

SS 210 Corrosion Protection and Rehabilitation of Maintenance Holes

Version 3

1 General

1.1 Intent

This document provides the minimum requirements for corrosion protection and rehabilitation of maintenance holes.

1.2 Scope

The following are covered by this document:

- Application of protective coating on the internal surfaces. This includes the required surface preparation;
- Sealing of maintenance hole against inflow and infiltration;
- Repair and/or replacing maintenance hole frame and cover;
- Raising buried maintenance hole to improve access and to avoid water run-off over cover; and
- Removing and/or replacing step irons.

1.3 Responsibilities

All works are to be undertaken by the Contractor unless stated otherwise. Where a submission, request, proposal is required, it is to be provided to Sydney Water for approval.

1.4 References

Document No	Title
AS 1012.9	Methods of testing concrete - Determination of the compressive strength of concrete specimens
AS 1627.4	Metal finishing - Preparation and pretreatment of surfaces - Abrasive blast cleaning of steel
ASTM D543	Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
ASTM D4263	Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D2240	Standard Test Method for Rubber Property—Durometer Hardness
CEN/TS 14429	Characterization of waste. Leaching behaviour tests. Influence of pH on leaching with initial acid/base addition
CEN/TS 14997	Characterization of waste. Leaching behaviour tests. Influence of pH on leaching with continuous pH-control

2 Quality Assurance

2.1 Control, Handling and Storage

All materials shall be brought to the site in their original unopened containers with the Supplier's label, batch number, application instruction and expiry date. The materials shall be stored under the conditions that would not lead to deterioration.

The materials batch numbers used for the works shall be recorded at all times and provided to Sydney Water upon request.

2.2 Supplier Specification

A written specification from the Supplier prior to the commencement of the work shall be submitted for each product. It must contain the requirements for the supply, storage, mixing, equipment, surface preparation, application, curing, inspection, testing and repair of defects of each product.

2.3 Supplier Supervision

A representative from the Supplier shall witness the application of his/her product during the trial period and other times deemed required/critical. The representative shall provide technical support relating to his/her product when required. The representative shall ensure and be satisfied that his/her product has been applied in accordance with the Supplier's specification.

2.4 Approved Applicators

Application of each product can only be carried out by an Applicator that is approved by the Supplier.

Upon request, Sydney Water shall be provided with an up-to-date work record detailing the time, location, names of product, equipment, method, and applicator(s) of each product application. This record shall be cross-checked for compliance with the Applicator data information submitted prior to commencement of the work.

2.5 Inspection and Testing

Sydney Water or its representative may elect to carry out inspection and testing to ensure that the works have been carried out in accordance with the relevant specifications. Where requested, access and quality control documentation shall be provided to Sydney Water.

3 Submissions

3.1 Prior to commencing the work

The Contractor shall submit the following information prior to commencing any work or trial.

- a) Asset isolation plan
- b) Product data:
 - 1. Supplier's specification (Clause 2.2)
 - 2. Material Safety Data Sheet (MSDS)
 - 3. Test certificates/reports issued by independent testing bodies indicating that the requirements specified herein are met.
- c) Applicator data:
 - 1. Evidence of Applicator's accreditation and training issued by the Supplier.
 - 2. Evidence of Applicator's equipment approval issued by the Supplier.
 - 3. Evidence of successful similar work using method specified here in.

3.2 At the completion of pre-construction inspection and trial

A report detailing the findings from pre-construction inspection and trial shall be submitted prior to commencing the work.

3.3 At the completion of the work

A report summarizing inspections and testings undertaken, observation/conclusion there-off shall be submitted within 2 weeks after the completion of the work.

4 Associated Works (where required)

4.1 Asset Isolation

The Contractor shall prepare plan and provide labour and equipment for asset isolation. It shall be suitable for the expected flow conditions, which will prevail while work is being carried out.

The asset isolation/bypass shall be set up in accordance with regulatory requirements and to the satisfaction of the relevant authorities and Sydney Water, particularly with respect to disruption of traffic and environmental safeguards.

4.2 Pre-Construction Inspection and Trial

This requirement only applies to application of protective lining work to rehabilitated structures.

Surface condition shall be verified prior to commencing surface preparation. Any noticeable discrepancy shall be reported to Sydney Water. Sydney Water shall be advised of the extent of work in cases where major variation is found. Allowances for variations in geometry and details arising from construction tolerances as well as corrosion shall be made.

A minimum of one trial shall be undertaken at the start of the work. The location and extent of the trial shall be selected to reflect the actual work condition. The trial shall include proposed methods of surface cleaning, surface restoration, and lining application. On completion of the trial, the testing specified herein shall be undertaken and the results shall be submitted.

If it becomes apparent during the trial that adjustments are required to the proposed materials, equipment or work methods, details of the necessary adjustments shall be submitted for approval.

The trial area shall be a part of the overall work. Any unsatisfactory trial Sydney Water must be removed and/or repaired at no additional cost to Sydney Water.

5 Materials

Materials used for this work shall conform to this standard.

The following subsections provide the requirements of the products referred to in this specification and the products that have been approved by Sydney Water. Other products of equivalent properties may be used subject to prior approval from Sydney Water.

A list of products that have been assessed by Sydney Water and deemed to meet the requirements may be obtained from Sydney Water upon request.

5.1 Calcium Aluminate Cement (CAC) Mortar

The CAC mortar used for protective lining shall be a proprietary pre-mixed product specially designed to withstand corrosive sewer environment. It shall use aluminate clinkers as the aggregates.

5.1.1 Composition

The chemical composition of the CAC mortars shall comply with the following table.

Substances	Weight %
Al ₂ O ₃	39-47
CaO	35-40
SiO ₂	2-7
Fe ₂ O ₃	9-17
Polymer additives	≤0.5
Others	≤ 5

Additional notes:

- Glass fibres may be used for strength and shrinkage control;
- The maximum aggregates size is 5 mm;
- Water used in mixing shall be potable standard water; and
- Accelerators may be used for curing sections that are exposed to early flows, subject to prior approval from Sydney Water.

5.1.2 Performance

The product shall have a minimum Acid Neutralisation Capacity (ANC) value of 1.8 relative to CaCO₃. Refer to Clause 11.10 for testing details.

The product shall have the following physical properties

a) Compressive strength	@ 24 hours	≥ 40 MPa
	@ 28 days	≥ 50 MPa
b) Flexural strength	@ 24 hours	≥ 6 MPa
	@ 28 days	≥ 8 MPa
c) Tensile strength	@ 28 days	≥ 2.5 Mpa
d) Drying shrinkage	@ 56 days	≥ 600 microstrain

5.2 Epoxy Mortar

The product shall be a multi-component epoxy mortar product suitable for concrete or masonry sewer repair applications. It may be trowel or spray applied.

5.2.1 Composition

The product shall:

- a) Be a mix of Bisphenol A epoxy resin and inorganic filler. The epoxy content level shall be between 15 to 95% as determined using Loss on Ignition (LOI) method.
- b) Have a maximum filler particle size of 250 microns for spray-applied epoxy or 750 microns for trowel-applied epoxy.

5.2.2 Performance

The product shall:

- a) Pass chemical resistance testing detailed in Clause 11.9
- b) Have a minimum thermal decomposition temperature of 370°C as measured using a Thermo Gravimetric Analysis (TGA) instrument with the following parameters:
 - Purge gas: Nitrogen
 - Gas flow rate: 10 litres/min
 - Heating ramp rate: 10°C/min
 - Sample mass (minimum): 5 grams
- c) Have a minimum peak height ratio of metal-carbon to metal-oxide (indicating the interaction between filler and epoxy) of 0.8 as measured using a Fourier Transform Infrared (FTIR) spectroscopy instrument
- d) Have a minimum compressive strength of 40 Mpa
- e) Have a minimum tensile strength of 6 MPa
- f) Have a minimum shore D hardness scale of 70
- g) Have bond strength of 1 MPa or more to the substrate material
- h) Be suitable for application in confined space with limited application time
- i) Have a light colour surface finish of e.g. cream, light grey, or ivory

5.3 Epoxy Novolac Coating

The product shall be a multi-component Bisphenol F epoxy novolac epoxy resin based coating suitable for applications onto cementitious substrates. It may be brush or spray applied.

The product shall pass chemical resistance testing detailed in Clause 11.9.

5.4 Polyurethane/Polyurea Lining

The product shall be high build solventless and designed specifically for corrosion protection of concrete and masonry sewers. It must be spray applied using airless spray equipment. In addition, the product shall:

- a) Pass chemical resistance testing detailed in Clause 11.9
- b) Have a compressive strength of 40 MPa or greater
- c) Have a tensile strength of 15 MPa or greater
- d) Form bond strength of 2.5 MPa or more to the substrate material

- e) Have a shore D hardness scale of 50 or greater
- f) Have an elongation at break of 250% or greater
- g) Be suitable for application in confined space with limited application time
- h) Have a light colour surface finish of e.g. cream, light grey, or ivory

5.5 Plastics Liner

Plastics liner shall be either high-density polyethylene (HDPE) or polyvinyl chloride (PVC).

5.5.1 HDPE Liner

The HDPE liner shall have a large number of anchoring studs manufactured during the extrusion process of the sheet. The minimum number of the anchoring studs 1230 per m². The liner shall have a minimum pull out strength of 55 kg per anchoring stud.

In addition, the liner shall meet the following requirements:

- a) Density ≥ 0.945 kg/l
- b) Yield strength ≥ 15 MPa
- c) Elongation at break $\geq 400\%$
- d) Hardness, Shore D ≥ 50

The liner shall pass chemical resistance testing detailed in Clause 11.9.

The liner shall have a light colour surface finish of e.g. cream, light grey, or ivory

5.5.2 PVC Liner

The PVC liner shall have continuous anchoring ribs manufactured during the extrusion process of the sheet. The liner shall have a minimum pull out strength of 20 kg per linear cm.

In addition, the liner shall meet the following requirements:

- a) PVC resin content $\geq 99\%$
- b) Yield strength ≥ 15 MPa
- c) Elongation at break $\geq 200\%$
- d) Hardness, Shore D ≥ 50

The liner shall pass chemical resistance testing detailed in Clause 11.9.

The liner shall have a light colour surface finish of e.g. cream, light grey, or ivory.

6 Surface Preparation

The section is divided into two parts, new concrete and aged concrete. It also includes requirements for masonry structures.

6.1 New Concrete

6.1.1 Curing

Unless approved otherwise, all new concrete works shall be cured to a minimum 28 days before application of polymeric linings.

6.1.2 Surface cleaning and roughening

Formwork release oil, surface hardeners, curing membrane, and all other foreign materials / contaminants shall be removed with abrasive blasting or other means of appropriate cleaning methods. All debris shall be removed following the cleaning and disposed of in an appropriate waste facility.

The concrete surface finish shall be sufficiently rough to receive the lining. Typically it is equivalent to sandpaper with grit 80 or coarser.

6.1.3 Defects

Repair all form of voids, bugholes, honeycombs, and other surface defects with a suitable patching product. Remove all form ties and metallic protrusion.

6.1.4 Moisture content

This clause only applies to polymeric linings (epoxy, polyurethane, and polyurea).

The moisture content of concrete substrates shall be tested using a moisture meter or qualitatively using the method described in ASTM D 4263, which involves taping down a 450 mm by 450 mm piece of 75 to 150 micron thick polyethylene film for a period of 24 hours.

Linings shall not be applied if any moisture is entrapped inside the film, or if the moisture content of the concrete substrate exceeds 4%.

6.2 Aged Concrete

6.2.1 Surface cleaning and roughening

Clean and roughen surface as per Clause 6.1.2.

6.2.2 Patch Repair

Patch repair using repair mortar shall be undertaken for areas with deep voids. If the reinforcements are exposed, clean and repair those as required. Reinforcements shall be fully embedded in concrete while patching. A minimum cover of 65 mm over the reinforcement shall be maintained unless required to match adjacent surface.

6.2.3 Resurfacing

Resurfacing is large-scale repair of irregular concrete surfaces. It may be undertaken for creating a uniform surface profile using repair mortar in order to minimise the amount of protective lining used or create an optimum substrate surface for the lining.

Where resurfacing is undertaken, the minimum thickness of repair mortar shall be 20 mm. Some locations may require thicker application to suit the structural and geometry requirements. The finished surface profile shall be made as such so an optimum bond with protective lining is achieved.

Where the invert and bench surfaces require repair, they shall be smooth and sloped in the direction of the flow.

6.3 Infiltration Repair

Active minor leaks should be stopped using a rapid setting hydraulic cement product specifically for such purpose.

For stopping major leaks, a chemical grout sealant injected forced into the joints and crack may be used. The sealant shall be acrylamide or urethane base gel type. It should be tinted to allow detection of grout in drill holes or at leakage locations.

Where tree roots are present, the grout shall have root inhibitor agent. Any holes shall be patched upon completion of the sealing operation.

6.4 Crack Repair

Any possible active cracks must be reported to Sydney Water. A qualified structural engineer shall then be engaged by the Contractor to assess if the cracks affect the structural integrity and to recommend a suitable repair method. Active cracks that do not affect the structural integrity may be treated as joints and repaired in accordance with Clause 6.5 below.

Non-active cracks, with opening greater than 1 mm, should be repaired using crack sealing method, where the path along the crack are opened up forming a wedge shape slot 20 mm wide x 20 mm deep and filled with repair mortar. Smaller non-active cracks may be filled with chemical grout.

6.5 Joint Repair

The purpose of the joint repair is to ensure the continuity of the protective lining system is maintained. It is also intended to address any areas where problems currently exist with either leakage or odour escape through the joints.

The system shall be compatible with movements. The repaired joints shall be airtight and watertight. Materials used to seal any joints in the lining need to be compatible with other repair materials for the adjacent concrete surfaces and have a comparable life expectancy.

The Contractor shall be responsible for developing the joint repair method as required to suit actual site conditions and joint materials. It shall be submitted to the Superintendent for approval prior to commencing the work.

6.6 Steel Reinforcement Cleaning and Repair

Any exposed steel reinforcement shall be cleaned to a Class 2 of AS 1627.4 and then coated immediately with a corrosion resistant zinc rich primer to avoid flash rusting.

Concrete steel reinforcement that has lost up to 10% of its diameter due to corrosion shall be reported to Sydney Water. A qualified structural engineer shall be engaged by the Contractor to assess if the loss is acceptable.

Any reinforcement that has lost 10% or more of its diameter, and any reinforcement that has lost up to 10% of its diameter but considered unacceptable from structural adequacy consideration shall be augmented by new reinforcement of similar size.

6.7 Masonry Structure

Any loose and protruding brick shall be removed using hammer and chisel. Voids caused by the removal of brick shall be reconstructed using sound clean bricks and suitable mortar. Care must be taken to ensure the integrity of the structure during this process. Lost mortar joints shall be repointed using suitable mortar material and the surface shall

be struck flush with the brick surface prior to lining application. CAC mortar is acceptable repointing material.

Any infiltration shall be stopped first prior to undertaking the repair using the method specified herein.

7 Lining Application

7.1 General

Unless otherwise specified, the work consists of applying the lining to all concrete surfaces of the maintenance holes i.e. wall, roof, bench, and invert. For maintenance holes deeper than 6 m, the application of lining onto the wall element is only required for the bottom 5 m section (measured from the overt).

The surface prior to lining application shall be clean and sound. Any crack, leak, defective joint, deteriorated inlet or outlet, or exposed reinforcement shall be repaired. The surface preparation method shall be in accordance with requirements detailed in the previous section.

During application, the inlets, outlets, and access equipment (handle areas only) shall be covered to prevent excess material from accumulating and contaminating the sewers.

The applied product shall form a smooth, uniform, and monolithic protective liner. The bench, invert, and transitions to the pipes shall be smooth and sloped in the direction of the flow. Abrupt irregularities shall not exceed 1mm. Gradual deviations from vertical or horizontal alignment of the finished coated surface shall not exceed 10 mm when measured against a 1 m straight edge. A spray-applied product on the walls and soffit does not need a trowel finish, providing that the heights between peaks and valleys are less than 1 mm. Any horizontal flat surface area, which may be used for stepping, shall be made slip resistance.

Where two or more coating systems are used in a structure, their joints shall be properly designed considering the durability and characteristics of each coating system.

The lining shall not be used for providing or restoring structural properties.

7.2 CAC Application

Only CAC mortar product(s) approved by Sydney Water shall be used. The material shall be applied strictly in accordance with the Supplier's written recommendations.

The mortar shall be prepared using potable quality water (sea water, recycled water, etc are not permitted). The water-cement ratio shall be restricted to less than or equal to 0.4 (corresponding to an effective w/c of 0.33 to 0.36).

The application may be carried out using spinning head shotcreting equipment for circular maintenance hole that is not greater than 1.2 m in diameter. For straight back taper maintenance hole, the spinning head must be centrally located inside the shaft.

For hand application, due consideration shall be given to the ambient temperature, heat of hydration, setting time, distance of placement from the point of mortar mixing so that the mortar remains workable during application.

CAC may not be hand applied to overhead or roof sections. Where CAC is applied to the wall and bench sections, alternative lining system must be used for the roof section.

Contact or contamination with any other type of cement shall be avoided. Residue of any such material in the equipment or on tools shall be cleaned before use. Lime or Portland cement shall never be mixed with CAC.

The surface prior to coating application shall be clean and sound. Any crack, leak, defective joint, deteriorated inlet or outlet, or exposed reinforcement shall be repaired. The surface preparation method shall be in accordance with requirements detailed in the previous sections.

The prepared concrete substrate shall be saturated with clean water just prior to the application. However the water shall not be so excessive as to affect the water/cement ratio at the interface.

Heat of hydration shall be controlled to avoid adverse effects on the mortar setting. Use of cool water in the preparation of the mortar or multiple layer application will be permitted.

During application, accumulation of excess material in the surrounding area shall be prevented if necessary by covering such areas and removing material after work.

The product shall be cured properly according to the manufacturer/supplier's recommendation before returning to active flow. If a subsequent layer of coating is required, after the previous coating has been exposed to the flow, then it shall be cleaned using high-pressure water and roughened to create optimum surface for bonding.

Unless otherwise specified, the minimum total thickness of the CAC coating application, over and above any surface restoration or filling surface irregularities shall be 25 mm.

The application thickness may be reduced to 10 mm on the riser / make up ring section where a full thickness application would reduce the minimum internal diameter below the acceptable limit. Alternatively, other lining system may be used for this section.

7.3 Epoxy Mortar Application

Application of this type of lining onto structures deeper than 15 m below ground level is not permitted without Sydney Water's approval, due to potential debonding caused by presence of groundwater pressure. If epoxy mortar is used on these structures, a hydrophobic (water retardant) bonding agent shall be applied.

The application may be undertaken either by spraying or trowelling. The concrete substrate shall be fully cured and has been prepared in accordance with Clause 6.

The required lining thickness depends on the type of epoxy mortar, which is governed by the proportion of epoxy resin within the product. Table 1 provides the requirement of absolute minimum dry film thickness (DFT).

A minimum of two coats is required to avoid formation of pinholes. A primer coat, if applied, is not counted as a coat.

The product shall be cured properly according to the Supplier's recommendation before returning to active flow. If subsequent layer of lining is required after the recommended relining period has elapsed or the lining has been exposed to flow, then the previous lining layer shall be cleaned, roughened, and/or chemically activated to create optimum bonding.

Table 1 Minimum Thickness of Coating according to Epoxy Resin Content

Epoxy resin (weight %)	95-88	87-80	79-72	71-64	63-56	55-48	47-40	39-32	31-24	23-15
For resurfaced/new structures (mm)	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5
For non-resurfaced structures (mm)	6	7	8	9	10	11	12	13	14	15

7.4 Epoxy Novolac Application

This lining system is only applicable to new concrete substrate or where aged concrete has been completely resurfaced with suitable repair mortar resulting in a new smooth surface. Additionally, application of this type of lining onto structures deeper than 15 m below ground level is not permitted without Sydney Water's approval, due to potential debonding caused by presence of groundwater pressure.

The application may be undertaken either by spraying or brushing. The concrete substrate shall be fully cured and has been prepared in accordance with Clause 6.

A minimum of two coats is required to avoid formation of pinholes. A primer, if applied, is not counted as a coat. The total minimum lining dry film thickness is 400 microns.

The product shall be cured properly according to the Supplier's recommendation before returning to active flow. If subsequent layer of lining is required after the recommended relining period has elapsed or the lining has been exposed to flow, then the previous lining layer shall be cleaned, roughened, and/or chemically activated to create optimum surface for bonding.

7.5 Polyurethane/Polyurea Application

Unless otherwise approved, this type of lining shall only be applied onto new structures that are not deeper than 6 m below ground level, due to potential debonding caused by presences of moisture in the substrate and groundwater pressure.

The application may only be undertaken by spraying method. The substrate shall be fully cured and dry, and has been prepared in accordance with Clause 6.

A minimum of two coats is required to avoid formation of pinholes. The primer, if applied, is not counted as a coat. The total minimum lining dry film thickness is 3 mm.

The product shall be cured properly according to the Supplier's recommendation before returning to active flow. If subsequent layer of lining is required after the recommended relining period has elapsed or the lining has been exposed to flow, then the previous lining layer shall be cleaned, roughened, and/or chemically activated to create optimum surface for bonding.

7.6 Plastics Liner Application

Application of this lining onto structures deeper than 15 m below ground level is not permitted without Sydney Water's approval, due to potential debonding caused by presence of high groundwater pressure.

For new structures, the liner shall be either factory installed during concrete fabrication or cast onto the concrete during construction on site.

For aged structures, the concrete substrate shall be prepared in accordance with Clause 6. The liner shall be fixed to a formwork and installed to the original substrate using high strength pumpable grout approved by the manufacturer. The grout shall fill all voids and crevices.

Nails should not be used for attaching liner to the formwork. Only use specially designed double-sided tapes. Liner may also be secured by tying the top anchors back to the formwork using strong non-corrosive wires. The wires must be removed prior to welding.

Specially designed joiner pieces shall be used to temporarily joint liner non-corner segments during concrete pouring, to ensure the segments are properly aligned and the joint area is free of contamination.

Where possible, pre-fabricated corners pieces should be used to minimise corner welding.

All joints shall be welded in order to form a monolithic lining. The welding must only be carried by an accredited geomembrane welder and approved by the supplier. All welding shall be tested in accordance with Clause 12.8.

The minimum thickness of the lining is 2 mm. A thicker application may be recommended by the manufacturer for application in more abrasive environment or areas with higher hydrostatic pressure.

8 Replacement of Maintenance Hole Frame and Cover

Existing maintenance hole frame and cover will normally be cleaned and reinstalled. Where required, the existing frame and cover shall be removed and disposed appropriately, and replaced with new ones. Lightweight plastics cover and frame shall not be used in trafficable or bushfire prone locations.

New maintenance hole frame and cover shall be in accordance with the Sewerage Code of Australia (Sydney Water Edition).

9 Raising of Buried Maintenance Hole

9.1 Raising \leq 500 mm

Existing buried maintenance hole shall be raised to ground level using either pre-cast concrete or plastics make up rings, or brickwork methods. Plastics make up rings shall not be used in trafficable or bushfire prone locations.

The internal surface of the brickwork shall be smooth rendered with pre-packed quick setting mortar with a minimum thickness of 12 mm. Where applicable, protective lining shall be applied to concrete and masonry elements.

The internal diameter of the raised maintenance hole shall not be less than 600 mm.

9.2 Raising $>$ 500 mm

Existing buried maintenance hole shall be raised to ground level using either pre-cast concrete sections or cast-in-situ methods.

A minimum of 75 mm of the base section of pre-cast concrete shall overlap with the top section of existing maintenance hole. They shall be embedded together using pre-packed quick setting mortar with a minimum thickness of 12 mm.

The internal dimension and access requirements (step irons/ladders) of the raised section shall be in accordance with the Sewerage Code of Australia (Sydney Water Edition).

10 Removing and Repairing Step Irons

The existing defective steps irons shall be removed by grinding off the step iron flush with the wall. If the maintenance hole is not being lined as part of the rehabilitation work, the exposed surface of the remaining step iron portions in the wall shall be coated with epoxy lining. If ladders and landings/platforms are present, direction needs to be sought from Sydney Water regarding their requirements.

Unless otherwise stated, the Contractor shall replace step irons in accordance with the Sewerage Code of Australia (Sydney Water Edition).

11 Inspection and Testing

The inspection and testing shall be undertaken in accordance with the following table.

Table 2 Schedule of Inspection and Testing

	Visual inspection	Delamination survey	Compressive strength testing	Hardness testing	Spark Testing	Thickness measurement	Bond strength testing	Welded joint testing	Chemical Resistance Test
Surface preparation	X	X	X			X	X		
Lining application									
▪ Epoxy/polyurethane	X	X		X	X	X	X		X
▪ CAC	X	X	X			X	X		
▪ Cured-in-placed	X	X		X	X	X			X
▪ Geomembrane	X	X	X		X		X	X	X

11.1 Visual Inspection

All surfaces shall be visually inspected before and after repair for cracks, spalls, rust stains, dampness, discolouration, honeycombing, etc. Any defects shall be repaired at no cost to Sydney Water.

11.2 Delamination Survey

The applied lining including patch repair or resurfacing material used in surface preparation shall be inspected for delamination (drumminess) using light hammer.

Any areas found to be drummy shall be assessed further. More tests may be required to determine the extent of defects. The Contractor may be instructed to remove and repair these areas at no cost to Sydney Water.

11.3 Compressive Strength Testing

For each batch or each day of the work, the Contractor shall prepare and send a cast sample of the applied material for compressive strength testing. In the case of anchored plastic lining application, it shall be undertaken for the grout used to fill the annular space. The testing shall be in accordance with AS1012.9 or equivalent, and undertaken by a third party material testing facility approved by Sydney Water.

Any areas found to have less than the specified compressive strength shall be assessed further. More tests may be required to determine the extent of defects. The Contractor may be instructed to remove and repair these areas at no cost to Sydney Water.

Subject to approval from Sydney Water, the above method may be substituted with non-destructive method using Schmidt hammer when consistent results have been achieved.

11.4 Hardness Testing

Hardness testing shall be carried out to verify that polymeric and cured in-place linings have cured properly. The sampling locations will be nominated by Sydney Water unless agreed to be randomly selected. Unless otherwise specified, the sampling rate shall be at least one for every 10 m² area. The testing shall be in accordance with ASTM D2240 or equivalent.

11.5 Spark Testing

The Contractor shall undertake spark testing using appropriate high voltage holiday detection equipment to detect the presence of pinholes, cracks, or other discontinuities in all areas. Any defective areas shall be repaired at no cost to Sydney Water.

11.6 Thickness Measurement of Applied Material

The Contractor shall measure the thickness of applied repair and/or lining material at any location selected by Sydney Water using core samples or a non-destructive method approved by Sydney Water.

Any areas found to be thinner than the specified minimum thickness shall be applied additional material at no cost to Sydney Water.

Unless specified otherwise, the sampling rate shall be one for every 10 m² repair area. The sampling frequency may be reduced by Sydney Water following consistent pass results.

11.7 Bond Strength Testing

Bond strength of the applied resurfacing/lining material shall be tested using core samples or dollies (50 mm in diameter). The sampling locations will be nominated by Sydney Water unless agreed to be randomly selected.

The testing shall be in accordance with AS 1580.408.5 or equivalent, and undertaken by a third party approved by Sydney Water. All core locations shall be repatched with the lining system.

Any areas found to have bond strength less than 1.5 MPa shall be further assessed by Sydney Water. More tests may be performed to determine the extent of deficient bonded areas. Where instructed by Sydney Water, they shall be removed and repaired at no cost to Sydney Water.

Unless specified otherwise stated, the sampling rate shall be one for every 10 m² repair area. Subject to approval from Sydney Water, the sampling rate may be reduced following consistent pass results.

11.8 Welded Joint Testing for Plastics Lining

The quality of every welded joint shall be inspected visually and tested using vacuum box, pressure channel, or spark testing methods. The testing shall be undertaken by trained and certified personnel. Any defective welded joint shall be repaired at no cost to Sydney Water.

11.9 Chemical Resistance Testing

The test method shall be a modified ASTM D543 with a total exposure period of 112 days at 25±3°C. Weight and hardness change specimens shall be 50 mm in diameter. Thickness of the specimens shall be the minimum thickness specified in Table 1 in Clause 7.3

The weight and hardness specimens shall 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 20% Sulphuric acid solutions (% in V/V):

At 28-day intervals selected specimens shall be removed, washed, surface dried and measured. The same weight and hardness change specimens shall 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:

1. 2% variation from the initial weight
2. 5% variation from the initial material shore D hardness
3. 10% reduction from the initial tensile strength

11.10 Acid Neutralisation Capacity Testing

The inhibitive property of cement based materials arising from its ability to neutralise the acid produced by hydrolysis of the products of anodic dissolution may be characterised by its acid neutralisation capacity. It involves plotting the steady state pH against the quantity of acid added to a series of ground samples to obtain a titration curve. The method is adopted from European Committee's CEN/TS 14429 and CEN/TS 14997.

The method involves milling sample with a ball mill and separating particles that passes through 100 µm sieve. Minimised sample contact with air to avoid carbonation. A series of tests are undertaken to generate at least 25 different points along a titration curve.

Each test consists of adding 1 g of ground sample to 10 ml of acidic solution to maintain a solid:liquid ratio of 1:10. The acidic solution is prepared by adding a predetermined quantity of 70% nitric acid to deionised water to generate a range of pH from 4 – 12. The tubes are kept at 28°C and agitated daily until the pH of the solution reaches a steady state (variation in pH is within ±0.3 pH unit). The pH of the solution shall be measured using a pH meter that had been calibrated using standard buffer solutions.

Document control

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Change History

Version	Date	Description of change	Approved by
1	03/05/2010	New document	JC
2	07/03/2011	<ul style="list-style-type: none">• Clauses 5.1 & 7.2 – Alignment with SS 208• Clauses 5.2 & 7.3 – Alignment with SS 204• Clause 7.4 – Making polyurethane only allowable for new construction• Clause 12.9 – Making sulphuric acid the only chemical solution and reducing variations for pass criteria	JC
3	18/10/2012	<ul style="list-style-type: none">• Clause 5.2 & 5.3 – Separating epoxy mortar and epoxy novolac coating systems• Clause 7.1 – Addition of application requirement to the roof section, adding requirement for joining details for multiple coating systems.• Clause 7.2.1 – Restriction to application of CAC to the roof section• Clause 7.2.2 – Allowing reduction of thickness for the riser ring section.• Clause 7.3 – Allowing reduced coating thickness for new/resurfaced substrate to align with PCS 100, and increasing the maximum depth of application to 15 m.• Clause 11.7 – Reducing bond strength requirement to 1.5 MPa.• Clause 11.10 – Adding acid neutralisation capacity testing	PG