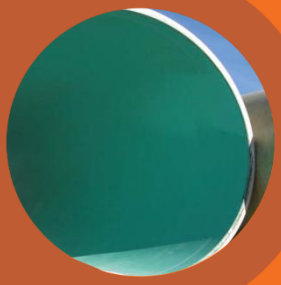

GRAVITY SEWER PIPE REHABILITAION

PIPE SEGMENT LINING – PERFORMANCE SPECIFICATION GUIDELINE

Document No. ESF-600-STD-211

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Watercare

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More information

If you have further queries, please contact the Asset Lifecycle team at standards@water.co.nz

DOCUMENT CONTROL

Document owner	Principal Asset Lifecycle Engineer (Standards)
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Definitions

ASTM	American Society for Testing Materials
CCTV	Closed Circuit Television – which includes cameras and displays to record and inspect pipelines.
Contractor	Main contractor engaged by Watercare, responsible for delivering the works
Defect	Any discontinuity, imperfection or inclusion arising from substandard materials, improper pipe preparation, or faulty manufacture, installation or workmanship which affects the hydraulic or structural performance of the lining
Flow management plan (FMP)	Contractor plan(s) and methods to divert flows whilst preventing overflows or any adverse consequences whilst preparing the host pipe and installing the new liner.
GRP	Glass-Fibre-Reinforced Plastic
IANZ	International Accreditation New Zealand
ISO	International Organisation for Standardisation
Liner	A liner comprising of moulded segments with vertical or horizontal joints which are assembled and hydraulically jacked through the existing pipe.
NDSRs	No-dig spot repairs
Project Specification	Project specific requirements specific by the design engineer which form part of the minimum requirements to be met during construction
Quality Control Plan	The Contractor's documentation that defines the procedures for delivering the level of construction quality required by the project.
Specialist Contractor	Contractor carrying out the physical installation of the liner in accordance with the project specifications and manufacturer's recommendations.
Watercare	Watercare's representative responsible for managing the project.

Table of Contents

1. Scope

This Performance Specification includes the minimum requirements for the rehabilitation of pipelines using pipe segment liners. These liners are thrust through an existing pipe using an appropriate pipejacking machine.

This document shall be read in conjunction with *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems.*

1.1 Overview

The lining shall be segments manufactured in a controlled environment and using a controlled reproducible process.

Lining with pipe segments involve pushing (jacking) pipe or moulded segments with vertical or horizontal joints through the existing pipe. This generally requires that the segment be bonded to the existing pipe using an appropriate grouting technique following segment installation.

***Table 1**: Application of segment liners*

Reference	Description
Liner material	GRP and Concrete
Roughness coefficient	Refer to AS 2200: Design charts for water supply and sewerage
Liner Classification	Class A – Fully structural
Applications	Wastewater: Non-pressure
Pipe sizes	Can be manufactured to bespoke sizes and shapes (if required) for up to large diameter (2000mm) installations
Installation	Manhole to manhole (or shaft to shaft)
Design life	GRP: 50 years Reinforced concrete: 100 years

2. Relevant Standards

***Table 2**: Standards applicable to segment liners*

Standards – General	Relevance
AS/NZS ISO 11295: Plastics piping systems used for the rehabilitation of pipelines - Classification and overview of strategic, tactical and operational activities	Planning and general
AS/NZS 2566.1: Buried Flexible Pipes - Part 1: Structural Design	Design
AS/ NZS2566.1 Supp1: Buried Flexible Pipelines Part 1: Structural Design - Commentary	Design
AS/NZS ISO 11296.1: Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks, Part 1: General	General
AS/NZS ISO 11296.8: Lining with pipe segments	Design, materials and testing
ESF-500-STD-601: Material Supply Standard	Materials
Standards – Applicable to GRP liner	**Relevance**
ISO 25780: Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Pipes with flexible joints intended to be installed using jacking techniques.	Material manufacture

Standards – Applicable to GRP liner	Relevance
ISO 16611: Plastics piping systems for drainage and sewerage without pressure –non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) – Dimensions, requirements and tests	Material manufacture
ASTM D3262: Standard Specification for "Fiberglass" (Glass-Fibre- Reinforced Thermosetting- Resin) sewer pipe	Material and testing
ASTM D3567: Standard Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings	Determining the physical dimensions of fiberglass pipe and fittings
ASTM D790: Standard Test Method for Flexural Properties of Plastics	Material and Testing
ASTM D2583: Standard Test Method for Indentation Hardness by Means of Barcol Impresser	Material and Testing
ASTM D638: Standard Test Method for Tensile Properties of Plastics	Material and Testing
ASTM D695: Standard Test Method for Compressive Properties of Rigid Plastics	Material and Testing
ASTM D4161: Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Elastomeric Seals	Standard Specification
ISO 16611: Plastics piping systems for drainage and sewerage without pressure –non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) – Dimensions, requirements and tests.	Material and testing
AS 1646: Elastomeric seals for waterworks purposes	Material and testing (Joint testing)
AS 681.1: Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications Vulcanized rubber	Material and testing (Joint testing)
ASTM F477: Standard Specification for Elastomeric Seals (Gaskets) for Jointing Plastic pipe	Material and testing (Joint testing)
ASTM D5365: Standard Test Method for Long-Term Ring-Bending Strain of Fiberglass (Glass-Fibre-Reinforced Thermosetting-Resin) Pipe	Material and testing (Long term Stiffness – Material creep & Long term ring bending strain test)
ASTM D3681: Standard Test Method for Chemical Resistance of "Fiberglass" (Glass–Fiber–Reinforced Thermosetting-Resin) Pipe in a Deflected Condition	Material and testing (Chemical resistance of pipe in a deflected condition)
ASTM D2105: Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube	Material and testing (Axial tensile strength)
ASTM D2290: Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe	Material and testing (Hoop tensile strength)
ASTM D2412: Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading	Material and testing Stiffness & flexural modulus

Standards – Applicable to GRP liner	Relevance
WRc materials standards for GRP (Guidance note WIS 4-34-02)	Materials
ISO 11296.4: Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks - Part 4: Lining with cured in place pipes.	Installation - laterals
Standards – Applicable to Concrete pipe liner	**Relevance**
AS/NZS 4058: Precast concrete pipes (pressure and non-pressure)	Material
AS 1646: Elastomeric seals for waterworks purposes	Material
ASTM C361: Standard Specification for Reinforced Concrete Low-Head Pressure Pipe	Material
ASTM C1417: Standard Specification for Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design	Material
ASTM C443: Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets	Material
AS/NZS 3725: Design for installation of buried concrete pipes	Design
CG: General Civil Construction Standard	Installation

3. Design

Design of the lining system shall meet all the relevant requirements of *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

The segment liner shall be designed using one of the following standards:

GRP segment liners:

- The lining shall be designed in accordance with AS/NZS 2566.1, to satisfy the critical performance criteria of deflection, strength and buckling, and to withstand the total combined loading at the maximum depth, without any strength contribution from the existing pipe.

Concrete segment liners:

- AS/NZS 3725: Design and installation of buried concrete pipes

The pipe manufacturer may consider alternative design methodologies such as finite element analysis design software. However, any such alternatives must receive prior written approval from WSL. Approval for alternative design methodologies will require the designer to demonstrate:

- Quality assurance documentation in respect of software.
- Quality assurance certification for designer and verifier accreditation as users of proposed software.
- Track record list for successful use of software prior use in comparable applications.
- Reference information for software and designer prior project applications.

3.1 Segment joint design

The liner segments shall be equipped with a mating joint that enables installation, alignment and restraint of the segments upon full engagement. This shall be achieved without causing damage to the pipe sections in which they occur, ensuring there is no internal lip or step at the joint. Additionally, the joints must be able to accommodate deflections as specified below:

- Horizontal deflections – up to 1%
- Vertical deflections – up to 1%

The sealing mechanism in the joints must be capable of resisting groundwater pressures specified in the design and temporary loads which may occur during liner segment installation without damage to the sealing mechanism.

4. Material requirements

4.1 Material properties

The Contractor shall submit test data to substantiate that the values for material properties nominated in the design calculations can be achieved by the materials supplied for the pipeline installation.

Segment liners shall be manufactured by a controlled reproducible process using the materials described in this section to result in a corrosion resistant structure to meet the operating conditions for this project. They can be of:

- Glass fibre filament-wound or glass fibre woven roving construction using similar resins as used in the pipe cylinder; or
- Reinforced concrete

4.1.1 GRP segment liners

The GRP segment liner shall where applicable at a minimum meet or exceed the material requirements specified in the standards below:

- **ISO 25780**: Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Pipes with flexible joints intended to be installed using jacking techniques.
- **ASTM D3262**: Standard Specification for “Fiberglass” (Glass-Fibre- Reinforced Thermosetting- Resin) sewer pipe
- **ISO 16611**: Plastics piping systems for drainage and sewerage without pressure –non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) – Dimensions, requirements and tests.
- **ASTM D5365:** Standard Test Method for Long-Term Ring-Bending Strain of Fiberglass (Glass-Fibre-Reinforced Thermosetting-Resin) Pipe
- WRc materials standards for GRP (Guidance note WIS 4-34-02)
- **ASTM D3681:** Standard Test Method for Chemical Resistance of “Fiberglass” (Glass–Fiber–Reinforced Thermosetting-Resin) Pipe in a Deflected Condition
- **ASTM D2105**: Standard Test Method for Longitudinal Tensile Properties of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube
- **ASTM D2290**: Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe
- **ASTM D2412**: Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
- WRc materials standards for GRP (Guidance note WIS 4-34-02)

The design service life of the installed lining system and all the materials used in its manufacture shall be a minimum of 50 years, or longer if specified.

4.1.1.1 Resin system

The manufacturer will use only approved resin and catalyst systems for which verifiable track record information is available, for comparable installation conditions and applications. The data shall have been acquired from a composite material of similar construction and composition as the product proposed for the project.

4.1.1.2 Glass reinforcements

The reinforcing glass fibres used to manufacture the components shall be of highest quality commercial grade of glass filaments suitably tested with binder and sizing compatible with impregnating resins.

The fibres used in the manufacture of the liner shall be ECR glass, manufactured in compliance with ASTM-D578.

4.1.1.3 Fillers

Silica sand or other suitable materials may be used as fillers in the laminates with prior approval from Watercare.

4.1.1.4 Additives

Resin additives such as pigments, dyes, and other colouring agents, if used, shall in no way be detrimental to the performance of the product nor shall they impair visual inspection of the finished product.

4.1.1.5 Hydrostatic design basis

Hydrostatic Design Basis (HDB) shall be obtained in accordance with procedure B of ASTM D2992.

4.1.1.6 Joints

Coupling joints shall be qualified in accordance with the tests of Section 7 of ASTM D4161 A suitable “closing” segment must be designed with joints that are able to be installed after the final central closing segment is installed. These joints must be designed to the minimum joint requirements specified in this document.

4.1.1.7 Elastomeric sealing rings

The rubber ring joints to be supplied shall conform to ASTM F477 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic pipe.

Where the lining is to be used to convey deleterious trade effluents a bio-deterioration resistant elastomer suitable for use under those conditions shall be used.

The dimensions and hardness of the rings shall be in all ways suitable for the type of rubber ring joint being used in the pipes supplied under this Specification. The Pipe Manufacturer shall state the rubber hardness, the ring type and significant dimensions of the rings proposed to be supplied. All rings supplied shall be legibly marked with the information listed below:

- Manufacturer's Name
- Diameter & Chord thickness
- Hardness scale and hardness value
- Date of manufacture

Each package of rings to be delivered shall be clearly labelled in waterproof ink with contract number and manufacturer's identification number.

Other standards that may be considered for elastomeric joints include:

- AS 1646: Elastomeric seals for waterworks purposes
- AS 681.1: Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications Vulcanized rubber

4.1.2 Concrete segment liners

The Concrete segment liner shall at a minimum meet or exceed the material requirements specified in one of the following standards below, and shall also meet the design requirements:

- **AS/NZS 4058**: Precast concrete pipes (pressure and non-pressure)
- **ASTM C361**: Standard specification for reinforced concrete low-head pressure pipe

The design service life of the installed lining system and all the materials used in its manufacture shall be at least one hundred (100) years

4.1.2.1 Durability requirements

The internal surface of concrete pipe segments shall be designed to resist or withstand biogenic corrosion for the design life of the system. This may include the use of, but not limited to, polymer liners, sacrificial layers (extra cover), use of calcareous aggregates and alumina cement lining. 100 years durability shall be calculated using existing wastewater quality data and the relevant equations of the US EPA Process Design Manual for Sulphide Control in Sanitary Sewage Systems.

4.1.2.2 Elastomeric sealing rings

Elastomeric sealing rings shall be used in accordance with their manufacturer's recommendation for the particular application and shall be manufactured meeting material requirements of AS 1646, AS 681.1 or ASTM C443.

Where the lining is to be used to convey deleterious trade effluents a bio-deterioration resistant elastomer suitable for use under those conditions shall be used.

The dimensions and hardness of the rings shall be in all ways suitable for the type of rubber ring joint being used in the pipes supplied under this Specification. The Pipe Manufacturer shall state the rubber hardness, the ring type and significant dimensions of the rings proposed to be supplied. All rings supplied shall be legibly marked with the information listed below:

- Manufacturer's Name
- Diameter & Chord thickness
- Hardness scale and hardness value
- Date of manufacture

Each package of rings to be delivered shall be clearly labelled in waterproof ink with contract number and manufacturer's identification number.

4.1.3 Qualification testing

The liner manufacturer shall provide a quality assurance plan for approval before manufacturing the segments that demonstrates quality assurance and testing procedures will be carried out to confirm compliance with these minimum requirements.

The physical properties and characteristics of the liner segments shall be determined by prototype testing of the manufactured product. With the Engineer's representative's approval, these tests may be conducted on a product previously completed provided the product is:

- Of similar composition
- Of similar material arrangement
- Are manufactured from the same material specification
- Are manufactured using a similar process.

All prototype test results must be retained by the manufacturer and be available for inspection by WSL upon request.

4.2 Chemical, temperature and abrasion resistance

The contactor shall provide evidence that the materials proposed, meet the applicable standards listed in this document. Refer to *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

4.2.1 GRP segment liners

For GRP segment liners, the manufacturer shall also carry out the full type testing as described in Procedure-A or Procedure-B of ASTM 3681, duly approved by accredited third party agency. Further, the manufacturer shall carry out the requalification test as described in reconfirmation test of ASTM 3681 on the same pipe / stiffness class as specified for the liner segments in the Project Specification.

5. Construction

For all general construction requirements refer to *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

5.1 Installation

5.1.1 Segment liner handling and storage

Segment liners are susceptible to damage from mishandling and impact. The Contractor must take precautions to avoid subjecting them to point loads or shock loads. All segments must be appropriately braced, stored, transported, and handled in accordance with the Pipe Manufacturer's guidelines to prevent deformation or damage prior to installation. The Contractor bears the responsibility of ensuring that the liner segments remain undamaged throughout the installation process after delivery to the site. Inspection of the liner segments upon delivery is mandatory, and any defective liner segments discovered must be promptly identified and reported to the Engineer's representative. Subsequently, the Contractor is obligated to replace any damaged liner segments at their own expense.

5.1.2 Marking

All lining units shall be indelibly marked on the inside face of each end. No method of marking shall affect the performance of the liner when in service. The marking shall include the following information:

(a) the manufacturer's name, initials or identification mark,

(b) the project title, client or contractor, contract number.

(c) dimensions

(d) identification of the production line (batch no.) and date of manufacture.

5.1.3 Liner installation

The liner segments shall be installed using an appropriately sized jacking rig to be manufactured and assembled for the lining operation that equivalently distributes forces around the circumference of the liner.

Point loading must be avoided. The jacking rig must have hydraulic jacks capable of generating the required installation forces while pushing liners into the pipe or tunnel and must have a monitoring system that allows smooth jacking operations without spikes in load. Continuous monitoring of jacking forces must be in place, as well as a method to alarm if safe jacking loads are being exceeded.

The installation methodology may need to allow for liner insertion in a live sewer – requirements shall be confirmed with Watercare. The methodology must also allow for the possibility of the excavation becoming flooded with wastewater or groundwater infiltration during periods of rainfall.

A plan to withdraw personnel and sensitive equipment and secure driven liner segments during high flow periods is imperative.

5.1.4 Lateral connections

Refer to *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

5.1.5 Segment liner grouting

Refer to *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

Grouting the annulus, or the space between the existing sewer and the installed liner segments shall be done to provide the required structural support, prevent groundwater infiltration, and enhance the overall stability of the system.

Following the installation of the liner segments, the annulus shall be grouted using a low-shrink, high-strength, low carbon grout with a cured compressive strength confirmed with the design engineer. A minimum compressive strength of 5 MPa shall be assumed, unless specified elsewhere in the *Project Specification*.

The Contractor is responsible for grouting the annulus gap.

The Pipe Manufacturer shall provide guidance and advice on the grout type, strength, and specify the maximum grout pressure allowable to prevent any damage to the liner segments.

The Contractor's grout installation methodology shall be submitted to Watercare's representative for acceptance prior to the grout installation commencing. The methodology shall detail the complete operation and include the following:

- Grout injection methodology
- Plan to verify annulus fill rate during injection
- Plan to avoid grout loss
- Plan to seal and make good the two free ends of the liner segments
- Plant to prevent floatation, enable air release and ensure final grouting port spacing is in accordance with the deign.
- Plan to ensure wastewater / groundwater doesn't impact grouting procedure.

The Contractor's methodology to install the grout must consider that it likely needs to be installed in several lifts. It is imperative that the liner maintains its location relative to the existing sewer during grout installation and does not move under the buoyancy effects due to grout pressure. The liner segments' final position shall be as close as practical to the invert of the existing sewer.

5.1.6 Defects

Liners shall be assessed for defects as per the relevant requirements of Section 5.2.10 of *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

The following defects are considered unacceptable:

- Defective or misaligned joints
- Excessive annular gap between liner and host pipe – annular gap results in the physical properties of the installed liner not meeting those used in the structural design of the liner (diameter, ovality), or leakage, or deformation that could trap debris.
- Leakage observed through the liner.
- Leak test does not comply with this specification.
- Poor quality cut outs
- Inadequate seals at manholes
- Liner thickness less than specified design value.
- Any other defects listed by the manufacturer as non-compliant.

Note: The defects listed above are not intended to be an exhaustive list. Installed liners will be assessed to confirm they meet the functional requirements over the design life of the lining system.

6. Acceptance Control

Refer to *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

6.1 Testing

6.1.1 Leak testing

Refer to *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

6.2 Sampling

The manufacturer's sampling and testing records shall be submitted and demonstrate compliance with the standards listed under Section 4: Materials

Appendix A: Example Inspection and Test Plan

Contractor Name	ABC Limited	**To be completed, submitted, and approved before works can commence**	**Complete Watercare's Health and Safety induction**	*Yes*	*Date*
Project Reference	(Project Name)		**Control of Work documentation submitted (AA, JSA, Work Permits etc.)**	*Yes*	*Date*
Contractor Representative			**Work Method Statement**	*Yes*	*Date*
			Flow management plan	*Yes*	*Date*
			Quality Control Plan	*Yes*	*Date*

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Upstream Structure (e.g. MH 01)	Downstream Structure (e.g. MH 02)	Pipe Cleaned (Yes / No)	Flow Management in place (Yes/No)	CCTV Inspection (Reference Report No.)	Confirm Pipe Size (internal) (mm)	Confirm Liner Size (OD/ ID) (mm)	Liner Material and Certificates	Confirm location of laterals	Pipeline preparation after cleaning (e.g. repairs)	Installed liner - no defects	Grouting around liner anulus (if required)	Liner termination and epoxy around manholes	Post-installation CCTV	Testing and sampling of pipeline	Remediate all defects	Contractor's Representative
MH01	*MH-02*	*Yes*	*Yes - in place (17/04/2024)*	*Yes: Report No. 1234 (18/04/2024)*	*1200 mm*	*1120mm (OD) 1020mm (ID)*	*GRP / Yes*	*Yes*	*Repairs completed (21/04/2024)*	*Yes*	*Yes – 5MPa completed to WMS*	*Yes (25/04/2024)*	*Yes: Report No. 9876 (26/04/2024)*	*Manufacturers certificates provided (30/04/2024)*	*Completed (02/05/2024)*	*Signed and Date*