Specification

SS 203 – Lining of Circular Person Entry Concrete Pipes

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Revision details

Version No.	Clause	Description of revision
1	-	Original issue
2	All sections 2.2	Minor edits, updated terminology and format Minor update of design loads, added reference to AS/NZS 2566.1

Introduction

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Acronyms

Acronym	Definition
AS	Australian Standard
ASTM	American Society of Testing and Materials
CIPP	Cured In Place Pipe
GRP	Glass Reinforced Plastics

General Terms & Definitions

Term	Definition
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
Design Thickness	The minimum calculated wall thickness of the lining material required to provide a structurally adequate lining for its entire service life
Deteriorated pipe condition	The long-term performance of the existing sewer is doubtful and the lining eventually bears the full load from the ground and traffic.
Inherent Defects	Defects which commonly occur with the lining system where it is not either possible or commercially practicable to take action for their elimination because of the inherent nature of the system
Intact Pipe Condition	The existing sewer is in good condition and is capable of carrying the externally imposed earth pressure loading. The liner is designed for hydrostatic loading caused by a water table located above the sewer
Reverted Slip Linings	Linings inserted into the existing pipe with a temporarily reduced diameter which are subsequently reverted in-situ to their finished diameter
Segmental lining	Linings installed with a series of short lengths which are joined in situ to form a continuous liner inside the original pipe
Neat Fit	Refer Section 4.4
Nominal Thickness	The proposed finished wall thickness for the lining system when properly Installed
Ovality	The difference between the mean outside diameter and minimum outside diameter in the same cross section of the lining
Slip Lining	Lining systems inserted into the existing pipe as a single continuous pipe string, or series of jointed sections, which form a new continuous pipe
Soft Lining Systems	Systems installed as a flexible resin impregnated hose which produce a liner after resin cure
Type I Lining	Linings that form a bond to the grout and/or the sewer wall, so that the renovated sewer acts as a composite section
Type II Lining	Linings which do not rely on the bond with the sewer wall. Structural improvement results from the strength of the lining
Wound Linings	Linings installed by the spiral winding of a profiled strip to form a continuous pipe

Notation

Symbol	Definition	Unit of Measurement
C	Ovality correction factor	-
C_b	Crown bending moment coffficient	-
D	Diameter at neutral axis of lining	m
d_{ay}	Mean internal diameter of the existing pipe	m
d_{min}	Minimum internal diameter of existing pipe	m
D_B	Out of roundness correction factor	-
D_e	External diameter of barrel of existing pipe	m
D_f	Deflection factor	-
E_b	Ring bending modulus of elasticity of lining material	MPa
E_{bl}	Long term ring bending modulus of elasticity of lining material	MPa
E'	Effective soil modulus	MPa
FS	Factor of safety	-
H	Depth of cover; vertical distance between the top of the pipe and the existing surface level	m
I	Moment of Inertia of lining wall for ring bending	m^4/m
K_b	Ratio of horizontal to vertical earth pressure	-
K_u	Buckling resistance enhancement factor	-
q_{all}	Critical buckling pressure for lining	kN/m^2
S_D	Ring bending stiffness of lining (per meter length)	N/m/m
S_{DL}	Long term ring bending stiffness of liner (per meter length)	N/m/m
t	Lining material thickness	mm
t_1	Minimum grouted annulus thickness	mm
t_2	Wall thickness of existing sewer	mm
w	Unit weight of soil	kN/m^3
W_g	External dead loading	kN/m
W_q	External live loadings	kN/m
Δ_y	Predicted long term vertical deflection of lining	m
Δ_y/D	Limiting long term vertical deflection of lining	%
υ	Poisson's ratio	-

1. General

1.1 Introduction

This specification nominates requirements for rehabilitation of person entry concrete sewers by lining.

This work may be required to protect the internal concrete surfaces from deterioration, restore structural integrity and/or hydraulic capacity, or prevent infiltration of groundwater and exfiltration of sewage.

1.2 Scope

This specification nominates requirements for the design, manufacture, installation, workmanship and testing of lining systems used to rehabilitate man-entry concrete sewers 900 mm and greater in diameter. It also includes requirements for associated works including preparation of the sewer pipeline, identification and reinstatement of connections, adjustments and repairs to maintenance holes and flow control measures.

The requirements of this specification are limited to Type I (bonded) and Type II (unbonded) linings.
The design requirements contained in this specification only apply for gravity sewers.
This specification is not applicable to linings which are installed using spray techniques.

1.3 Proprietary items

Nomination of a proprietary item by Sydney Water does not imply preference or exclusivity for the item identified.

Alternatives that are equivalent to the nominated items can be submitted to Sydney Water for acceptance. The submission must include appropriate technical information, samples, calculations and the reasons for the proposed substitution, as appropriate.

2. Lining Product

2.1 Materials

The minimum required service life of the installed liner material is fifty [50] years. The liner system must be comprised of materials which are chemically and biologically resistant to internal exposure to sewage, sewage related gases and mild concentrations of industrial effluent for the service life of the liner.

The material must be tested in accordance with the following method to demonstrate its resistance properties. The test method is a modified ASTM D543 with a total exposure period of 112 days at 25±3°C. Weight and hardness change specimens must be 50 mm in diameter. Thickness of the specimens must be the minimum thickness available for the liner system or as per agreement with Sydney Water.

The weight and hardness specimens must be initially conditioned in a mechanical convection oven for 7 days at 43±3°C, then cooled in a desiccator for 3 hours at 25±3°C, measured, and then immersed in a chemical solution of 20% sulphuric acid. At 28-day intervals selected specimens must be removed, washed, surface dried and measured The same weight and hardness change specimens must be reconditioned in a mechanical convection oven for 7 days at 43±3°C, then cooled in a desiccator for 3 hours at 25±3°C and measured again. No re-measuring is required for the tensile strength samples. If any specimen fails to meet the requirements specified below, the material will be deemed unsatisfactory. A satisfactory chemical resistance is defined as having a maximum of:

a) 2% variation from the initial weight

b) 5% variation from the initial material shore D hardness

c) 10% reduction from the initial tensile strength

Furthermore, the liner must be comprised of materials which will not be subject to excessive shrinkage, thermal contraction, recovery or reversion affecting the shape or dimensions on the liner following installation. Residual stresses must be released during the installation process. The liner material must have satisfactory abrasion resistance to the migration of silt, sand and debris along the pipe. It must be sufficiently robust not to be damaged by pipe cleaning equipment or cleaning process which may be required to remove any future blockage (debris, roots, etc.) following installation. The Contractor must provide evidence that the liner will not be damaged because of normal cleaning and jetting processes.

2.2 Design

2.2.1 General

2.2.1.1 Condition of existing pipe

The condition of the existing sewers at the end of the service life of the lining has been classified for design purposes as INTACT or DETERIORATED.

2.2.1.2 Material Properties

Where material properties under load vary with time, material properties of the lining at the end of the fifty (50) year service life must be used in design calculations. The exception to this is design of the lining for loads applied only during installation, which may be based on short term material properties.

The two-year values for ring bending stiffness of the lining measured by testing may be used in the calculations for a DETERIORATED host pipe as representative for the fifty (50) year buried pipe stiffness.

The material properties used in the design must be consistent with the composition of the lining material. These must be the same values as those nominated by the Contractor in the Schedule of Technical data.

The Contractor must submit test data in accordance with Clause 3.10 to substantiate the values for material properties nominated by the Contractor in the Schedule of Technical Data.

2.2.1.3 Short Term Design Check

Short term design checks must be carried out for the lining material, either in its final or one of its intermediate states, to ensure the lining is stable and will not be overstressed during the installation and/or curing of the particular system. Short term materials properties may be used to verify the suitability of installation and curing methods.

2.2.1.4 Design Calculations

Design calculations must be provided in a Design report in accordance with requirements of the Sydney Water Technical Specification - Civil. These calculations must demonstrate that the proposed nominal wall thickness of each lining given by the Contractor in the Schedule of Technical Data is greater than or equal to the design thickness.

Unless noted otherwise, all calculations must assume a minimum factor of safety of 2.

Review of the Contractor's design calculations must not be construed as acceptance of the calculations. Responsibility of the design remains with the Contractor.

The Contractor must also provide a copy of the calculations for short term design checks.

All work on the preparation of the design calculations, including verification, proof checking and review, must be incorporated in the Contractor's Quality Assurance System.

2.2.1.5 Design Loadings

Vertical earth pressures must comprise the full height of soil above the pipe without reductions for trench effects. The bulk unit weight of soil (w) must be 20 kN/m^3.

Maximum hydrostatic pressures from groundwater must be based on the design ground water level specified in the Technical Specification – Civil.

The live load, Wq, must comprise traffic surcharge loadings calculated in accordance with AS/NZS 2566.1. Traffic surcharge loads must be taken as given in AS5100.2 for the following loading types:

Table 1 Traffic loading

Type	Description	Load
A – Major Road	Major public and private road carriageways, driveways in industrial and commercial areas	Maximum load case for SM1600 single or dual lane
B – Minor Road	Minor public and private road carriageways, driveways in residential areas, footpaths/verges/median strips not restricted to vehicles, parkland with no restriction to vehicular access	Maximum load case for SM1600 single lane
C – Field Load	Areas within private properties, and public places, pedestrian malls and footways not subjected to vehicular loading or have no access for vehicles	60 % of minor road loading

The design loading on each linings must be the maximum load produced from the combination of soil loadings and traffic surcharge loadings for the particular lining. Determination of the maximum load must include the case where the ground water level is located at the crown of the pipe.

2.2.2 Type I Liner

2.2.2.1 Bond Between Lining and Existing Pipe

All linings supplied in accordance with this clause of the specification must be designed assuming that in the long term, the renovated sewer is considered to be acting as a composite section comprising of the original sewer, the grout and lining to be considered as a Type I lining, the shear bond strength between the lining and grout, and between the grout and the wall of the sewer must exceed 1.0 MPa. The minimum allowable tensile bond strengths at the same locations must exceed 0.5 MPa. If requested, test data must be provided to substantiate minimum bond strength requirements.

2.2.2.2 Design

The liners must generally be designed in accordance with the procedure set out in the Water Research Centre, Sewer Rehabilitation Manual Volume III, Section 4 except as varied below. The determination of the lateral earth pressures and the crown bending moment vary with the pipe support conditions. The pipe condition must be taken as either INTACT or DETERIORATED.

For the DETERIORATED condition, the support may be assumed to be enhanced if the Contractor proposes to fill possible voids outside the sewer as part of the lining installation Process. The values used in the design for the soil unit weight (*w*), the lateral earth pressure coefficient (K_b) and crown bending moment coefficient (C_b) for the different support conditions must be taken as follows:

Table 2 Type I liner design values – Deteriorated condition

COEFFICIENT	DETERIORATED CONDITION	
	Without Grouting	Enhanced by Grouting
w	20 kN/m^3	20 kN/m^3
K_b	0.00	0.40
C_b	0.50	0.30

Traffic loads are to be those given in Clause 2.2.1.5.

The wall thickness of the existing sewer (t_2) must be taken as the nominal wall thickness of the pipe less an allowance for deterioration. The allowance for deterioration must be based on site specific assessment or as nominated by Sydney Water, but not less than 15mm. Nominal wall thickness must be based on site specific assessment or as nominated by Sydney Water.

2.2.3 Type II Liner

2.2.3.1 Bond Between Lining and Existing Pipe

All linings supplied in accordance with this clause of the specification must be designed assuming that in the long term, there will be no bond existing between the original pipe and the lining.

2.2.3.2 Design of INTACT pipe

A lining within an INTACT pipe must be designed to support the hydrostatic loads imposed externally from groundwater. The design must be based on the buckling strength of the lining with account taken of the enhancement provided against a buckling mode of failure by the existing pipe.

The following equation must be used to determine the required stiffness of the lining:

$$q_{all} = \frac{24 \times K \times S_{DL} \times 10^{-3}}{(1-v^2)} \times \frac{C}{FS}$$

Where:

FS = 2.0

K = 7.0 when lining and pipe are in intimate contact or the annular gap is grouted

= 4.0 when the gap between the outside of the lining and inside of the pipe exceeds a mean value of 1mm.

$$S_{DL} = \left(\frac{E_{BL} \times I}{D3} \right) \times 10^{6}$$

$$c = \frac{\left(1 - \frac{d_{av} - d_{min}}{d_{av}} \right)^{3}}{\left(1 + \frac{d_{av} - d_{min}}{d_{av}} \right)^{2}}$$

The ovality of the existing pipe must be based on site specific assessment but must not be less than 2 %.

Each lining must be designed to resist hydrostatic pressures resulting from groundwater. The design ground water level must be as specified in the Sydney Water Technical Specification – Civil.

The linings must also be designed for stresses induced from bending moments arising from the ovality of the out of round lining.

2.2.3.3 Design of DETERIORATED Pipes

A lining inside a DETERIORATED pipe must ignore any contribution from the original pipe. The lining must be designed as a flexible pipe and be capable of supporting all imposed loads in its own right. The lining must be designed in accordance with AS/ANZ 2566.1 to satisfy the critical performance criteria of deflection, strength and buckling.

The predicted long-term vertical deflection must be less than six percent (6 %) of the diameter of the lining. A soil modulus of E'= 2.0 MPa assumes that voids may be present outside the pipe. This value must be used unless the Contractor proposes to fill possible voids. Where filling of voids is to be incorporated as part of the liner installation, a maximum value of E'= 4.0 MPa may be used for deflection and buckling calculations.

For strength calculations, the long-term flexural strain developed in the wall of the lining for any load or load combination must not exceed the nominated permissible value appropriate for the liner material nominated by the Contractor in the Schedule of Technical Data.

In addition to the requirements of AS/ANZ 2566.1 the lining must be provided with a minimum ring bending stiffness to satisfy the local buckling requirements for an INTACT pipe.

2.3 Hydraulic Requirements

The lining system must not reduce the internal diameter of the existing pipe by more than 5% of its original dimension.

Where the liner causes a reduction in the sewer's cross-sectional area, the liner must provide a reduction in flow resistance (i.e. improved surface smoothness) such that the flow capacity is equivalent or better than the existing flow capacity determined in accordance with Water Research Centre, Sewer Rehabilitation Manual, Volume II, Appendix J. Account must be taken of the build-up of slime and any joints and/or defects which may affect hydraulic performance.

2.4 Degree of Fit

The lining must be designed and fabricated in a manner that, when installed, will neatly fit the internal wall and length of the pipe being lined. Where lining technology requires, suitable allowance must be provided for longitudinal and circumferential stretching of the lining during installation.

A lining must be considered to neatly fit if the mean difference between the inside of the pipe and outside of the lining is less than or equal to 1 mm. A neat fit also includes a lining where any gap formed between the lining and the pipe is subsequently grouted.

2.5 Retention of Existing Sewer Condition

No activity of the Contractor during preparation of the sewer section and installation of the liner must adversely affect existing structural integrity of the sewer.

2.6 Manufacture of Lining

The manufacture of the lining must be carried out in accordance with a specification purpose written for the particular system. This specification must detail all labour, materials and equipment required to combine the various constituents to produce the lining ready for delivery to site.

The purpose written specification must also include testing and inspection work carried out to verify the dimensions and quality of the manufactured lining. A copy of this specification must be provided by the Contractor upon request by Sydney Water.

The Contractor must be responsible for measuring the dimensions of the existing sewer prior to fabrication, to ensure that proper fit is achieved. This must include measurement of the horizontal and vertical alignment at changes in direction and bends.

Prior to the commencement of manufacture, the Contractor must submit details of measurements taken inside the sewer. As a minimum this must include measurement of the internal width and height at each manhole, and at 20 m maximum intervals between manholes.

All work involved in the measurement, inspection and testing of the lining during manufacture must be included in the Contractor's Quality Assurance System.

3. Execution

3.1 Preparation of Pipeline

All pipes must be inspected to confirm they are cleaned and ready for installation of the lining. Visual inspection must be carried out for all pipes with diameters greater than 1500 mm diameter and in all smaller sizes which will be using a lining system requiring person entry installation techniques. Closed circuit television (CCTV) inspection in accordance with the relevant clauses of the Technical Specification must be provided for pipes with internal diameters between 900 and 1500 mm which use non- person entry installation techniques (eg soft lining systems). The CCTV must be run opposite to flow direction to ensure full view of any branch entering at an acute angle.

3.2 Surface Preparation

The extent of the surface preparation must vary depending on whether the lining relies on bond (Type I) or is self-supporting in its own right (Type II). The selection equipment and methods used for the surface preparation must be the Contractor's responsibility. Sydney Water must be given the opportunity to visually inspect the prepared internal surfaces before the commencement of any lining work. The Contractor must give Sydney Water a minimum of two working days' notice of his intention to commence lining. The Contractor must provide back up support (flow control, ventilation, safety equipment etc) for Sydney Water to undertake the inspection.

3.2.1 Type I (bonded Linings)

The Contractor must remove all loose or softened material to ensure the prepared surface comprises exposed aggregate and unattacked concrete. This must where necessarily include the use of abrasive blast cleaning and/or handheld percussive tools such as needle guns. The Contractor must give Sydney Water notice of intention to use abrasive blast cleaning and not less than seven (7) days prior to commencement. Blast cleaning must be carried out generally in accordance with AS 1627.4 and the requirements herein. The Contractor must furnish Sydney Water a sample of the abrasive which is to be used for the works. The use of silica sand in dry abrasive blast cleaning is prohibited. The grit must be dust free, dried, screened and graded. Abrasive grit must not be reused. Used grit must be collected and disposed of by the Contractor. All compressed air used in blast cleaning, and blowing down after cleaning, must be free from oil and moisture.

If directed by Sydney Water, the Contractor must spray on phenolphthalein to confirm the prepared surface has an alkalinity consistent with sound concrete. This should be applied immediately after cleaning. Fresh surfaces may need to be exposed if there is any delay between leaning and application of the phenolphthalein. Correctly prepared surfaces should turn pink.

Sydney Water may also nominate up to three locations per maintenance hole length at which the Contractor must extract core samples 50 mm in diameter to confirm the quality of the surface preparation. These must be forwarded to Sydney Water for inspection and independent testing.

If necessary, the Contractor must treat the surface by scabbling or application of a priming or bonding agent or similar, to ensure adequate bond is obtained between the inside face of the existing sewer and the grout used to fill the annular gap between the lining and pipe.

3.2.2 Type II (unbonded linings)

The Contractor must remove all loose or softened material to ensure the prepared surface comprises exposed aggregate and unattacked concrete.

3.3 Treatment of exposed reinforcement

Following the cleaning of the pipe and prior to lining, any exposed reinforcement must be wire brush cleaned and coated with a zinc rich epoxy primer approved by Sydney Water supplement.

Additionally, for soft lining systems, reinforcement must be coated with a minimum thickness of 3 mm of epoxy mortar to avoid potential damage to the containment tube during installation. In the case of severe deterioration of the pipe reinforcement, additional precautionary work must be undertaken as given in the relevant clauses of the Technical Specification or as directed by Sydney Water.

3.4 Maintenance holes

Where a maintenance hole has to be altered by the Contractor, as part of these works, the Contractor must notify Sydney Water of the change, prior to the work.

The Contractor must reinstate all maintenance holes, in accordance with Sydney Water standards and to the satisfaction of Sydney Water.

The bottom half of the circular lining must be continued through the maintenance hole to prevent irregularities around the edges of the linings and any irregularities or differences in level which may cause accumulation of debris in the sewer or maintenance hole channel. Where linings are terminated on both sides of the maintenance hole an epoxy mortar coating which has a thickness equivalent to the lining must be applied to the walls of the maintenance hole to match the bottom half of the lining.

Where a lining has been installed to one side of the maintenance hole, the maintenance hole channel must be rendered using an epoxy mortar or other material approved by Sydney Water to form smooth transition between the lining and the walls and base of the maintenance hole. The transition at any upstream edge must be sufficient to prevent accumulation near the liner edge and any ponding or silt accumulation in the invert.

3.5 Bypass Pumping

The Contractor must provide labour and equipment for bypass pumping consistent with the installation technique used for lining. Equipment supplied must include necessary back up and spare parts.

The bypass system must be suitable for the expected flow conditions which will prevail while work is being carried out inside the sewer.

The bypass must be set up in accordance with the details nominated by the Contractor in the Schedule of Technical Data. The bypass must be set up in accordance with regulatory requirements and to the satisfaction of the relevant authorities and Superintendent, particularly with respect to disruption of traffic and environmental safeguards.

3.6 Delivery and Installation of Liner

3.6.1 General

The Contractor must clean the sewer or portion of sewer immediately prior to lining. Flow should be isolated during the lining operation to ensure that no debris enters which may get trapped between the liner and the original pipe. The Contractor must make arrangement to ensure that any connections are not in use during the lining operation.

Visual or a closed-circuit television (CCTV) inspection similar to that carried out following cleaning and pipe preparation (Refer Clause 3.1) must be carried out after installation to establish that the lining has been installed in the desired manner and that all live laterals have been reconnected properly. The CCTV inspection must be carried out as per the relevant specifications.

The Contractor is solely responsible for the details of execution and suitability of methods and procedures used to satisfy the peculiar conditions of each lining length.

Delivery and installation of the lining must be carried out in accordance with a specification purpose written for the particular lining system. This specification must detail all labour, materials, equipment and procedures necessary to deliver and install the liner.

The specification must also include testing and inspection work carried out to verify the quality of the installed lining.

3.6.2 Type I Liner

Access to the sewer must be via existing maintenance holes unless other locations have been nominated by the Contractor in the Schedule of Technical Data submitted with the Tender. Additional access shafts must not be excavated without the prior written approval of Sydney Water. Excavation, backfilling and reinstatement of access shafts must be carried out in accordance with statutory requirements and to the satisfaction of the relevant authorities.

The Contractor must ensure that at the completion of each shift that the section of the lining which has been installed is secured and suitable for inundation in the event of wet weather. The Contractor must be responsible for making the necessary arrangements and obtaining approvals for the stacking and/or storage of segmental units on site prior to installation.

Joints between segmental units must be watertight against infiltration and exfiltration.

The Contractor must be aware of radii of bends and change in diameter and must tailor segments and panels to suit the geometry of the sewer. Installations and joining techniques at bends must be carried out in accordance with the method nominated by the Contractor in the Schedule of Technical Data accompanying the Tender. Further details must be supplied to compliment the information in the tender if requested by Sydney Water. The Contractor must provide written advice and a detailed explanation of the need for changes prior to their inclusion in the works.

Segmental liners must be trial assembled above ground for the full length of any bend to ensure they match the measured length and curvature inside the existing sewer.

Joints between lining units must be made and secured in accordance with manufacturer's written instructions. Contact surfaces must be thoroughly cleaned immediately prior to joint.

The existing geometry of the sewer must be reinstated at any access shaft using the same materials as the remainder of the original pipe and lining.

3.6.3 Type II Liner

The Contractor must install the lining in a continuous operation. The installation procedure must be carefully executed so that infiltration is prevented into the annular space between the existing pipe and the lining.

If, due to a broken or misaligned pipe at the maintenance hole wall the new lining fails to make a tight seal, a seal must be applied at that point. The seal should comprise of resin, grout or other material which is/are compatible with the lining and the original pipe. The sealing material must have a service life which is comparable with the lining material.

For all spirally wound lining installations, the gap between the ribbed profile and the existing pipe must be filled with grout. The grout must ensure that the space between the host pipe and the lining is fully sealed and does not allow any water migration.

3.7 Reinstatement of Connections

The Contractor must reinstate maintenance holes and incoming connections. The Contractor must allow sufficient time for any movement of the installed lining relative to the host pipe before finishing the cut outs. This must include movements caused by shrinkage, thermal contraction, stress recovery, mechanical adjustment in material properties during curing or any other action.

Cutting equipment must be capable of reinstating the opening into the sewer for slope or square connections. The cutting tool must leave a smooth, bevelled edge free of any protrusions. The cut out must be flush with the inside surface of the branch sewer line.

There must be no discontinuity between the lining material at the cut hole and the branch sewer line. Each required opening must have initial rough cut on the day of lining and be 100 per cent completed after the lining has reached its final dimensions in terms of length and diameter.

The Contractor must ensure that each hole cut by this equipment, or otherwise reinstated, will not inhibit flow into the sewer from the junction, cause any constrictions or be such that it will catch solid material and cause a choke.

At each incoming connection, a polyurethane grout must be used to seal the connection at the sewer and up to the first collar of the junction. As an alternative, a short-form liner may be used, if approved by Sydney Water. Polyurethane grout of minimum 10% solids must be used for grouting.

3.8 Finish (hydraulic acceptability)

The installed lining must be continuous over its length and must be free of any defect which is likely to affect the satisfactory hydraulic performance of the lined pipe or cause accumulation of solids.

The finished lining must be free of any leakage from the lined section of pipe to the surrounding ground or from the ground to the inside of the lined pipe.

Openings through the lining at junctions must be finished so as not to inhibit the flow of sewage in the pipe.

3.9 Defects

The finished lining must be free of all defects which affect hydraulic performance or structural adequacy. This must include defects arising from substandard materials, faulty or inaccurate manufacture, inadequate pipe preparation, faulty installation or workmanship, or inadequate curing. The only exception is inherent defects, as defined in Clause CL 1.4, which must satisfy the requirements of this clause.

For the Contractor's lining system, inherent defects must be those nominated by the Contractor in the Schedule of Technical Data. The acceptance limit for each defect must be those negotiated and/or agreed with Sydney Water.

If during the execution of the contract it becomes apparent that there are further inherent defects which have not been nominated by the Contractor, then, provided the Contractor can substantiate such defects satisfy the definition of "inherent defects", these may be accepted as such by Sydney Water. In these instances, Sydney Water may nominate the acceptance limit for the defects in terms of its frequency and dimensions and this must be binding on the Contractor.

Defects which are considered unacceptable in all liners include, but are not be limited to the following:

- hydraulic performance
- structural adequacy
- foreign inclusions
- irregularity in lining caused by inadequate pipe preparation
- leakage through the lining
- leakage through welded, glued or mechanical locked joints
- unsatisfactory alignment of joints
- inadequate cover
- incomplete grouting
- excessively stepped joints
- inadequate material curing
- inadequate resin impregnation
- excessive resin loss during installation
- dry spots, bubbles, cracks or delamination
- pinholes
- any other defect not nominated as inherent to the lining system
- inadequate bond
- excessive distortion

The following will be considered as unacceptable defects if they exceed the limits given in brackets below:

- inadequate lining thickness (finished thickness < 90% of nominal lining thickness)
- excessive variation in thickness around the circumference of the lining (variation in minimum or maximum thickness > 20% of mean lining thickness).

3.10 Testing

3.10.1 General

The Contractor must carry out testing on the lining material and its constituents. The Contractor must give Sydney Water 7 day’s notice of the date, time and place of all tests on the lining following manufacture and provide all facilities required. All work on the testing of the lining constituents, manufacture of the lining, during and after installation must be included in the Contractor's Quality Assurance System.

3.10.2 Pre Installation Testing

If the Contractor is relying on local or overseas test data to justify the suitability of the lining system in terms of its physical and chemical properties, Sydney Water may request copies of such test results. These results must be forwarded to Sydney Water prior to commencement of lining manufacture. Any property which cannot be verified by such test data must be retested prior to commencement of manufacture of the lining.

Where the lining system is manufactured by a combination of a number of constituents which can be varied to suit the requirements of the Contract, the testing program must include the testing of three prepared samples for the same series of tests (excluding leak tests) to those required for the installed liner.

All tests on the constituents of lining material and manufacture of the liners must be in accordance with the relevant Australian or overseas standards.

Where the lining system utilizes materials, which are prefabricated in segments prior to installation, tests must be carried out to verify the quality and physical properties of the units. As a minimum these tests must include determination of the short term tensile flexural strength and the short-term flexural modulus. These tests and other type tests normally carried out on the lining material must be performed in accordance with the relevant Australia or overseas standard for the lining material. Details of the tests and applicable standard must be included in the Schedule of Technical Data submitted with the tender.

The frequency of testing for the prefabricated units must be in accordance with BS 6001: Part 1. As a minimum the testing frequency must include one segmental unit for each maintenance hole to maintenance hole length.

The Contractor must also carry out a pressure test to confirm that the jointing system proposed for the works can achieve a watertight seal.

This test must be performed to a pressure of 1.5 times the maximum internal and external pressures

3.10.3 Post Installation Testing

This clause lists the minimum requirements for testing which must be carried out on the installed lining. Unless noted otherwise each of the listed tests must be carried out once on each installed maintenance hole to maintenance hole length.

Alternative overseas or Australian standards to those listed may be accepted by Sydney Water for testing purposes providing the test method provides an accurate measure of the required physical property or aspect of installation quality.

For Type I linings three core samples must be taken from each maintenance hole to maintenance hole length on completion of lining work to inspect the quality of the bond between the lining and the grout and between the grout and the prepared internal surface of the sewer.

Locations of the cores will be nominated by Sydney Water. Core holes must be filled with epoxy mortar. For PVC linings a PVC patch must be glued over the hole following filling. Patches must be heat welded over holes for HDPE linings.

3.10.3.1 Soft linings

Gravity Pipe Leakage Test in accordance with ASTM F1216 carried out prior to cutting of laterals.

- Hardness in accordance with ASTM D2583
- Short Term Tensile Strength in accordance with ASTM D638 or BS 2782: Method 1003 (3 samples for each lining length).

- Short Term Flexural Strength and Flexural Modulus in accordance with ASTM D790 or BS 2782: Method 335A (3 samples for each lining length), or, Short Term Ring Stiffness in accordance with AS 3572.10.

Samples for testing may be prepared using the procedure given in Appendix C of WIS 4-34-04.

3.10.3.2 Slip linings and segmental linings

Gravity Pipe Leakage Test in accordance with ASTM F1216:

- Grout Cube Strength in accordance with BS 1881: Part 116. (Three for each batch or grout with a maximum of six for any one length of lining).
- Grout Slump Test in accordance with BS 1881: Part 102. (One for each batch of grout)

These testing requirements assume the lining material is fully tested to confirm its tensile and flexural properties for each batch of pipes produced. It also assumes the pipes are not modified in any way by heat or temperature during installation.

3.10.3.3 Wound or Strip Linings

- Gravity Pipe Leakage Test in accordance with ASTM F1216.
- Impact Test in accordance with WIS 4-31-05 with the impact weight contacting with the joint between strips.
- Grout Cube and Slump tests as for slip linings.

3.10.4 Failure During Post Installation Testing

- A test result must be deemed to have failed if the minimum values nominated by the Contractor in the Schedule of Technical Data are not achieved.
- If only one sample has been extracted from a length of lining then failure of the sample must be interpreted as indicating that the lining in question is defective.
- The Contractor may repeat the tests which have failed from representative samples of the same lining length. These samples may be obtained from excavation and extraction from within the lined section of pipe or alternatively from spare samples prepared during lining installation. The lining will be accepted if the test results of two of the three samples extracted and the average of the three results exceeds the nominated minimum values.
- If three samples are extracted from a length of lining, testing will indicate the lining is acceptable when two of the three results and the average of the three results exceed the nominated minimum values.

3.10.5 Test Records

Results of all tests must be entered into a book and initialled as correct by the Contractor or their representative present when the tests were made. This book must be kept at the works and be open to inspection by Sydney Water or his nominated Representative.

4. References

Standard	Document Title
AS 3571	Glass Filament Reinforced Thermosetting Plastic (GRP) Pipes Polyester Based - Water supply, Sewerage and Drainage applications
AS 3725	Design and Installation of Buried Concrete Pipes
AS 3572	Glass filament reinforced plastics (GRP) - Method for determining the ultimate tensile strength and unit modulus of test laminate
ASTM D638	Test covers the determination of the tensile properties of unreinforced and reinforced plastics
ASTM D790	Test to determine the flexural properties of unreinforced and reinforced plastics and electrical insulating materials
ASTM D-2412	Test method covers the determination of load-deflection characteristics plastic pipes under parallel plate loading
ASTM F1216	Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
AS 2566.1	Buried Flexible Pipes – Part 1: Design and Embedment
BS 1881	Testing Concrete Part 102 Method of determination of slump Part 116 Method for the determination of compressive strength of concrete cubes
BS 2782	Methods of Testing Plastics Method 335A Determination of flexural properties of rigid plastics Method 1003 Determination of tensile properties
WIS 4-34-04	Specification for renovation of gravity sewers by lining with CIPP
WIS 4-31-05	Specification for Solid Wall Concentric External Rib- reinforced PVC Sewer Pipe
WIS 4-12-06	Specification for precast and insitu ferrocement
WIS 4-12-05	Specification for precast Gunite Sewer Linings
WIS 4-34-05	Specification for Polyester Resin Concrete (PRC) Sewer Linings
WIS 4-34-02	Specification for Glass Fibre Reinforced Plastic (GRP) Sewer Linings
WRC	Water Research Centre, Sewerage Rehabilitation Manual
CPDMS0023	Sydney Water Techncial Specification - Civil
AS 5100	Bridge Design Code

Ownership

Ownership

Role	Title
Group	Asset Lifecycle, Engineering and Technical Support
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Change history

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2	Amer Mohammed	25/02/2021	Norbert Schaeper	4/03/2021
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