

**Specification for Type A – Structural and Non-Structural
Maintenance Hole Rehabilitation**

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TS 4.13.01 Scope

This specification is for the Type – A (Bonded) maintenance hole rehabilitation products that are sprayed into place or troweled into place and does not include or apply to thermosetting Cured-In-Place (CIP) or other Type B (Un-Bonded) products. The specification applies to rehabilitation of existing circular and non-circular (square/rectangular) sewer maintenance holes made of concrete and brick materials including:

- Application of products for structural (circular) and, non-structural (for rectangular) maintenance hole rehabilitation, including cleaning and required surface preparation;
- Sealing of maintenance hole against inflow and infiltration;
- Repair of cracks, deformities, and other structural and non-structural issues
- 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 iron step.
- QA/QC
- This specification does not include any rehabilitation or other repair that would require excavation at or around the maintenance hole

Prior to applying the Type A product, cracks and active infiltration have to be repaired with hydrophilic cement, chemical grout, and other appropriate repair techniques. It is the responsibility of the contractor to select Type A product that will meet requirements listed herein. Replacing of product Type A product after bid closing is not permitted.

This specification applies to Type A products that are sprayed into place or troweled into place, it does not include or apply to thermosetting Cured-In-Place (CIP) or other Type B products. If the contract specifies Type B products and other specifications or drawings, the contractor shall provide design submittals complying with Type B design requirements and product supplier recommendations.

The objectives of maintenance hole rehabilitation are:

- Providing structural rehabilitation for circular maintenance holes in most cases as described in this specification and providing non-structural rehabilitation for square and rectangular maintenance holes.
- Prevent deterioration of interior surfaces including corrosion due to H₂S and other sewer gases and microbial induced corrosion.
- Prevent leakage of groundwater into the interior including infiltration driven by external groundwater pressure.
- Provide a smooth and uniform interior surface finish resistant to debris build-up.

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- Fulfill all objectives over the design and performance life of the rehabilitation.

Where a new chimney, frame, grade adjuster rings, cover and other improvements are specified in the contract, the contractor shall comply with these requirements. In case of new chimney and new maintenance holes, the contractor shall apply a minimum 5 mm thickness or more of the Primary Coating System (PCS) material to prevent future corrosion as per Table 1 – Section 2.5.

TS 4.13.02 References

This specification refers to the following standards, specifications or publications:

City of Toronto Standard Specifications

TS 4.01	Construction Specification for Sewer Bypass Flow Pumping
TS 4.02	Construction Specification for Sewer Bypass Flow Pumping for Trunk Sewers
TS 4.10	Specification for the Cured-In-Place Lining of Sewers
TS 4.xx	CCTV of Maintenance Hole (under development)

American Standards:

American Society for Testing and Materials (ASTM):

- i. C109, Standard Test method for Compressive Strength of Hydraulic Cement Mortars.
- ii. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
- iii. C495, Standard Test Method for Compressive Strength of Lightweight Insulating Concrete.
- iv. D882, Standard Test Method for Tensile Properties of Thin Plastic Sheeting.
- v. D2834, Standard Test Method for Nonvolatile Matter (Total Solids) in Water-Emulsion Floor Polishes, Solvent-Based Floor Polishes, and Polymer- Emulsion Floor Polishes.
- vi. D3574, Standard Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams.
- vii. D1042, Standard Test Method for Linear Dimensional Changes of Plastics Under Accelerated Service Conditions.
- viii. D2240, Standard Test Method for Rubber Property—Durometer Hardness.
- ix. D79058T, Procedure: Flexural Properties.
- x. D63860, Procedure: Ultimate Elongation.
- xi. D756, Practice for Determination of Weight and Shape Changes of Plastics Under Accelerated Service Conditions.
- xii. F2414, Standard Practice for Sealing Manholes Using Chemical Grouting
- xiii. F2551 Standard Practice for Installing a Protective Cementitious Liner System in Sanitary Sewer Manholes
- xiv. C150 Standard Specification for Portland Cement Type I
- xv. C33-86 Standard Specification for Concrete Aggregates
- xvi. C78 Standard Test Method for Flexural Strength of Concrete; Using Simple Beam with Third Point Loading
- xvii. C109/C109M-05 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)

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- xviii. C157/C157M-06 Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
 - xix. C267 Test Methods for Chemical Resistance of Mortars, Grouts and Monolithic Surfacing and Polymer Concretes
 - xx. C293-02 Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
 - xxi. C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
 - xxii. C321-00(2005) Standard Test Method for Bond Strength of Chemical-Resistant Mortars
 - xxiii. C348-02 Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars
 - xxiv. C494-86 Standard Specification for Chemical Admixtures for Concrete
 - xxv. C496/C496M-04e1 Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
 - xxvi. C666/C666M-03 Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
 - xxvii. C882-05 Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear
 - xxviii. C952 Standard Test Method For Bond Strength for Mortar and Masonry unit , crossed brick couplet, mortar, masonry
 - xxix. T277 – Rapid Determination of the Chloride Permeability of Concrete
 - xxx. D4414 – Standard Practice for Measurement of Wet Film Thickness by Notch Gages , circular notched gage, rectangular notched gage Permeability of Concrete
 - xxxi. D4541 – Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers , adhesion, coatings, field, metal substrates, paint
 - xxxii. D7234 – Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers

International Concrete Repair Institute

Technical Guideline No. 03732 – Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings and Polymer Overlays

National Association of Corrosion Engineers

No 6. / SSPC SP 13 Surface Preparation of Concrete

TS 4.13.03 Definitions

For the purpose of this specification, the following definitions apply:

Bonded Layer means the layer of the maintenance hole rehabilitation that is bonded to the maintenance hole concrete or brick structure for bonded systems.

Build-out Layer means for some bonded systems, a layer additional to the Bonded Layer for the purpose of providing increased thickness for uniformity of rehabilitation and to meet minimum overall thickness requirements. A Build-out Layer always builds from the bonded layer surface inwards towards the interior of the maintenance hole.

Dolly means loading fixture used for pull testing to substantiate adhesion.

MH means the maintenance hole.

PCS means the Primary Coating System

Performance Life the performance life for the rehabilitation product shall be 50 years.

The performance life assumes that no new factors such as degradation of maintenance hole structural integrity or a different corrosive environment not typical of municipal sewage will have an impact on the rehabilitation.

Substrate means the maintenance hole material surface to which the rehabilitation material is bonded (Type A Product) or applied (Type B Product). The substrate is normally the maintenance hole material surface after cleaning and preparation. Where filler material(s) are used to fill gaps, pockets or voids on the maintenance hole wall or to smooth out the maintenance hole wall surface, the substrate is the combination of the maintenance hole material and the filler material. See Figure 1 for illustration of substrate surface.

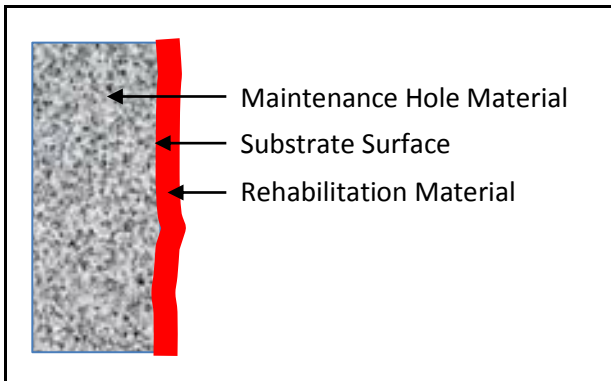


Figure 1: Illustration of substrate definition

Type A Product means the rehabilitation material is bonded to the interior surface of the maintenance hole to achieve performance objectives and requirements of this specification.

Type B Product means the inherent wall strength of the in-place rehabilitation material achieves performance objectives and requirements of this specification. While the product may also adhere to the interior of the maintenance hole adherence–bonding–is not necessary for achieving required performance.

TS 4.13.04 Design and Submission Requirements

TS 4.13.04.01 Information to Be Submitted With the Tender Submission

The following information shall be submitted with the Bid to ensure the contractor's preliminary design and the bid is prepared based on this standard and other requirements listed in the tender. Further information could be required to be submitted elsewhere in the Tender Call other than in TS 4.13 herein. This submission is not the design. A separate shop drawing submittal is required following the contract award, after confirming field conditions and measurements.

Failure to submit this information to the satisfaction of the Contract Administrator may result in disqualification of the bid.

Information to Be Submitted With the Tender Submission

- 1) The name of the professional engineer licensed in the province of Ontario who will prepare and stamp the maintenance hole engineering designs required according to the design requirements in TS 4.13 herein. The professional engineer shall be authorized to perform such work by Professional Engineers Ontario (PEO).

Submission of a specific MH design is required for each brick and concrete, circular and square/rectangular MH to be rehabilitated for this tender to take account of the deflection and wall stresses (critical beam theory) under hydrostatic load after considering ground water depth of 1.5 metre. .

- 2) Preliminary PCS design calculations for all sewer sections identified in the Tender Call. The liner design shall be in accordance with the requirements of TS 4.13 specified herein.
- 3) A PCS coating/liner example/sample preliminary design with calculations is required if specific maintenance holes are not identified at the time of Tender: The preliminary liner design example shall be submitted according to TS 4.13 herein. The example/sample shall be illustrative of future designs that shall be submitted during the Contract. The detailed designs shall when submitted prior to the construction shall bear the seal and signature of the Professional Engineer licensed in the province of Ontario.
- 4) Include information of the proposed PCS material and confirm the product meets performance specifications listed in Table 2. Product specific strength values, including the short term flexural modulus and the long term flexural modulus strength, must be substantiated by third party testing which will be submitted with bids.
- 5) The performance specification conformance must be a certified original copy complete with supporting literature from the manufacturer.
- 6) Include one example of the spray application process, to be utilized for application of the Type A product, prepared in conformance with the PCS product datasheets including discussion of:
 - a. weather condition requirements and minimum and maximum temperatures and humidity levels for application and how the Contractor will ensure compliance with the required parameter.
 - b. cleaning and preparation requirements.
 - c. repairs of cracks, and infiltration and other deformities.
 - d. PCS application, number of lifts, coating thickness, benching repairs,
 - e. how the contractor plans to complete the benching portion of the work
- 7) Provide the bond strength that will be achieved by the field application of the rehabilitation product. Provide test information from accredited laboratory to substantiate that the bond

strength at minimum thickness specified in TS 4.13 herein, shall meet the minimum bond strength requirements specified in TS 4.13 herein.

- 8) The quality control and quality assurance procedures to be used. Include description of how the required thickness will be assured. Provide description of how the required maintenance hole substrate surface finish will be assured and how the required bond strength will be assured.
- 9) Design Criteria and Calculations to be submitted for Circular Maintenance Holes with the bid to demonstrate fully structural detail designs. The name of the professional engineer licensed in the province of Ontario who will certify the engineering designs.
- 10) Provide verifiable evidence to demonstrate the PCS application crew, has at least 3(three) years active experience in applying the product and is certified by the manufacturer and has completed PCS application of the same PCS product for at least 250 maintenance holes in past 5 years.
- 11) The PCS product shall be installed in more than 1,500 maintenance holes in wastewater collection systems in North America and Europe. To verify this requirement, provide a list of approximate number of installations in each municipality in North America and Europe in past years and identify the years when the installation was completed.
- 12) Crack repair material to be used and manufacturer's product datasheet
- 13) Chemical grout material to be used and manufacturer's product datasheet
- 14) MECP License to haul waste

TS 4.13.04.02 Final Design and Shop Drawings Requirements

Detailed design of all maintenance holes after field verification of dimensions, verifying defects, infiltration, and confirming if the PCS material can be applied.

The design must be prepared in accordance with the requirements listed in TS 4.13 herein and shall be stamped by a professional engineer licensed in the province of. The professional engineer shall be authorized to perform such work by Professional Engineers Ontario (PEO).

If after V1 and V2 actual field conditions are found to be different (e.g. dimensions, significant structural issues) to the information than provided/suggested in the contract, the design shall be adjusted based on the actual field conditions. The adjusted design may result in a thicker PCS liner. Any additional cost involved shall be determined according to the Contract Price and if Contract Prices are not applicable, then shall be negotiated with the Contract Administrator.

If the actual field conditions mean a Type-A rehabilitation product will no longer meet the necessary performance requirements, then at Toronto Water's discretion semi-structural Type-A rehabilitation may be accepted. If the semi-structural Type-A rehabilitation is not acceptable, the Contractor shall submit an alternative Type B rehabilitation proposal to the Contract Administrator for review. The Contract Administrator and Toronto Water shall review the Type B proposal and if deemed acceptable shall negotiate a unit price for preparation of designs and installation of the Type B rehabilitation, including all necessary plant, labour, materials and equipment required for installation and testing to confirm the installation meets the performance requirements for a fully structural design.

No liner shall be installed that does not meet the requirements for actual field conditions, including required liner thickness for actual field conditions.

Designs shall be submitted to the Contract Administrator for approval as part of shop drawings review and acceptance process. No lining shall be installed without an accepted design.

Final Design and Shop Drawings

- 1) Final design calculations for each maintenance hole shall be stamped by a professional engineer licensed in the province of Ontario. A separate design submission is required for each brick and concrete and, circular and square/rectangular MH to be rehabilitated as a part of this tender to take in to account the applied deflection and wall stresses (critical beam theory) under hydrostatic load specified for each MH location. . For circular maintenance holes provide design calculations to demonstrate the Type A rehabilitation product will achieve a fully structural design. For rectangular maintenance holes provide design calculations to demonstrate the PCS material will provide Class II semi-structural bonded rehabilitation.
- 2) Include information of the proposed PCS material and confirm the product meets performance specifications listed in Table 2. Product specific strength values, including the short term flexural modulus and the long term flexural modulus strength, must be substantiated by third party testing which will be submitted with bids.
- 3) The performance specification conformance must be certified original copy complete with supporting literature from the manufacturer.
- 4) Include one example of the spray application process, to be utilized for application of the Type-A product, prepared in conformance with the PCS product material datasheets and specification, and shall include discussion of:
 - a. weather condition requirements and the minimum and maximum temperatures and humidity levels for application and how the contractor will ensure compliance with the required parameters.
 - b. cleaning and preparation requirements.
 - c. repairs of cracks, and infiltration and other deformities.
 - d. PCS application, number of lifts, coating thickness, benching repairs,
 - e. how the contractor plans to complete the benching portion of the work
- 5) Provide test information from accredited laboratory to substantiate that the bond strength at the design calculation thickness shall meet the minimum bond strength requirements specified in TS 4.13 herein.
- 6) The quality control and quality assurance procedures to be used:
 - a. Name and address of testing firms that will be completing testing
 - b. Number of tests of each type per maintenance holes, which shall comply with quality assurance section of this specification TS 4.13.

- 7) Provide verifiable evidence to demonstrate the PCS application crew, has at least 3(three) years active experience in applying the product and is certified by the manufacturer and has completed PCS application of the same PCS product for at least 250 maintenance holes in past 5 years.
- 8) The PCS product shall be installed in more than 1,500 maintenance holes in wastewater collection systems in North America and Europe. To verify this requirement, provide a list of approximate number of installations in each municipality in North America and Europe in past years and identify the years when the installation was completed.
- 9) Crack repair material to be used and manufacturer's product datasheet
- 10) Chemical grout material to be used and manufacturer's product datasheet
- 11) MECP License to haul waste

Provide final thickness design calculations for each maintenance hole to be rehabilitated during shop drawing review and acceptance process. The physical properties for the materials utilized in the contract shall have physical properties equal to or greater than the physical properties of the materials used in the long term testing to determine initial flexural modulus and the long term reduction factor used in the design. Design calculations shall use parameters below (Table 1).

Table 1:

<u>Parameter</u>	<u>Design Requirement</u>
1.	Structure Condition - Fully Deteriorated for circular maintenance holes unless specified differently in other sections of the contract. Partially deteriorated for rectangular maintenance holes unless specified differently in other sections of the contract.
2.	<p>2.1 Design Thickness - ASTM 1216-07a for circular maintenance holes and Two Way Flat Wall Beam Analysis for rectangular maintenance holes.</p> <p><u>Type A product – Circular Maintenance Holes</u></p> <p>2.1 For circular maintenance holes, minimum 10 mm thickness of PCS and maximum thickness based on design calculations up to 5 m depth of the maintenance hole. The PCS shall be able to provide fully structural solution and withstand ground water pressure as per ground water parameter 10 of this table. Any thickness change shall be gradual and smooth. For thickness of PCS coating beyond 5 m depth of the maintenance hole see 2.2 below.</p> <p>2.2 Beyond 5 m depth, of circular maintenance holes, minimum 20 mm thickness of PCS material is required and maximum thickness based on design calculations. The PCS shall be able to provide fully structural solution and withstand ground water pressure as per ground water parameter 10 of this table. Thickness change shall be gradual and smooth.</p> <p>In both cases above, the Contractor shall provide confirmation from the manufacturer to confirm the material can be applied to the required highest thickness and the warranty will be valid for applications up to this thickness.</p> <p><u>Type A product – Rectangular and Non-Circular Maintenance Holes</u></p>

2.3 For non-circular maintenance holes, the design calculations shall demonstrate partially deteriorate Class III design with following thickness requirements. PCS coating thickness shall be minimum 15 mm thickness and maximum up to 25 mm thickness up to 5 m depth of the maintenance hole. The product shall be able to withstand ground water pressure as per ground water parameter 10 of this table. Thickness change shall be gradual and smooth. For thickness of PCS coating beyond 5 m depth of the maintenance hole see 2.4 below.

2.4 Beyond 5 m depth of non-circular maintenance holes, the design calculations shall demonstrate partially deteriorate Class III design with following thickness requirements. Beyond 5 m depth, the PCS coating thickness shall be minimum 20 mm thickness and maximum up to 35 mm thickness. The product shall be able to withstand ground water pressure as per ground water parameter 10 of this table. Thickness change shall be gradual and smooth.

In both cases above, the Contractor shall provide confirmation from the manufacturer to confirm the material can be applied to the required highest thickness and the warranty will be valid for applications up to this thickness.

Type A product – New Circular and Non-Circular Maintenance Holes

2.5 For new circular and non-circular maintenance holes minimum 5 mm thickness of PCS lining is required as a corrosion barrier up to 5 m depth of the maintenance hole. Additional thickness shall be required at higher depth to be able to withstand ground water pressure as per ground water parameter 10 of this.

3. Ovality for circular maintenance holes	Not greater than 5%
4. Soil Load	1,900 kg/m ³
5. Traffic Load	AASHTO-HS-20 or higher loading depending on the location of the maintenance hole.
6. Soil Modulus	6.9 MPa
7. Soil Weight	1,922 kg/m ³
8. Safety Factor	2.0
9. Soil Cover maintenance hole	Distance from grade to invert of the
10. Water Table	1.5 m below grade or actual level if it is less than 1.5 m measured at the closest well in geotechnical report.

TS 4.13.04.03 Design of ladders, safety platforms, gratings, handrails and other ancillaries as applicable

Submit designs and shop drawings for all appurtenances within each MH as shown on the contract drawings. The designs shall be prepared in accordance with requirements in this specification and OHS regulations and shall be sealed and signed by a professional engineer licensed in the province of Ontario.

TS 4.13.05 Materials

TS 4.13.05.01 Applicable Maintenance Hole Material and Rehabilitation Product Types

For crack repair, infiltration repair, specific materials and products used for the rehabilitation shall be approved by the contract administrator.

Hydraulic Cement Material - Very fast setting cementitious material designed to stop active leaks in maintenance holes. It shall be formulated with calcium silicate, calcium aluminate, mineral fillers and specially selected additives for set control. Material shall prevent water infiltration over 50 years expected rehabilitation life. Short term temporary infiltration preventing materials are not acceptable.

Chemical Grout Material - Means a chemical sealant solution containing principle chemical sealant constituent, initiator and catalysts specifically recommended for the purpose of reducing or eliminating groundwater inflow to seal larger volume leaks in concrete cracks and fissures. The chemical grout is a two part system (grout and accelerator), that, when it makes contact with water, is designed to set-off and cut-off gushing water. Once cured, the chemical grout shall become closed cell foam that is resistant to most organic solvents, mild acids, alkali, petroleum and micro-organisms. The chemical grout physical properties when cured shall meet the following minimum performance requirements listed below

- Density 1,050 kg/m³
- Tensile Strength 385 kPa
- Compressive Strength 6,000 kPa
- Bending Strength 1450 kPa
- Bond Strength to Bending Bond Strength 190 kPa
- Mortar Joints Shearing Bond Strength 1,750 kPa
- Toxicity Non-Toxic
- Absorption (6 month immersion) 15%

Chemical grouts shall be carefully selected by grout specialist depending on the issue to be addressed, ground condition and other constraints. Acrylic gels, polyurethane foams and other chemical grouts shall be used to fill voids and to provide soil stability behind the wall of maintenance hole chamber. Where voids have occurred behind below grade structures, the highly expansive polyurethane hydrophobic foams can be used to fill the void.

Permitted Type A products/material for maintenance hole rehabilitation Primary Coating System (PCS)

Only one of the following coating materials shall be permitted as the Primary Coating System (PCS):

- Polyurea, Epoxy, Polyurethane or other Polymeric compound that meets the performance criteria listed in Table 2. The PCS shall be a spray applied or trowelled, ultra-high build, self-priming epoxy or polyurethane resin system. The PCS shall be 100% solids and VOC (Volatile Organic Compounds) free. The PCS shall have the ability to reinstate structural integrity, provide infiltration control, and supply chemical resistance to the structure from sewer gases. The PCS shall be able to withstand vibrations caused due to heavy vehicles including transit vehicles and future construction activity in the area surrounding the maintenance hole.

- The PCS shall be used to form a sprayed or troweled, structurally enhanced monolithic liner covering all interior surfaces of the structure, including benches and inverts of manholes. The finished liner shall be 100% Solids and VOC free. The physical properties of the PCS must be supported by long term performance testing carried out through an independent and accredited third party testing laboratory within the last five years and a certified copy of the test results must be submitted with the designs and shop drawing submittals. If the bid does not include verifiable, independent third party testing and does not demonstrate conformance with the required physical properties, the design shall be ruled non-compliant and may be rejected and the contractor will have to resubmit designs.

The PCS shall provide minimum performance requirements as per Table 2:

Table 2 – Performance Parameters for Maintenance Hole (MH) PCS.

Parameter	Test Method	Requirements
Material	Polyurea, Epoxy, Polyurethane or other Polymeric compound meeting criteria of this table and be able to meet design criteria provided in Table 1.	
Compressive strength	ASTM D 695	> 110 MPa
Tensile strength	ASTM D 638 Square/ Rectangular	> 45 MPa
Substrate Pull-off Strength from MH Structure	ASTM C1523	> 1.4 MPa (200 psi) the surface tension of the MH substrate shall meet or exceed this requirement.
Rehabilitation Material (PCS) Pull-off Strength from Substrate – the Bond Strength	ASTM D7234 Using 50 mm dolly	> 1.0 MPa (150 psi) or 12 times the hydrostatic pressure, whichever of the above is greater.
Flexural Modulus (Long Term)	ASTM D790	> 4,500 MPa
Flexural Strength (Long Term)	ASTM D2990	> 50 year design life retaining 60% of Flex Modulus
Chemical Resistance:	ASTM D543	Meet ASTM D543 in its entirety
Design and Performance Life		Minimum 50 years
Hardness	ASTM D2240	> Shore D 75

Submission of a specific MH design is required for each brick and concrete, circular and square/rectangular MH to be rehabilitated to take into account of the applied deflection and wall stresses (critical beam theory) under hydrostatic loading specified for each MH location.

TS 4.13.06 Equipment

As required by the PCS manufacturer for application of the Contractor's selected PCS.

TS 4.13.07 Construction

Materials used shall conform to this standard. The following subsections provide the requirements of the products.

TS 4.13.07.01 Safety

The Contractor shall perform all work in accordance with applicable Ontario Health and Safety Act (OHSA) and regulations and complying with safety requirements recommended by the manufacturer. Emphasis shall be placed upon the requirements for entering confined spaces, the equipment being utilized for maintenance hole rehabilitation components and with the protection of workers from potential sewer gases, dust and various products being used by the contractor.

The contractor shall have:

- Material Safety Data Sheet (MSDS) and other safety Personal Protective Equipment (PPE) recommended by the manufacturer and based on their risk review of the work being undertaken.
- Gas monitor capable of testing and detecting combustible gas, oxygen deficiency, carbon monoxide and hydrogen sulfide.
- Confined space access and retrieval system.
- Ventilating fans with 12" diameter ventilation hoses.
- Particulate respirator.
- Air respirator if required.
- Safety harness and fall protection devices.
- All equipment to be available for use, in sufficient quantity by the Contractor for the duration of the project.

All entries into or work within confined spaces shall be conducted in accordance with the OHSA requirements, contractor's policies and City of Toronto policies

The Contractor shall submit a proposed Safety Plan to the City, prior to beginning any work, identifying all competent persons, equipment and operating procedures. The plan shall include a description of a daily safety program and daily safety meeting for the job site and all emergency procedures to be implemented in the event of a safety incident. All work shall be conducted in accordance with the contractor's submitted Safety Plan.

TS 4.13.07.02 Notification to Public

If the maintenance hole rehabilitation is standalone (no sewer relining), distribute construction notice to nearby residents. If the maintenance hole rehabilitation is together with sewer lining, comply with notification requirements listed in TS 4.10. The construction notice distribution area will depend on the impact to traffic and residents based on the location of the maintenance hole and shall be determined in conjunction with City staff and the contract administrator. The Contractor must schedule the works in accordance with information provided in the notification.

The Contractor shall provide the Contract Administrator and City Project Lead with a copy of such notice for their review and approval.

TS 4.13.07.03 Site Investigation

The Contractor shall investigate each site before commencing any construction work in order to determine the existing conditions and identify any obstructions or any other problems that may affect the completion of the proposed works. No additional payment shall be made on account of difficulties to complete the works because the Contractor failed to investigate the site prior to commencement of the Work.

TS 4.13.07.04 Locating Maintenance Holes

TS 4.13.07.05 The Contractor shall be responsible for locating the maintenance holes identified in the Tender Call for rehabilitation. Where a maintenance hole is found to be inaccessible due to being buried or paved over, or cannot be found within reasonable effort, the Contractor shall report this finding to the Contract Administrator. The Contract Administrator will arrange for Toronto Water to locate the buried or missing MH. The contractor shall plan locating all maintenance holes at the early stage in project. No additional time or costs will be provided as a result of delays associated with locating buried or missing MH's. Weather Conditions

The PCS application and infiltration repairs may be sensitive to weather conditions including rain and temperatures below freezing as specified in the weather condition and minimum and maximum temperature and humidity requirements for the contractor's selected PCS provided at the time of bid and during detailed design/shop drawings requirement herein. The Contractor shall review the Environment Canada Weather forecast or other suitable forecast bureau prior to commencement of rehabilitation operations. Where the forecast or anticipated weather conditions are such that the expected temperatures or conditions do not meet the manufacturer's requirements for application or installation, it is the responsibility of the contractor to provide suitable protection or measures to ensure conditions within the maintenance hole meet the minimum manufacturers requirements to allow application of the selected PCS material to proceed without delay, or to delay the proposed application until favourable weather conditions are expected. The Contractor shall include the equipment and labour costs for all requirements to maintain minimum temperatures and the required humidity for the application of the chosen product within their unit rates for MH rehabilitation. No additional time or costs will be provided due to unfavourable weather conditions for PCS lining.

TS 4.13.07.06 Maintenance Hole Pre Inspection and Condition Check

At the early stage in the project, the contractor shall complete pre-inspection of all maintenance holes together with the Site Inspector and prior to any material procurement or installation work. The Contractor shall perform a condition check of the maintenance hole sufficient to verify that the existing interior condition and structural integrity is suitable for Type-A rehabilitation using their selected Type-A rehabilitation products including the PCS.

The contractor shall provide a pre-inspection report to the contract administration for all maintenance holes, confirming structural integrity is suitable for their Type-A product, and noting any major deviations from the contract information.

The pre-inspection and condition check shall verify that:

- The condition of the concrete or brick and mortar will allow for the interior surface to be reliably, completely and uniformly prepared to the specified concrete surface profile (CSP) without jeopardizing the structural integrity of the maintenance hole.
- The maintenance hole has not collapsed, collapsing—by visual check only—or leaning.
- The maintenance hole is of similar shape, material of construction and ball park dimensions as per the contract.

The Contractor is not required to make a structural evaluation. The condition check shall be based on observations pertaining to visible defects such as excessive cracks, deformations and misalignments that would reasonably suggest that the structural integrity against external loads is suspect.

In the condition check, the Contractor shall identify the existence of any sewers or forcemains incoming to the maintenance hole, which may impact on the level of flow control to be used in the rehabilitation installation.

Where the Contractor's condition check finds that the condition is not suitable for rehabilitation, the Contractor shall advise the Contract Administrator and include the reason for the non-suitable finding. The Contract Administrator shall provide further instruction in regard to the rehabilitation within a timeframe that will not negatively impact the Contractor's operations or schedule.

Should the Contractor, in the condition check, find other reasons why the maintenance hole is not suitable for rehabilitation, the Contractor shall advise the Contract Administrator of this finding prior to proceeding with any other Work.

TS 4.13.07.07 Flow Control

The Contractor shall provide flow control and temporary bypass consistent with the requirements for the humidity/dryness needed for application of the rehabilitation.

Rehabilitation of the benching and invert areas shall be completed with temporary bypass in operation. The cost for temporary bypass is high, and hence the contractor shall plan to repair at least the benching portion during main line lining, if maintenance hole rehabilitation is being carried out in conjunction with sewer lining, with temporary bypass in operation.

When interruption of sewer line flows is necessary to properly conduct the work acceptable methods of flow control shall be provided by the Contractor. Where by-pass pumping is used, flow control shall be in according to TS 4.01 and TS 4.02 as applicable.

TS 4.13.07.08 V1, V2 and V3 - 3D CCTV Inspections

The V1, V2 and V3 inspections shall be completed with very high resolution multiple cameras inspection equipment. A complete 360° view of the entire maintenance hole shall be provided. Provide video files and MACP inspection report.

The CCTV shall be according to National Association of Sewer Companies (NASSCO) Maintenance Hole Assessment and Certification Program (MACP) Level 2 for CCTV maintenance hole inspections. The Contractor shall also provide a NASSCO MACP inspection database. The Contractor shall record the spray lining product type and name under Additional Info field. Maintenance hole inspections shall be conducted using IBAK PANORAMO SI, 3D Scanner equipment or equivalent.

The CCTV camera shall enter from the top of the maintenance hole and complete 360 degree inspection of the entire surface of the maintenance hole as the camera is lowered at a uniform and steady manner to the bottom of the maintenance hole. Zoom inspection of sewer lines entering and exiting the maintenance hole is not required. The minimum recorded video resolution must be 1080p high resolution. Where any potential defects or other questionable events are seen on the surface of the rehabilitation, the CCTV inspection shall zoom into view such locations in greater detail.

All submissions to be made on a USB portable hard-drive of reliable quality. Hard drives will become the property of Toronto Water and will not be returned to the Contractor.

All hard drives to be properly labelled with the following information:

- a) Contractor's name
- b) Contract number
- c) Contact person and phone number
- d) Date

TS 4.13.07.09 Surface cleaning and Preparation

The Type-A PCS relies on bonding to the maintenance hole surface to provide structural strength as well as protection from corrosion. Bonding is a function of both the applied product and the surface to which it is applied. The interior maintenance hole surface requires a high degree of cleaning and preparation to achieve a durable bond of sufficient strength. Preparation includes producing a suitable maintenance hole surface profile to achieve the durable bond. Acid wash is not an accepted method of cleaning and preparation.

All debris, grease, slime, scale and foreign material shall be removed from the interior surface of the maintenance hole. In the case where a cementitious coating has been applied to a brick maintenance hole, the contractor shall remove the cementitious coating to the best of their ability without causing damage to the brick or mortar surfaces. The means and execution of cleaning is the Contractor's responsibility.

The Contractor shall dispose of debris from cleaning and preparation at an approved location. No debris from cleaning and preparation operations and shall remain in, or be allowed to enter, the sewer system.

Surface preparation of the maintenance hole shall be according to NACE No. 6/SSPC-SP 13 and to ICRI Technical Guideline No. 03732 (see Appendix C). For reference in ICRI Guideline No. 03732 bonded maintenance hole rehabilitation products shall be considered as a polymer overlay. All cracks or fractures greater than 12.5 mm shall be sealed using an acceptable backer and filler material prior to spraying the maintenance hole PCS. Any backer or filler used to seal cracks in the substrate including the use of the liner material will form part of the substrate and therefore will be held to the same standard as entire substrate. After surface preparation, there shall be no cracks or fractures in the concrete substrate greater than 12.5 mm. Cleaning and surface preparation requirements will be the responsibility of the Contractor.

Surface Profile

Concrete Surface Profiles (CSPs) are defined in the ICRI Guideline No. 03732 (see Appendix C).

Required concrete surface profile: CSP 5 or higher CSP number.

It is the Contractor's responsibility to employ a preparation method that will achieve the required CSP number. While several preparation methods are capable of achieving a CSP 5, it is recommended that high or ultra high-pressure (5,000 – 10,000 psi) water jetting will be used as described in the ICRI guideline.

In the event that the condition of the existing maintenance hole concrete is not capable of being prepared to CSP 5, the Contractor shall advise the Contract Administrator of this finding and halt any further work. This may be evident by continual erosion or removal of the concrete during the preparation process so that a CSP 5 cannot be obtained or cannot be obtained without removing more than 20 mm locally or 6 mm generally of concrete material. In advising the Contract Administrator of this finding, the Contractor shall identify whether this is a localized problem in the maintenance hole or is a general problem with the maintenance hole concrete structure. The Contract Administrator shall provide instruction to the Contractor in regard to whether to proceed with the rehabilitation or to delete the maintenance hole from the rehabilitation list. If deleted from the rehabilitation list, the Contractor will be paid for work to this point providing the maintenance hole concrete condition was not identified or identifiable during the Contractor's maintenance hole pre-inspection and condition check work step.

On completion of the first two maintenance holes surface preparation, the Contractor shall test that the substrate meets surface tension requirements. Testing shall be as specified in the Quality Assurance section of this specification .

The Contractor shall take digital photographs that show the prepared concrete surface. The photographs shall be of sufficient quantity and clarity to allow the Contract Administrator to verify that the concrete surface preparation meets with the concrete surface profile requirement.

It is the responsibility of the contractor to ensure, the maintenance hole surface including the invert is properly prepared to meet the surface preparation requirements of various repair products including the proposed PCS.

Moisture Control

Successful PCS installation requires a dry surface. Immediately prior to the application of PCS's that are intended to bond to the concrete, the concrete shall be dry to the point of no visible signs of dampness or moisture. The Contractor is responsible for the method by which this dryness is achieved. The contractor shall use fans, heat drying, dehumidifier and other means required to remove moisture.

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 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% or as specified by the product manufacturer. The above moisture test shall be completed by the contractor at their cost and provided to the contract administrator prior to commencing lining. Application of rehabilitation material(s) that are intended to bond to the maintenance hole shall not be accepted where the maintenance hole dryness requirement is not met.

Should the Contractor at any time during the preparation phase of work, find any reasons why the maintenance hole is not suitable for rehabilitation, such that the final liner application will not be able meet any of the required specification, the Contractor shall advise the Contract Administrator of this finding prior to proceeding with any further work on the maintenance hole.

TS 4.13.07.10 Patch Repair

Patch repair using corrosion resistant and fast setting 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.

TS 4.13.07.11 Resurfacing

If the PCS requires large-scale repair of irregular concrete surfaces, concrete patch repair may be completed in advance and proper curing of concrete shall occur before PCS material is applied. Cementitious material is not acceptable as PCS. High strength, fast setting and corrosion resistant repair concrete/mortar shall be used. The finished surface profile shall be such that the surface provides an optimum bonding surface with the PCS lining.

Benching shall be repaired with 20 MPa corrosion resistant concrete prior to applying the PCS material at benching. All benching repairs shall be completed together with main line lining where applicable, and when the temporary bypass is in operation. If main line lining is not part of the scope and if the flow cannot be reduced preventing repair of the existing benching with concrete, use pre-cast concrete inserts pre-coated with PCS material to and rehabilitate benching. Where the invert and bench surfaces require repair, they shall be smooth and sloped in the direction of the flow.

TS 4.13.07.12 Infiltration Repair

Any maintenance hole with active infiltration shall be grout sealed by injection of grout from the inside prior to installation of any rehabilitation materials. The Contractor shall identify all active infiltration and stop this infiltration with a suitable grout sealing material. There shall be no active infiltration present during the application and curing of any rehabilitation material applied to the interior surfaces.

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.

The grout installation method and the grout type used to stop all active infiltration during application and curing of the rehabilitation materials are the Contractor's responsibility. The material used for repair shall comply with material section of this specification.

TS 4.13.07.13 Crack Repair

If there are large cracks identified during pre-inspection step above and which are not identified in the contract, the contractor shall retain a qualified structural engineer to assess if the cracks affect the structural integrity and to recommend a suitable repair method. Payment for structural engineer's assessment and specialized repair work can be negotiated with the Contract Administrator. Active cracks that do not affect the structural integrity shall be treated as joints and repaired as per 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.

TS 4.13.07.14 Joint Repair

Repair joints with hydrophilic grout sealant to prevent active infiltration. 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

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 Contract Administrator for approval prior to commencing the work.

TS 4.13.07.15 Steel Reinforcement Cleaning and Repair

Any exposed steel reinforcement shall be cleaned 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 augmented by new reinforcement of similar size.

TS 4.13.07.16 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 corrosion resistant, high strength and fast setting 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. Any infiltration shall be stopped first prior to undertaking the repair using the method specified herein.

TS 4.13.07.17 Installation of Primary Coating System

The details of the installation methods and procedures are the responsibility of the Contractor subject to the following provisions:

- 1) Installation methods and procedures shall be according to the rehabilitation system manufacturer recommendations.
- 2) Installation methods and procedures shall not produce a conflict with Contract Document requirements.

- 3) The PCS application procedures shall conform to the recommendations of the protective coating/lining manufacturer, including material handling, mixing, environmental controls during application, safety, and spray equipment.
- 4) The PCS spray equipment shall be specifically designed to accurately ratio and apply the specified protective coating/lining materials and shall be regularly maintained and in proper working order.
- 5) The PCS must be spray applied by a Certified Applicator of the protective coating/lining manufacturer.
- 6) The PCS shall be applied in recommended thickness lifts and after ensuring timing between each lift meets PCS manufacturer requirements. If necessary, subsequent additional lifts/coats of the PCS should occur as soon as per manufacturer recommendations, no later than the recoat window for the specified products. Additional surface preparation procedures will be required if this recoat window is exceeded.
- 7) If the PCS is a multi-component system, a multi-component spray application equipment approved by the PCS supplier shall be used to apply each coat of the protective coating/lining.
- 8) Minimum thickness as per Table-1 and that shall meet all design criteria.

TS 4.13.07.18 Areas of Coverage for Maintenance Hole Rehabilitation

All interior surfaces shall receive the rehabilitation treatment except the lid and lid fitment surfaces as shown in Figure 2. There shall be no gaps, cracking, peeling, pinholes, leaking or any other imperfections between the maintenance hole PCS liner/coating and the sewer CIPP liner; in the case where a sewer CIPP liner exists or is to be installed under the Contract. The finished product must be one completely sealed system that will prevent infiltration and any corrosion of the surface subject to rehabilitation coverage.

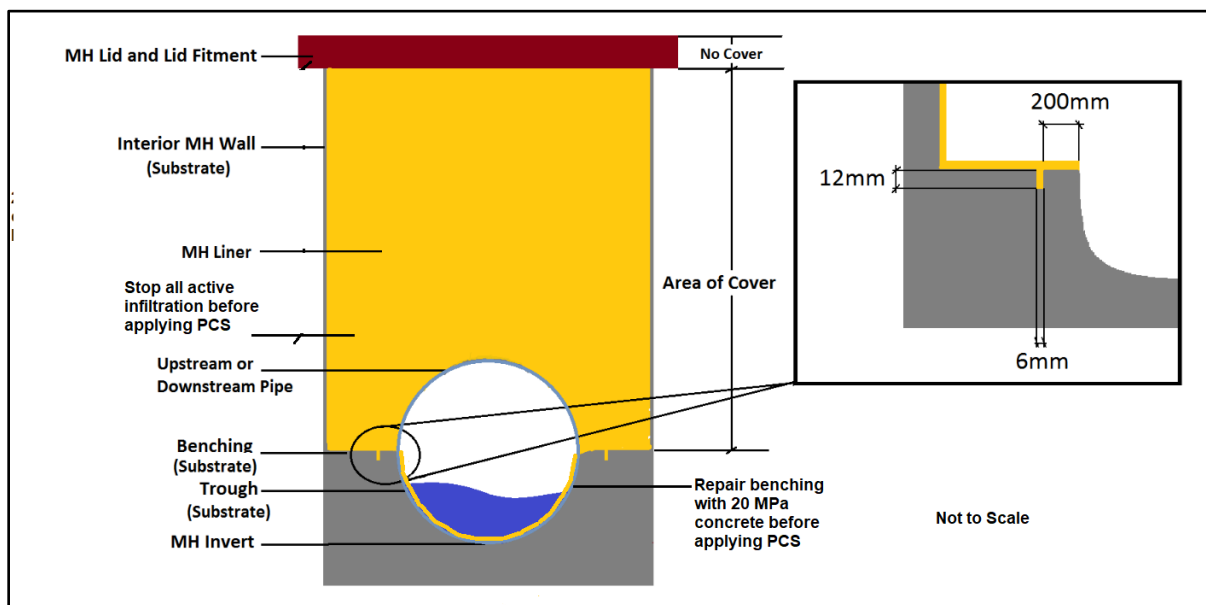


Figure 2: Requirements for maintenance hole rehabilitation liner area of coverage

Liner Edge Finish

The finished edge of a maintenance hole liner along the benching shall prevent ground water leakage. In order to improve the liner performance in preventing infiltration at the finished edge of the liner, prior to applying the liner a groove shall be cut into the maintenance hole bench. The groove shall be cut into the benching approximately 200 mm away from the trough edge, as shown in Figure 2. The groove shall be a minimum of 6 mm wide and 12 mm deep along the full length of the maintenance hole bench. During the liner application this groove shall be completely filled with the rehabilitation product ensuring the liner material does not bridge over the cut groove.

If configuration of the maintenance hole makes it impossible to configure the above groove, the Contractor shall propose an alternative groove configuration which achieves the same results.

CIPP Liner Continuously Extending through the MH

The following applies when a CIPP sewer liner extends continuously through a MH.

This scenario will result in the trough being lined with CIPP with the upper portion of the CIPP cut out for access. In this case the MH rehabilitation shall be applied after the portion of the CIPP above the trough has cured, been cut away and removed. The MH rehabilitation shall be applied in a manner to form a complete seal (interface) between the CIPP liner and the MH rehabilitation product. There shall be no areas within the interface that allow for the infiltration of groundwater or exfiltration of sewage. See Figure 3 for the round pipe profile coverage area. The gap between the maintenance hole PCS and the main line liner shall be sealed with a flexible seal as specified in TS 4.10, which shall account for differential expansion and contraction of the two materials (PCS material and main line CIPP liner material).

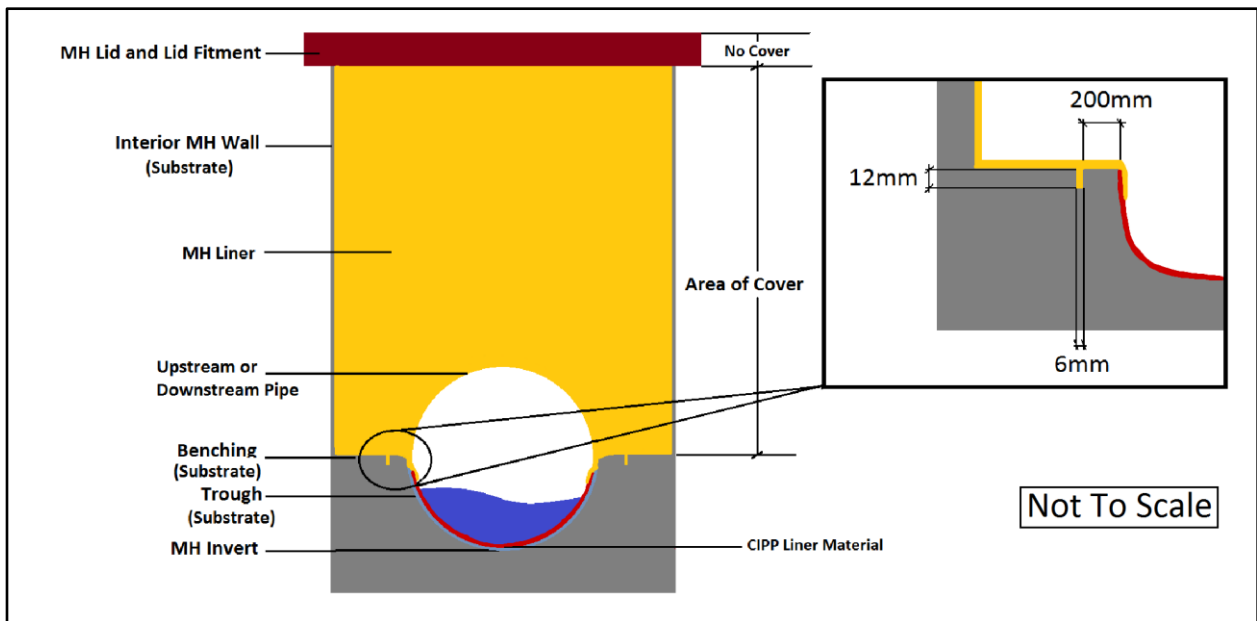


Figure 3: Round Pipe Profile with Sewer Rehabilitation Extending Through the MH

TS 4.13.07.19 Installation Procedure for Determining Applied Thickness

The Contractor shall employ a method acceptable to the Contract Administrator, which during the installation process will determine the applied thickness of the rehabilitation materials. The Contractor shall submit details of the proposed method to confirm liner thickness to the Contract Administrator for review and acceptance. The intent of the procedure is to Installation shall not commence prior to acceptance of the proposed test method by the Contract Administrator..

TS 4.13.07.20 Fit and Finish

The final rehabilitation shall provide a smooth and uniform fit, finish fit and cover to all surfaces of the maintenance hole consistent with the objectives for rehabilitation. There shall be no ledges, shoulders or other protrusions where debris may attach or collect except as may be required for zones of permitted wall thickness changes as per the design requirements. There shall be no gaps, cracking, peeling, pinholes, leaking or any other imperfections between the interface of the maintenance hole rehabilitation material and the CIPP sewer liner.

All areas of coverage shall be fully bonded to the maintenance hole surface beneath without any locations that indicate looseness or lifting.

TS 4.13.07.21 Rungs, Ladders, Handrail, Grating/Platforms, Vent Pipe New and Replacements

Rungs and Ladders:

All existing rungs and ladders shall be removed prior to the application of the linings. All bolts are to be cut flush with the maintenance hole wall. A punch or grinder is to be used to remove any sharp edges from remaining portion of the steel bolts to ensure the steel does not protrude beyond the surrounding concrete.

The Contractor shall install new fibre reinforced plastic ladder in each lined maintenance hole at the same location and on the same wall that the existing rungs and ladders were located on, unless specified differently on or as per the design drawings. Installation shall be as per City standard drawings.

Rungs and ladders shall be installed after the maintenance hole rehabilitation lining has been installed. Rungs and ladders may be installed prior to rehabilitation provided that all rungs and ladder surfaces are covered and protected from being covered or splattered by the rehabilitation materials.

At each location where the platforms and ladders are required to be attached to the newly lined wall, the hole for the stainless steel anchor bolts shall be drilled through the liner by a carbide drill bit. The hole size to be just sufficient to permit the bolt to pass through the liner with a very tight fit. Bolts must be generously coated with SIKAFLEX 1A immediately prior to installation.

Materials:

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1. Where possible, provide end products from one manufacturer in order to achieve standardization for appearance, maintenance, and replacement.
 2. Unless otherwise specified, provide all products manufactured by a pultruded process using vinyl ester resin.
 3. Provide products manufactured with ultra-violet (UV) inhibitor additives.
 4. Provide exterior surfaces with a synthetic surface veil covering.
 5. Furnish molded products as an option where permitted by specifications.
 6. Fire Retardance:
 - a. Maximum flame spread less than 25 as measured by ASTM E84.
 - b. Include combinations of aluminum trihydrate, halogen, and antimony trioxide, where required to meet fire retardance, in the resin system.
 - c. Meet self-extinguishing requirements of ASTM D635.
 7. Disperse colour pigment in resin system.
 8. Fabricate FRP products exposed to outdoor conditions with an additional 0.025 mm thick UV coating to shield product from UV light.
 9. Seal all cut ends, holes, and abrasions of FRP shapes with resin to prevent intrusion of moisture.
 10. Design units to applicable parameters established by the OBC and CAN/CSA S806 including snow loads and wind loads for return period of 1 in 30.
 11. Design for erection loads, effect of creep and other causes of dimensional change.
 12. Design for strength and integrity at service conditions in accordance with engineering practices prevalent in the field of fibreglass reinforced plastics.
 13. Provide products free of defects such as voids, porosity, cracks, pits, scratches, dry spots, and any other irregularity.

GRATING AND STAIR TREADS

1. General:
 - a. 4.8 kPa minimum, unless otherwise shown.
 - b. Maximum Deflection: 6 mm, unless otherwise shown.
 - c. Stair Tread: 4.8 kPa uniform load or concentrated load of 1.3 Kn on area of 2600 mm² located in center of tread, whichever produces greater stress.
2. Molded Type:
 - a. Nonskid No. 200 silica grit affixed to top of bar surface or a concave, meniscus top to all bars, providing skid resistance.
 - b. Load bars in both directions with equal stiffness.
 - c. Square mesh, 38 mm maximum spacing.
3. Pultruded Type:
 - a. Main bars joined by cross bars secured in holes drilled in main bars.
 - b. Cross bars, with 150 mm maximum spacing, shall mechanically lock main bars in position such that they prevent movement.
 - c. Intersections: Bond using adhesive as corrosive-resistant as pultrusion resin.
 - d. Main Bar Ends: Minimum bearing support width of 38 mm.
 - e. Skid-Resistant Surface: No. 200 silica grit adhesively bonded, manufacturer's standard.
 - f. Provide extra stiffness around openings.
4. Hold-Down Clamps: Type 316 stainless steel.
5. Bolts, Connectors and Supports:
 - a. Corrosion-resistant FRP or Type 316 stainless steel.
 - b. Size and strength to meet Code requirements.

6. Fabrications:
 - a. Field measure areas to receive grating. Verify dimensions of new fabricated supports, and fabricate to dimension required for specified clearances.
 - b. Section Length: Sufficient to prevent its falling through clear opening when oriented in span direction when one end is touching either concrete or vertical leg of grating support.
7. Manufacturers:
 - a. Fibergrate Composite Structures, Inc.
 - b. IKG/Borden.
 - c. Strongwell Corp.
 - d. Access Industrial Inc.

STRUCTURAL PLATFORMS AND WATERTIGHT ACCESS HATCHES

1. Deflection and Safety Factors:
 - a. Deflection Criteria: Not to exceed $L/360$.
 - b. Safety Factors: Minimum ratios of ultimate stress to allowable static service stress:
 - i. Flexural Members: 2.5.
 - ii. Compression Members: 3.0.
 - iii. Shear: 3.0.
 - iv. Connections: 4.0.
 - c. Minimum design safety factors for dynamic or impact loads shall be twice the values for static service loads.
2. Loads:
 - a. 4.8 kPa uniform live load over platform.
 - b. Static and dynamic loads for equipment shown.
 - c. Design load for safety platforms in manholes shall be 14.4 Kpa.
3. Glass fibre reinforced polyester or vinyl ester resin matrix, approximately 50 percent resin-to-glass ratio.
4. Continuous glass strand rovings shall be used internally for longitudinal strength.
5. Continuous strand glass mats shall be used internally for transverse strength.
6. Watertight access hatches shall seal sewer during sewer surcharging, when hinged cover is in closed position. Gaskets shall be neoprene.
7. Material Properties:

Minimum Ultimate Coupon Properties (UN)		
Material Properties	Test Method	Units
Pultruded Fibreglass Structural Shapes		
Ultimate tensile stress in longitudinal direction, Mpa	ASTM D638	207
Ultimate compressive stress in longitudinal direction, Mpa	ASTM D695	207
Ultimate flexural stress in longitudinal direction, Mpa	ASTM D790	207
Ultimate short beam shear in longitudinal direction, Mpa	ASTM D2344	31

Minimum Ultimate Coupon Properties (UN)		
Material Properties	Test Method	Units
Ultimate tensile stress in transverse direction, Mpa	ASTM D638	48
Ultimate compressive stress in transverse direction, Mpa	ASTM D695	103
Ultimate flexural stress in transverse direction, Mpa	ASTM D790	69
Density kg/mm ³	ASTM D792	0.00166-00194
Water absorption (25-hr immersion)	ASTM D570	0.60 max, % by weight
Barcol hardness	ASTM D2583	45
Coefficient of thermal expansion 10 ⁻⁶ mm./mm/° C	ASTM D696	8
Thermal conductivity, w (m°K)	ASTM C177	0.58
Flame-Retardant Properties		
Flammability test	ASTM D635	Self-extinguishing
Surface burning characteristics	ASTM E84	25 maximum
Flammability class	UL 94	VO
Temperature index	UL 94	130°C

8. Manufacturers and Designers:
 - a. Strongwell Corp.
 - b. Fibergrate Composite Structures, Inc.
 - c. Access Industrial Inc.

EXECUTION

1. Examination:
 - a. Examine surfaces to which work is to be anchored, and job conditions.
 - b. Report surfaces and conditions which would adversely affect installation.
 - c. Do not commence installation until unsatisfactory surfaces and conditions are corrected.

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2. Install in accordance with manufacturer's written instructions.
 3. Install plumb or level, rigid and neat, as applicable.
 4. Furnish fasteners and anchorages for complete installation.
 5. Seal field cut holes, edges, and abrasions with catalyzed resin compatible with original resin.

GRATING

1. Anchor grating securely to supports to prevent displacement.
2. Install each grating section such that it is easily removable.
3. Clearance (Grating to Vertical Surfaces): 6 mm (plus or minus 3 mm tolerance).

HANDRAIL

1. Provide and install expansion and contraction connections as shown on approved Shop Drawings.

STRUCTURAL SHAPES

1. Connect parts with approved connectors meeting manufacturer's design requirements and with corrosion resistance equal to structural shapes.
2. Provide supports and bracings required to comply with applicable codes and design requirements.

LADDERS

1. Epoxy and rivet joints and rungs.

STEPS

1. Provide and install as shown on approved Shop Drawings.

WATERTIGHT ACCESS HATCHES

1. Install to operate freely and not rattle when closed or open. Install and anchor according to manufacturer's recommendations. Review layout with Contract Administrator prior to installation.

VENT PIPES

1. Resin Systems: The manufacturer shall use only approved polyester resin systems with a proven history of performance of in this particular application. The historical data shall have been acquired from a composite material of similar construction and composition as the proposed product.
2. Glass Reinforcements: The reinforcing glass fibers to be used to manufacture the components shall be of the highest quality commercial grade of glass filaments suitably treated with binder and sizing compatible with impregnating resins. Pipes for the conveyance of sanitary sewage shall use E-glass CR (Corrosion Resistant) glass.
3. The internal liner shall be a glass reinforced thermoset liner suitable for service in a sewer pipe, and shall be highly resistant to exposure to sulfuric acid as produced by

- biological activity from hydrogen sulfide gases. Pipe shall meet or exceed requirements off ASTM D3681.
4. Silica Sand: Sand shall be minimum 98% silica with a maximum moisture content of 0.2%
 5. The Pipe shall be manufactured using a continuous advancing mandrel process utilizing continuous glass fiber reinforcements in the circumferential direction. Both continuous glass fiber rovings and chopped roving will be incorporated for high hoop strength and axial reinforcement. A sand fortifier shall be used to provide increased stiffness with placement near the neutral axis in the core.
 6. The pipes shall be manufactured in accordance with ASTM D3262. The pipe shall meet the following cell limits: Type 1, Glass-fiber-reinforced thermosetting polyester resin mortar (RPMP polyester), Liner 1, Grade 1; pipe stiffness as specified on plans.

TS 4.13.08 Quality Assurance (QA) Testing

Corrosion Resistance

Provide ASTM D543 test result from the manufacturer. From the dolly test and other samples collected for QA, work with the contract administrator and at random pick 1 sample per 5 maintenance holes and complete and provide ASTM D543 test results.

Performance Testing – Type A Product

Table 3: Quality assurance requirements

Test	Standard	Frequency and Location
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 the City.
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 the City. If the contractor disagrees, complete bonding test at this location to verify.
Compressive Strength Testing	ASTM D695	One test per maintenance hole.
Hardness Testing	ASTM D2240	Unless otherwise specified, the sampling rate shall be one test per maintenance hole less than 8 m deep. For maintenance hole > 8 m deep 2 samples one above 8m and second below 8m depth. Sample location to

		be determined by the contract administration and the contractor.
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 the City.
Thickness measurement	ASTM D6132 using ultrasonic or magnetic gauge, or other pre-approved method by the contract administrator or destructive method.	Any areas found to be thinner than the specified minimum or design thickness shall be addressed by applying additional PCS material after surface preparation and ensuring environment control required as per this specification and manufacturer's recommendations, at no cost to the City. Any patch due to destructive testing shall be repaired by the contractor. Unless specified otherwise, the measurement shall be at a minimum 10 different locations. If destructive testing is required, number of samples can be reduced to 5 samples.
MH substrate	ASTM C1583	For each of first two MHs. If the results fail, continue up to 2 successful MHs. After that one test per 10 MHs.
Rehabilitation material bond to substrate	ASTM D7234-12 Use 50 mm Loading Fixture (Dolly)	1. Three tests for each rehabilitated MH less than 5 m deep. 2. Five tests for each rehabilitated MH more than 5 m deep Test locations at the benching, near invert, intermediate and near top or at locations as directed by the Contract Administrator
Rehabilitation material build out layer(s) Inter-layer bond <i>See Note b</i>	ASTM D7234-12 Use 50 mm Loading Fixture (Dolly)	One test for each rehabilitated MH at location as directed by the Contract Administrator
Hardness test	ASTM D2240	One per every maintenance hole or as directed by the Contract Administrator

Chemical Resistance Testing	ASTM D543	One test for every 5 maintenance holes.
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- Note a: Maintenance hole *rehabilitation* can fail due to failure of the interface or failure of the concrete substrate. Therefore the substrate must be prepared to a level where the required bond strength to the structure is not compromised by substrate failure occurring below the required bond strength. This requires a suitable substrate strength, which is achieved by preparation of the maintenance hole surface area to which the bonded layer is attached
- Note b: This test is only applicable for multi-layer rehabilitation products for which the bond strength–adhesion–between the build-out layer(s) is less than the bond strength of the innermost layer–the bonded layer–to the maintenance hole substrate. At the Contractor’s option, the test(s) for the build-out layer(s) may be incorporated into the pull-off test for the bonded layer so that both bonded layer and build-out layer(s) bond strengths are tested at the same time. This option assumes that all build-out layers inter-layer bonding is equal to or greater than the required bond strength to the maintenance hole substrate.

Substrate Testing For First Two Maintenance Holes

The Contractor shall test the substrate of the first two maintenance holes for which cleaning and preparation of the maintenance hole substrate has been completed. For each of the two maintenance holes, the Contractor shall make three pull-off tests of the substrate. Unless locations are otherwise directed by the Contract Administrator, the tests shall be located near the top, near the mid point and near the bottom of the maintenance hole. The placement of the pull test dollies shall be consistent with the requirements of the liner pull tests and completed in the presence of the Contract Administrator.

In the event that any of the substrate pull tests do not meet the required strength, the Contractor shall make further substrate preparation and repeat the tests. Should any follow up tests fail, the Contractor shall change or otherwise revise the method of preparation, re-prepare the maintenance hole and repeat the testing above.

No maintenance hole liners shall be applied until substrate tests meet requirements.

Post-application Rehabilitation Material Testing

The Contractor shall make pull-off adhesion tests of the bond strength of the rehabilitation material to the maintenance hole surface and, where applicable, the bond strength of any build-out layers. The Contractor shall use a portable pull-off adhesion tester according to the requirements of ASTM D7234-12 and shall use a 50 mm diameter loading fixture–dolly–for all pull-off adhesion tests.

The Contractor shall obtain successful test results on the first two maintenance holes rehabilitated before proceeding with the application of the rehabilitation material for any further maintenance hole.

The Contractor shall advise the Contract Administrator at least 24 hours in advance of when both dolly setting and pull testing is to take place so that the Contract Administrator may be present for the testing. Tests done without the Contract Administrator present may be rejected by the Contract Administrator.

The pull-off test shall be performed until failure—break—of substrate, adhesion, cohesion or dolly glue, that is to say the destructive pull test as defined in this specification and not halted at the minimum specified adhesion pressure. Pull test locations shall be equally spaced along the depth of the MH and subject to the approval of the Contract Administrator prior to conducting the pull tests. A break of the substrate — concrete or mortar-brick is visibly adhered to the liner on the dolly. A break between the substrate and the liner — break of the bond to the concrete substrate

No separation, pull-off, pull-apart or other breakdown of the rehabilitation material or similar breakdown of the concrete substrate shall occur below the minimum required bond strength. Any separation, pull-off, pull-apart or other breakdown—including at/in the concrete substrate—that occurs before the required bond strength—bonded layer or build out layer—is achieved shall be considered a deficiency.

The failure of the dolly adhesive will not be accepted as a completed pull test and the Contractor will be required to redo the pull test. However, the failure of the dolly adhesive at 150 psi will be accepted as a completed pull test and the Contractor will not be required to redo the pull test.

In the case where the build-out layer(s) is tested separately from the bonded layer, there shall be no separation, pull-off, pull-apart or other breakdown—including at/in bonded layer and at/in the concrete substrate—below the minimum required bond strength. Any separation, pull-off, pull-apart or other breakdown—including at/in the bonded layer and at/in the concrete substrate—that occurs before the required build-out layer(s) bond strength is achieved shall be considered a deficiency.

The Contractor shall report all pull-off testing results by completing the *Maintenance Hole Pull Test Data Sheet* (see Appendix B) for each maintenance hole and submitting to the Contract Administrator within five Working Days of liner application. Should the pull-off test results not be provided within the required five Working Days, the Contract Administrator may at their discretion order a suspension of work for maintenance hole liner installations until pull-off test reports have been submitted.

Repair of Test Locations

The location of all destructive tests shall be repaired consistent with the rehabilitation and to the satisfaction of the Contract Administrator.

Rehabilitation Material Thickness Measurement

The Contractor shall measure and record applied liner thickness with ultrasonic or magnetic gauge as per Table 3 above. For destructive testing, thickness can also be measured from pull test dolly used for bond testing. The thickness shall be recorded on the *Maintenance Hole Pull Test Data Sheet* form.

Rehabilitation Material Cup Test Sample

At the request of the Contract Administrator, the Contractor shall supply a cup sample of the liner material immediately prior to the liner installation. The cup shall be at least 100 mm in diameter and deep enough to spray the equivalent thickness of material being applied to the maintenance hole including the full thickness if the material is being used as backer and filler. The cup material shall be made of a plastic material such that it may be peeled away from the cured material.

Testing and Cost of Testing

The Contractor shall pay for the cost for testing of samples of cured liner at an independent accredited testing agency (or agencies) approved to perform the tests. The testing agency shall be subject to the approval of the Contract Administrator. At random, the City/Contract administrator may also complete testing at another testing facility. The Contractor shall authorize the testing agency to forward the test reports directly to the Contract Administrator via email and communicate with the Contract Administrator concerning the testing and results. The testing firm shall not submit the results first to the Contractor. The Contract Administrator will arrange for delivery of the samples in custody to the testing agency. Samples shall be tested for all tests identified in Table-3. The contractor will have to coordinate with the testing agency and the site inspector. The contractor will provide samples as directed by the testing agency staff the contract administrator/site inspector. The testing agency will prepare the required test samples from the field samples. The provision of testing service shall allow for the obtaining of test reports within 10 days of delivery of the sample to the testing agency for most samples.

The Contractor shall provide the test agency with the specifications and design parameters with the sample. These values shall have been identified in the Contractor's liner design. The testing agency's report shall reference these values as the specified values.

TS 4.13.08.01 CCTV Inspection of Finished Maintenance Hole Rehabilitation

The Contractor shall complete V3 360 degree CCTV if each completed and finished rehabilitated maintenance hole as per CCTV specification here in using IBAK PANORAMO SI, 3D Scanner equipment or equivalent.

TS 4.13.09 Warranty

A three (3) year warranty is required for maintenance hole rehabilitation. Warranty period starts on the date the City accepts the Works performed under the contract. This warranty includes material and workmanship for ladder, platform, grating, crack and infiltrations repairs, frames, covers and PCS coating/lining system. The material and performance bond for the contract is generally for 2 years. Therefore, near end of 2 year, the contractor shall provide an additional performance bond for material and labour in the total amount of maintenance hole rehabilitation costs plus 15% of the total amount of maintenance hole rehabilitation costs to provide for additional 1 year warranty which will result in total 3 years warranty.

TS 4.13.10 Payment

Payment at the Contract Price shall be full compensation for all labour, Equipment and Material to do the Work and shall be as per below:

There shall no separate measurement for all the appurtenances and the maintenance hole fiberglass reinforced plastic products (including ladders, platforms, handrails, vent pipes, covers, frames, grade adjusters) and the cost shall be deemed to be included in the lump sum price of maintenance hole rehabilitation. If there is variation from the contract for the maintenance hole dimensions, the cost shall be prorated or negotiated and paid through contingency allowance.

- 5% of payment on submission of detailed design shop drawing for specific maintenance hole

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- 5% of payment upon approval of detailed design shop drawing for specific maintenance hole
 - 5% after V1
 - 10% after cleaning, crack repairs, infiltration repairs, preparing the MH for PCS application and V2
 - 35% after installing and curing of PCS
 - 15% after installation of all other appurtenances specified in the contract including ladders, platforms, new chimney if applicable, hand rails, grade adjusters, frame & cover, vent pipe and any other appurtenances as applicable
 - 5% after acceptable V3
 - 20% after testing addressing of deficiencies including deficient thickness and upon final acceptance

Appendices

Appendix A: Requirements for the Consulting Engineer.

Appendix B: ICRI Technical Guideline No. 03732 – Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings and Polymer Overlays

Appendix 4.13-A, January 2019
For Use While Designing and Administrating City Contracts

Note: This is a non-mandatory commentary appendix intended to provide information to the City and for the designer during the design and construction stage of a contract on the use of this TS specification in a City contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an owner's design decisions and methodology.

Rehabilitation and Replacement Design Guideline for the Consultant

Engineering consultant is the designer for this appendix purposes. City's intention is to design and construct a fully structural solution using Type A products specifically for circular maintenance holes. However, due to reasons listed below if fully structural rehabilitation is not feasible due to constraints, City will accept non-structural rehabilitation. But this decision has to be made by the engineering consultant at the time of design working in conjunction with City staff. For square and rectangular maintenance holes, it is City's understanding that fully structural rehabilitation through Type A products is not feasible or is not practical due to significant thickness of application. The designer shall review Type B products available, shortlist Type B products specific to the project and recommend Type B products if fully structural solutions is required. Alternately the consultant shall work with City staff to determine if nonstructural Type A rehabilitation can be considered or a new maintenance hole is required depending on the condition of the maintenance hole as described herein.

Maintenance hole rehabilitation is practical when the existing or post-preparation conditions are considered or deemed structurally sound against external and internal loads. Such external loads include earth loads and loads transmitted from other locations, for example surface vehicle loads. Such internal loads include internal hydraulic surcharging and the anchoring of rungs and platforms within the maintenance hole.

Determining whether a maintenance hole is fundamentally structurally sound and therefore is suitable for rehabilitation is not straightforward. In many cases a maintenance hole with cracks, H₂S gases deteriorated concrete or mortar or missing fabric of construction may remain fundamentally structurally sound in its situation even though it has deteriorated significantly from its originally installed condition. Careful consideration should be exercised in assessing a maintenance hole as non-structurally sound and therefore not suitable for rehabilitation.

The designer shall review condition assessment information, complete site visit, and determine if it is safe to rehabilitate the maintenance hole or replace it completely or partially.

After reviewing background information, site conditions, inspection videos, meeting with operations and other City staff, the designer shall prepare scope of work for maintenance hole. Below are a few guidelines.

- City prefers that maintenance hole liner thickness as specified in this specification for all Type A rehabilitation products and with minimum parameters provided in this specification.
- If the maintenance hole is significantly deteriorated and even after applying coating the maintenance hole still poses significant Health and Safety Risk for workers entering the chambers, a portion or entire maintenance hole shall be replaced as required. The consultant shall complete design accordingly.
- Minimum chimney diameter after rehabilitation shall be no less than 685 mm. In such case review in conjunction with City staff following options and complete design accordingly:

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- If the chimney is narrow for a significant length (> 0.5 metre), replace the chimney or the maintenance hole as per City standard drawings, and complete design accordingly.
 - Less thickness minimum 12 mm rehabilitation product application in top portion of the chimney, and higher thickness in all other areas of the maintenance hole where diameter is not a constraint. If the performance parameters listed in the specification demonstrates, the lower thickness will result in non-structural rehabilitation, it may be acceptable, if the maintenance hole is in good condition and not structurally deteriorated. Acceptance by City staff depends on location and criticality of the maintenance hole and its condition. Complete design accordingly.
 - Potentially review feasibility to abandon the maintenance hole. City may agree to abandon the maintenance hole if:
 - there is no drop in the sewer pipe at the maintenance hole
 - there is no connection
 - the next upstream and downstream maintenance holes are not too far and the sewer can be easily inspected and maintained through upstream/downstream maintenance holes.
 - there is no bend at the maintenance hole and the sewer can be easily inspected and maintained through upstream/downstream maintenance holes.
 - In some cases the maintenance hole could be deep and the hydrostatic pressure may exceed the allowable pressure for Type A application. Reasonably assuming ground water level, based on location of the maintenance hole and nearby geotechnical bore hole information, the consultant shall determine, up to what depth Type A product shall be applied. The consultant shall look at other options such as water proofing. In exceptional cases, the City will agree to increase the thickness of Type A rehabilitation product to 35 mm, provided the Type A product supplier provides written confirmation that 35 mm coating thickness can be applied and will work with hydrostatic pressure over long term.
 - The abandonment and rehabilitation decisions shall be made at early stage during design reviewing as-built and verifying field conditions.
 - Consider the requirement for temporary access roads to facilitate the MH rehabilitation activities and acquire permits accordingly.
 - Situations can exist where missing concrete, bricks or other material dislocations exist but do not make the maintenance hole fundamentally structurally unsound assuming these can be suitably repaired prior to the rehabilitation.