designed to be watertight against external water pressure assuming that groundwater extends to the ground surface.

11.8.4 Installation Equipment

1 Pipe bursting equipment shall be hydraulically or pneumatically powered incorporating an expander at the nose of the machine which will fragment the existing pipe and expand the space uniformly to a diameter sufficient to allow the replacement pipe to be inserted. The annular space between the expander and the replacement pipe shall not exceed 20 mm unless otherwise agreed by the Engineer.

2 The method of inserting the replacement pipe shall be such that stresses transmitted to the replacement pipe shall not damage the pipes or exceed the tensile capacity of the replacement pipe.

3 Pipe bursting equipment shall be capable of

(a) Working from existing manholes so that they can be used as launch and reception shafts wherever possible. Provision shall be made for remote starting and stopping.

(b) Dealing with small quantities of unreinforced concrete of maximum 150 mm nominal thickness found surrounding pipes, joints, saddles and service connections and for bursting pipes laid on a concrete cradle without being deflected off line and level.

(c) Working under a hydrostatic pressure of groundwater.

(d) Operating at maximum depth of 10.0 m from surface level.

(e) Operation without jamming of moving parts or other malfunction due to the ingress of groundwater or sand particles.

4 Where the Contractor has not previously used the equipment or demonstrated the pipe bursting technique to the satisfaction of the Engineer then he shall demonstrate the suitability of the equipment as follows:

(a) construct in open ground at a location approved by the Engineer, a 50m long temporary section of pipe of the same bore and material as the sewer to be rehabilitated at similar depth, complete with unbenched chambers at each end;

(b) backfill the excavation;

(c) demonstrate the pipe bursting procedure.

(d) on completion of the pipe installation flood the site to artificially bring the water table to the ground surface and demonstrate that infiltration requirements of Part 4 of this Section are met.

5 Should difficulties be encountered in completing the trial installation the Contractor shall modify his proposal for approval by the Engineer before recommencing work.

6 Measures shall be taken to ensure that the replacement pipe does not become separated from the pipe expander should the system employ an insertion technique which allows the replacement pipe to slide within the pipe expander.

11.8.5 Installation

1 Shafts for launch and reception shall be existing manholes and excavations made over existing inspection chambers and service connections where the latter are proposed to be reconnected to the pipeline. Service connections to be abandoned or redirected to upstream or downstream chambers or manholes shall not be excavated.

2 Unless specifically approved by the Engineer pipe bursting shall not be carried out by constructing shafts adjacent to manholes. Where necessary, the channel, benching and walls of existing manholes shall be altered to receive the pipe bursting equipment. All manhole alterations shall be made good.

3 The Contractor's attention is drawn to the potential problems arising from the inflow of groundwater and loss of ground from the outside of manholes. His proposed method of working shall take these into consideration and shall be subject to the Engineer's approval and shall ensure that no inflow of groundwater or loss of ground occurs. Where manholes are located in roads, the Contractor shall obtain permission from the Roads Division prior to carrying out any wellpoint dewatering operations around the manhole. In the event that means of stabilising the ground around the manhole and connecting pipelines are not approved by the Engineer, the Contractor shall not use pipe bursting methods at that location unless any other alternative method is approved by the Engineer.

4 Existing service connections shall be disconnected from the existing pipeline in advance of pipe bursting and reconnected on completion of the installation of the replacement pipe. In the interval, the Contractor shall maintain service by temporarily connecting service connections to the sewerage system downstream of the section, by overpumping, or by such other method the Contractor may propose for the Engineer's approval.

5 Sewer lengths to be rehabilitated shall be checked for the presence of collapses occurring subsequent to cleaning by gauging between shafts. Where a collapse is detected its position shall be determined and an additional shaft shall be excavated if the debris cannot be removed.

6 Pipe bursting shall not commence unless sufficient lengths of replacement pipes are available on Site to complete the length of pipe to be rehabilitated.

7 Where pipe bursting is delayed for a period exceeding 7 days following cleaning, the pipeline shall be reinspected.

8 Winching shall conform to the following requirements:

(a) Details of the proposed winching method shall be submitted to the Engineer for approval at least 7 days before the insertion date

(b) Winches shall be of the constant load type fitted with a direct reading load gauge. At the end of each day's work, the Contractor shall provide the Engineer with a copy of the winching loads recorded at the start of any pull and during the pull at increments of 20 m of winching distance and at any restart following temporary stops

(c) Winches shall be fitted with an automatic device to disengage when the load exceeds a preset maximum load.

(d) The Contractor shall supply sufficient cable in one continuous length to ensure the pull is continuous between approved winching points

(e) Winches, cables and cable drums shall be provided with safety cages and supports

(f) The Contractor shall provide a system of guide pulleys and bracings at each manhole

(g) Nose cones fixed to the head of pipe expanders shall be fitted with a swivel attachment to prevent twist transmission between the winch cable and the nose cone

(h) Where the Contractor proposes to use a lubricant to ease the pull, the type of lubricant, method of introduction, removal and quantity to be used shall be submitted for the Engineer's approval before beginning winching

(i) Trench sidewall support in the insertion trench shall remain completely separate from the pipe support system and shall be designed so as not to be in contact with the pipe or the winch cable.

9 Replacement pipe shall be inserted in accordance with the following requirements:

(a) the maximum force shall be within the stress limit of the pipe

(b) continuous length pipelines shall not be used. The maximum pipe length for insertion shall be 1.5 m where pipe bursting is undertaken between excavated shafts and either 700 mm or 800 mm where pipe bursting is undertaken from manhole to manhole

(c) where a device is employed to exert force on the rear of the inserted pipe lengths, the force applied to the inserted pipe shall be evenly distributed around the wall of the pipe

(d) Where lengths of pipe are joined and a device is employed to exert force to the rear of the inserted pipe lengths, precautions shall be taken to ensure that no buckling, crushing, twisting, or damage to the joint of the pipe takes place. Where, in the opinion of the Engineer, excessive deformation of the pipe has taken place, the pipe shall be replaced at the Contractor's expense.

10 Where the lining is to be joined using 'Snap-Lock' or similar fittings, the Contractor shall comply with the manufacturer's recommendations for jointing. Means of verifying the critical dimensions of the joints shall be provided on site by the Contractor. The joint shall be fitted with a suitable sealing ring and shall be designed to be watertight against an excess external water pressure of 20 metres head.

11.9 INSPECTION AND TESTING OF PIPE LINES AFTER REHABILITATION

1 The completed sewer shall meet the leakage requirements of pressure tests or air tests as specified in Part 4 of this Section.

2 After completion of each length of sewer, the Contractor shall flush the pipeline and undertake a CCTV and deflection survey and provide video tapes, pictures on digital format and site coding sheets to the Engineer.

3 Where necessary the Contractor shall remove any debris and carry out any remedial work identified. Upon completion of remedial work and removal of debris the section shall be resurveyed and the Engineer provided with the latest CCTV video tapes. Further additional CCTV surveys resulting from the need to again clean or carry out further remedial work shall be at no additional cost to the Employer.

4 The rehabilitated sewer shall be returned to service only after the written approval of the Engineer.

5 During the guarantee period any defects which will affect the integrity or strength of the pipe shall be repaired at the Contractor's expense, in a manner mutually agreed by the Engineer and the Contractor.

11.10 MANHOLE REHABILITATION

11.10.1 Scope

1 The scope of work consists of the materials and types and methods of repair for the rehabilitation of manholes.

11.10.2 General

1 Manhole rehabilitation shall comprise but not be limited to any combination of the following:

(a) Rehabilitation of walls or bases by plugging, patching, and removing, providing or replacing mortars, coatings, sealants and liners, to improve structural condition, prevent infiltration, provide corrosion protection or external tanking protection.

(b) Repair of shaft and cover slab and reconstruction to the required level

(c) Reinstallation or replacement of manhole frame and cover

(d) Installation of manhole sealing plate.

11.10.3 Materials

1 Materials used shall be suitable proprietary materials for manhole rehabilitation and the specific application in which they are used. The materials shall be supplied in factory-labelled containers. All materials shall be mixed and applied in accordance with the manufacturer's instructions.

2 Materials used for plugging holes and stopping infiltration in manholes shall be either:

(a) Premixed hydraulic cement consisting of Portland cement, graded silica aggregates, special plasticising and accelerating agents with a set time of approximately 50 s and a 10 min compressive strength of approximately 3.5 MPa and free of chlorides, gypsum, plasters, iron particles, or gas-forming agents

(b) Siliconate-based liquid accelerator mixed with neat Portland cement with a set time of approximately 50 s.

3 Materials used for patching, filling and repairing non-infiltration holes, cracks, and breaks in concrete and masonry manholes shall comprise a premixed Portland cement-based hydraulic cement consisting of Portland cement, graded silica aggregates, special plasticising and accelerating agents with a set time of approximately 3 min or 15 min to suit application and a one-hour compressive strength of approximately 4.2 MPa. It shall not contain chlorides, gypsum, plasters, iron particles, or gas-forming agents.

4 Materials used for waterproofing membrane, corrosion protection, and strengthening of concrete and block work manholes shall be:

(a) liquid polymer modified water based waterproof coating which shall provide a secure mechanical and chemical bond with a curing time of approximately 1.5 h and a cured compressive strength of approximately 40 MPa. The coating shall be applied with a brush to surfaces without cracks or voids wider than 1.5 mm

(b) 100 % solids, three-component system consisting of a two-component epoxy resin and a special blend of fillers which shall provide a secure mechanical and chemical bond with an initial curing time of approximately 4 h and a cured compressive strength of approximately 76 MPa. The resin with fillers shall be applied with a trowel to a thickness of 3 mm to 12 mm. Epoxy resin (without fillers) used for waterproofing and corrosion protection shall be applied with a brush.

5 Remove all defective linings together with 100mm of adjoining good lining in existing manholes and other structures, including areas of lining covering leakage points.

6 Break out defective concrete to sound concrete surface.

7 Apply approved epoxy bonding agent and reinstate concrete using an approved concrete repair material.

11.10.4 Rehabilitation of Manhole Walls and Bases

1 Surfaces of manhole walls and bases shall be thoroughly cleaned to remove all loose material and surface contaminants. Cleaning shall be accomplished by pressure jetting, sandblasting, or applying a 10 % solution of muriatic acid or hydrochloric acid. Where an acid solution is used the surface shall be thoroughly rinsed and neutralised before the application of mortars and coatings.

2 After surface preparation and before the application of mortars and coatings, infiltration shall be stopped by sealing as specified in Clause 11.3.4.

11.10.5 Rehabilitation of Manhole Shafts and Slabs

1 The Contractor shall take all necessary precautions to prevent debris from damaging the manholes and the sewer.

2 Shafts and cover slabs shall be repaired and rehabilitated with suitable sound materials approved by the Engineer.

3 Rings shall be provided as appropriate to reconstruct the shaft to the required elevation.

11.10.6 Manhole Cover, Frame and Sealing Plate Reinstallation or Replacement

1 The Contractor shall remove covers, frames, and sealing plates. Where the Engineer determines that cover, frames and sealing plates are to be replaced, the Contractor shall dispose of them.

2 The Contractor shall adjust the level and slope of the manhole cover as required. The manhole shall be raised by building precast concrete rings.

3 Covers and frames determined by the Engineer to be in good condition shall be grit blasted and coated on all exposed faces with a zinc primer and coal-tar epoxy paint finish as specified for System C in Part 8 of this Section. Replacement covers, frames and sealing plates shall be as specified in Part 6 of this Section.

4 The Contractor shall reinstall or replace the manhole cover and frame using either of the following methods in accordance with the Contract Drawings and clause 4.4 of this Section.

5 Sealing plates shall be installed as specified in Part 6 of this Section.

11.10.7 Inspection and Testing

1 Completed rehabilitation works shall be visually inspected in the presence of the Engineer. Work that has become defective shall be redone at no additional cost to the Employer.

11.11 MANHOLE LINING

11.11.1 Scope

1 The scope of work comprises structural rehabilitation of manholes by the installation of in-situ glass fibre reinforced manhole liners.

11.11.2 Materials

GRP liner materials shall be as specified in Part 7 of this Section.

11.11.3 Installation of Lining

1 The cover slab and manhole cover shall be removed and disposed of off Site. The manhole cover and frame shall be thoroughly cleaned, treated with two coats of bituminous paint and delivered to CED store and placed into storage.

2 Step irons shall be removed and the walls made good and prepared with 3:1 sand/cement mortar.

3 Concrete surfaces to be lined shall be cleaned and lightly abraded prior to the application of the GRP. The GRP lining shall be built up by applying isophthalic or vinyl ester resin. A layer of ECR glass mat shall then 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 veil shall then be used to complete the lining.

4 Top surfaces of benching shall incorporate silica sand to form a non-slip surface.

5 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.

6 GRP ladders of an approved pattern as specified may be purpose made to suit the depth of each manhole. Fixings for ladders shall be approved stainless steel stud anchors. Fixing holes shall be grouted with epoxy mortar and sealed as above. Rungs or treads shall be ribbed to provide a non-slip surface.

11.11.4 Inspection and Testing

1 After the manhole lining has been installed, the manhole shall be visually inspected in the presence of the Engineer and subject to the approval of the Engineer.

2 Before the expiration of the Period of Maintenance, the Contractor shall visually inspect the lined manholes in the presence of the Employer or Engineer. Work that has become defective shall be redone at no additional cost to the Employer.

END OF PART