

**SPECIFICATION FOR SPRAY-IN-PLACE THERMOSET PLASTIC FLEXIBLE  
LINING (SIP-TPFL) FOR SEWERS, STORMS AND CULVERTS**

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**Appendices**

Appendix A: Service Connection Statement

TS 4.14 Version 18062020

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#### **TS 4.14.01 SCOPE**

This specification is for Sprayed-in-Place Thermoset Plastic Flexible Lining (SIP-TPFL) of various maintenance hole to maintenance hole (MH-MH) sections of sewers and drainage culverts in the city of Toronto. The sewers may include sanitary sewers, storm sewers and combined sewers. This specification is limited to applications of SIP-TPFL in existing circular pipelines not less than 1200 mm in inside diameter for circular pipelines and in existing non-circular pipelines with a minimum dimension in any direction of not less than 1200 mm. Pressurized sewers (forcemains) are not included.

SIP-TPFL, when completed in place inside the existing pipeline, shall have the capacity to deflect up to 15% under external load without cracking, distress or deterioration occurring in the lining wall. This specification does not apply the cementitious geopolymer liners or similar liners that do not have the capability to deflect up to 15% without cracking.

This specification includes a design method for determining the wall thickness of SIP-TPFL in circular pipelines. The wall thickness design of SIP-TPFL for non-circular pipe shall be considered on a case-by-case basis subject to the Contract Administrator's acceptance of the design method and results. Except for this specification's design method for circular existing pipelines, all other provisions of this specification apply to non-circular pipelines except as may be specifically noted.

Within this specification the term sewer section refers to a MH-MH section of the existing pipeline and in the context a culvert refers to MH equivalent access points. SIP-TPF means Sprayed-in-Place Thermoset Plastic Flexible. SIP-TPFL means Sprayed-in-Place Thermoset Plastic Flexible Lining (or Liner).

The Work shall include performing the following operations: notification of public, CCTV inspections, determining sewer and liner dimensions, determining/confirming design parameters for liners, flow control and bypass pumping, cleaning and preparation of the sewers to be lined, service connection investigation and related work, installation and curing of the SIP-TPFL liners, reinstatement of sewer service connections, making and testing of SIP-TPFL installation samples, return of the lined sewer to regular service plus any other work required for and incidental to the foregoing.

The work involved requires special equipment to be handled, operated and monitored by persons experienced in all phases of the Work.

#### **TS 4.14.02 LINING OBJECTIVES**

The SIP-TPFL shall accomplish the following objectives throughout the design life of the rehabilitation.

- Prevent infiltration of ground water into the lined pipeline
- Prevent exfiltration of flow out of the lined pipeline
- Provide structural performance against external load in accordance with requirements herein.
- Prevent corrosion or erosion occurring in the rehabilitated pipeline
- Prevent root intrusion into the lined pipeline

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- Provide a continuous rehabilitation over the full length of the pipeline without any gaps, joining or structural discontinuities
  - Provide flow capacity in accordance to the requirements herein

#### **TS 4.14.03 INFORMATION TO BE REVIEWED PRIOR TO BID SUBMISSION**

For Tender Calls or RFPs where the sewer sections for rehabilitation have been identified in the tender or RFP documents, all bidders shall review the City CCTV inspection records of these sections prior to submission of their Bid. Arrangements for viewing these records shall be made according to the instructions in the Tender Call. Upon viewing, the prospective bidder shall fill out and sign the *CCTV Review Sign Up Sheet*.

If, for bidding purposes, the contractor is of the opinion further inspection is required in order to properly assess the work to be undertaken, the contractor will be responsible to perform such additional inspection. Permission to enter the City's sewer system for inspection purposes shall be obtained from the Contract Administrator.

#### **TS 4.14.04 INFORMATION TO BE SUBMITTED WITH BID**

The Tender Call requires the following information to be submitted with the Bid for the review and approval of the Contract Administrator. Further information could be required to be submitted elsewhere in the Tender Call other than in TS 4.14 herein.

Submit with Bid:

- 1) The name of a professional engineer licensed in the province of Ontario who will provide the SIP-TPFL liner engineering designs required according to the liner design requirements in TS 4.14 herein. The professional engineer shall be authorized to perform such work by Professional Engineers Ontario (PEO).
- 2) SIP-TPF liner designs for all sewer sections identified in the Tender Call: The liner design shall be according to TS 4.14 herein. The designs shall bear the seal and signature of the engineer identified in 1) above.
- 3) A signed letter from the bidder confirming lining material, design and installation procedure to be used for this project do meet all requirements of this specification.
- 4) A signed letter from the lining material supplier confirming that the material to be used for this project meets all the requirements of this specification.
- 5) Material specifications and structural details of the proposed sewer liner in sufficient detail to enable confirmation by the Contract Administrator that the SIP-TPFL proposed will meet the design requirements in TS 4.14 herein. Include the SIP-TPFL material manufacturer, material type(s) and manufacturer's identification number(s).
- 6) Third party test reports for the proposed SIP-TPFL liner that support the physical properties (short-term values and long-term design values) used in design. Include third party ASTM D790 test report(s) for flexural modulus and flexural strength.

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- 7) Third party testing demonstrating the proposed SIP-TPFL liner has the capability to deflect up to 15% without cracking or exhibiting any other wall distress or deterioration. Include third party ASTM D2412 test report. The testing shall be done on a minimum 900 mm diameter full cylindrical sample with a maximum DR of 36. For a 900 mm sample, DR 36 corresponds with a wall thickness of 25 mm.
  - 8) A sample of the proposed SIP-TPFL liner that has been prepared by using the same methodology that will be used to apply the SIP-TPFL conduit(s) to be lined on the contract. The sample shall have the following minimum dimensions. Thickness 25 mm; Width 200 mm; Length 200 mm.
  - 9) A complete list of equipment including CCTV cameras, robotic spray equipment, robotic service connection cutters (if to be used), reamers and other necessary major items to be dedicated to the work. The list of equipment shall specify type, manufacture and quantity of equipment.
  - 10) A summary of the Contractor's proposed the SIP-TPFL liner procedure. The summary shall include, along with other information, the following:
    - Temperature limits (both upper and lower) for the application of the SIPCL including as recommended by the SIPCL material supplier.
    - Maximum and minimum time between applications of succeeding layers required to build-up the required thickness.
    - Surface treatment required when maximum time between applying succeeding layers has been exceeded.
    - Surface moisture/dampness limits for application of the material to the existing pipeline.

At any time the Contract Administrator has the right to accept or reject the material proposed by the Contractor for the Contract based on analysis of the material and/or subsequent information obtained from the Contractor that, in the opinion of the Contract Administrator, the material does not conform with the material accepted for award of Contract or does not conform with the Contract requirements. In such case the Contractor shall provide the material that conforms to the material accepted for award of Contract or that meets Contract requirements.

#### **TS 4.14.05 NOTIFICATION TO PUBLIC**

Prior to commencement of any Work on the Contract, the Contractor shall deliver written notices to all affected parties a minimum of 7 Days to a maximum of 14 Days prior to any work commencing at each location. The Contractor must schedule the works accordingly. Such written notices shall consist of letters supplied by both the Contract Administrator and the Contractor and both must be delivered at the same time.

From time to time during the Contract other notices, such as the *Service Interruption Notice*, shall be distributed by the Contractor.

Contractor's notices shall be typed on the Contractor's letterhead and clearly indicate both daytime and after hours local contact telephone numbers. Telephone numbers shall be either local area code or toll free numbers. No work will be allowed to commence without such notices. Any Contractor's written notice shall be submitted to the Contract Administrator for approval prior to notice delivery.

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The Contractor shall be responsible for notifying the homeowners to limit their sewer use, including the use of any mechanical devices, for example sump or ejector pumps from discharging to the sewer service, in a manner that may adversely affect the lining process.

The Contractor shall provide the Contract Administrator with a copy of such notice for approval.

#### **TS 4.14.06 SITE INVESTIGATION**

Before commencing any construction work at a site the Contractor shall investigate each site to determine the existing site conditions and identify any obstructions or any other problem 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 4.14.07 EXISTING VIDEO INSPECTION RECORDS AND DRAWINGS**

The Contract Administrator shall provide the Contractor with a list of sewer sections for the SIP-TPFL lining along with the City's available CCTV inspections, inspection reports and sewer map drawings for the sections. This information will be provided either in full at the start of the contract or alternately on an incremental monthly basis during the contract. The method of provision either in full or incrementally will depend on the structure of the specific contract tender including the structure of schedule of unit prices and quantities.

The Contractor shall review the inspection information and drawings prior to undertaking any work in the sewer sections.

#### **TS 4.14.08 WEATHER CONDITIONS**

It is the Contractor's responsibility to review Environment Canada weather forecasts prior to commencement of pipeline preparation and lining operations to ensure anticipated weather conditions (i.e. sewer/drain flows) do not:

- exceed the Contractor's flow control capacity
- cause potential basement flooding such as blocked laterals due to the liner
- negatively effect the installation (i.e. placement and/or cure) of the SIP-TPFL

Where the anticipated weather conditions are such that it may cause potential problems, commencement of construction that requires flow control shall be delayed until favourable weather is forecast.

This applies to all pipeline sections to be lined.

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## **TS 4.14.09 FLOW CONTROL AND BYPASS**

When interruption of sewer line flows is necessary to properly conduct the work including such as for CCTV inspection and lining operations, acceptable methods of flow control shall be provided. In situations where flow control exceeds the standard flow allowed for in this specification (defined below) and includes bypass pumping, flow control for these situations shall be according to TS 4.01 – *Construction Specification for Temporary Sewer Bypass System*.

The Contractor is to make all necessary arrangements with the owners of each building. The Contractor shall contact all affected property owners or tenants or both to co-ordinate the repair work to the sewer and minimize any impact on residents or businesses or both.

During the inspection and rehabilitation, sewer flows in the pipeline section being lined shall be shut off in order to enable proper inspection of the pipe, including the invert and for the SIP-TPFL installation. After the work is completed, flows shall be restored to normal. Excess sewage flows shall be transported through a closed, leak tight pipeline or by tank trucks to the nearest or most economical disposal area.

On all liner installation dates when flow control is executed by bypass pumping, the Contractor must maintain on site both a primary and stand-by bypass pump and pump power supply. Sufficient power supply and hoses must be on site in order to allow the pump to discharge into the next downstream sewer section. The stand-by bypass pump and power supply shall be of an equal or better capability than the primary bypass pump and power supply. No bypass pumps or related equipment shall be disconnected or removed from the sewer or job site until after all service connections have been reinstated and the Contractor has recorded the post-installation video.

All bypass pumping shall be in place and operation prior to the final pre-installation inspection. All bypass pumping capacities and configurations must be approved by the Contract Administrator prior to the actual liner installation date.

All bypass pumps and related equipment must be silenced equipment or contained within an acceptable sound reduction structure.

### **Standard Flow Control**

The Contractor shall provide for all flow control bypass capacity up to and including 150 mm pump configurations where a 150 mm pump shall have a minimum capacity of 4540 L/min (1200 USGPM), which shall be the Standard Flow Control and included in all unit rates.

The Contractor shall be responsible for determining the required flow control or bypass capacity for the work. Where the Contractor determines that the required flow control/bypass requires capacity exceeds the Standard Flow Control, the Contractor shall advise the Contract Administrator of the requirement and any additional cost for the higher flow control/bypass capacity. The Contract Administrator shall provide further instruction to the Contractor as needed including, as required, negotiation of additional payment for the bypass capacities exceeding the Standard Flow Control.

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### **Sufficient Capacity for Flow Control**

No flow control or bypass pumping shall be employed that has insufficient capacity to maintain flow in the sewer system. It is the Contractor's responsibility to employ and maintain flow control of sufficient capacity. No work requiring flow control shall proceed until flow control arrangement is in place that provides sufficient flow control capacity including for situations that exceed the Standard Flow Control

### **TS 4.14.10 CCTV INSPECTIONS AND REPORTS**

CCTV inspections for V1, V2 and V3 assessments shall follow the following:

#### **CCTV Equipment**

The cameras and transmission cables utilized under this contract shall produce colour recordings and the recording equipment utilized shall produce MPEG-1 or MPEG-2; one MPEG file per sewer section inspection.

The CCTV camera used the inspections shall be colour, pan, tilt and zoom view type capable of radial rotation of 360°, lateral rotation of 270°, and of producing a continuous picture resolution of not less than 400 lines at the periphery of the picture. Picture resolutions shall, at the discretion of the Contract Administrator, be confirmed using a RS Resolution Chart—Retina Type.

The cameras shall be equipped with a self-contained, adjustable, directed light source compatible with the lens angle and dispersed to create even distribution of the light around the pipe perimeter without the loss of contrast, flare out of picture or shadowing.

The camera shall be self-propelled. The mounting of the camera shall be adjustable such that the central axis of the camera lies at a point equidistant between the invert and overt of the pipe during inspection of the sewer. In the case of egg shaped sewers, the camera lens must be positioned vertically above the invert at a height two thirds of the vertical dimension of the sewer. In all instances, when transporting the camera through the sewer the camera lens must be positioned on, and looking along the central axis of the sewer.

The equipment and cables utilized shall be capable of inspecting a minimum sewer length of 150 m, without reversal.

#### **Pipeline Conditions for CCTV Inspections**

The sewer section under inspection shall be sufficiently dry so that any remaining water does not obscure any part of the interior of the sewer during the CCTV inspection. Where required, flow control shall be used to accomplish this clear viewing of the sewer.

The camera shall provide sufficient light and proper focus to enable clear viewing of the pipe surface at all locations.

The sewer section under inspection shall be free of any fog or vapour that obscures the view. Where required ventilation or other provision shall be used to eliminate such fog or vapour.

The inspection speed shall allow proper analysis of the sewer condition. The maximum camera travel speed shall be 5 m/minute.

When required for a specific inspection, the CCTV camera shall stop and view each service connection clearly and completely for at least five seconds.



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Each individual CCTV inspection shall be continuous over the sewer section.

### **Notice to City of Inspections**

The Contractor shall provide 48 hours notice prior to a required CCTV inspection in order that, if required, the Contract Administrator can arrange to be present for the CCTV inspection.

### **CCTV Screen Information**

A sewer information screen in the format indicated in the attachments shall be displayed for a minimum of 10 seconds at the start of all inspections. Inspection of the sewer shall not proceed while the information screen is being displayed. Upon commencement of, and throughout the inspection, the following information shall be continuously displayed on-screen and captured on the recording: start and ending maintenance hole numbers, street name, continuous chainage, and feature/defect coding as per the National Association of Sewer Companies (NASSCO) Pipeline Assessment and Certification Program (PACP), in accordance with PACP Reference Manual – Version 6.0.1 – November 2010, as per attachments attached.

### **Sewer Condition, Defect Coding and Inspection Reports**

When required CCTV Inspections must be carried out in accordance with National Association of Sewer Companies (NASSCO) Pipeline Assessment and Certification Program (PACP). The cost of providing the above requirement shall be included in the lining items. As part of this requirement, the following must be applied:

The sewer inspection reports shall be in the format identified in attachments, as adopted from the most current version of the PACP Reference Manual. The report shall identify the chainage and defect code for all defects and construction features as established from the classification definitions. Alternative classification systems will not be accepted. Defect coding may not be required for all CCTV inspections. See individual CCTV inspection sections in this specification.

The Contractor shall submit inspection reports and videos to the Contract Administrator in a timely manner using portable hard drives. The final submission that includes all videos (i.e. V1, V2, V3 and post deficiencies inspection) shall be also submitted two copies on portable hard drives. The City will no longer accept CD/DVD media for sewer lining contracts.

The cost of hard drives or uploading shall be included in the sewer lining items.

### **CCTV Inspection Video Player Requirements**

CCTV inspection video files shall play properly and completely on commonly used video file playing software applications. The video files must play properly and completely on correctly configured, up to date versions of Microsoft Windows Media Player, VideoLAN VLC Player and Apple QuickTime Player. Video files that do not play properly and completely on all these three players, in either Windows OS versions or Mac OS versions, will be rejected. The Contractor is advised that playback problems often can be traced back to the software or equipment that was used to generate the MPEG files. Playback problems may also be traced back methodologies employed for writing files to the storage media or for uploading to remote servers.

### **Inspection Reports**

Each CCTV inspection submitted shall be accompanied by an electronic format sewer inspection report in PDF file format that is generated from the sewer.dat file. The reports shall be in the format required by the City. The PDF reports shall be included on the approved media or uploaded along with the video file and sewer.dat file.

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Prior to the regular contract required submissions of CCTV inspections/reports, the Contractor shall submit a trial inspection report in PDF format for approval by the Contract Administrator.

#### **TS 4.14.11     CCTV TRUCK UNITS**

Proper seating accommodation must be provided by the Contractor to enable two people, in addition to the operator, to clearly view the screen of the on-site monitor, which displays the inspection work in the main line sewer or sewer service as such work proceeds. No equipment utilized within the sewer shall be allowed to be stored in the viewing area.

The Contractor will equip the inspection units and crew supervisor with a cellular telephone utilizing province of Ontario telephone numbers and will provide the Contract Administrator with the cellular telephone numbers.

Each inspection unit shall be equipped with all fans or blowers or both necessary to remove any fog that may be present in the sewers during inspection.

#### **TS 4.14.12     PRELIMINARY CCTV INSPECTION – V1**

The Contractor shall make a preliminary CCTV inspection—called the V1—of the sewer section before undertaking any work required for the SIP-TPF lining of the section. The purpose of the V1 is to determine and record the initial condition of the sewer section and to determine if a significant changed condition exists versus the CCTV inspection provided to the Contractor by the Contract Administrator. Significant changed condition means a condition that will prevent lining of the section, require an unexpected excavated repair before lining, require a change in the liner design resulting in an increased liner thickness to deal with the changed condition or any other situation, which in the Contract Administrator’s opinion, is a significant changed condition.

Where a significant changed condition is encountered, the Contractor shall immediately inform the Contract Administrator.

In making the V1, the Contractor shall employ only such preliminary cleaning that is necessary to obtain a CCTV inspection sufficient to record the initial condition including a count and condition of service connections.

De-watering of the sewer shall be sufficient for V1 inspection purposes and sewer flow control shall be done where the sewer is not sufficiently clear for V1 inspection purposes.

Sewer defect coding is not required for the V1.

The V1 CCTV inspections shall be submitted to the Contract Administrator according to the requirements of TS 4.14 herein.

#### **TS 4.14.13     FIELD MEASUREMENT OF PIPELINES**

The Contractor shall measure the internal diameters of the sewer sections to be lined and the length of the sections to be lined. The measurements taken shall be suitable for proper sizing of the liner(s) to be installed. Refer to requirements for the SIP-TPFL in TS 4.14 herein.

The Contractor shall not rely on dimensions provided by the City. Measurements shall be provided to the Contract Administrator on request.

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#### **TS 4.14.14 SERVICE CONNECTION STATEMENT**

The Contractor shall record details of all service connections on a sewer section on a *Service Connection Statement* form. The form shall be fully completed identifying all service connections on the sewer section to be lined prior to installation of the liner. The form shall be completed as part of the V1 and V2 CCTV inspection work.

The statement shall be updated during service connections reinstatement to show which service connections have been reinstated with date and time of reinstatement.

The statement shall be provided to the Contract Administrator on request.

For a sample of the *Service Connection Statement* form, see Appendix A.

#### **TS 4.14.15 SERVICE CONNECTION INVESTIGATION**

Where, in the Contractor's opinion, service investigation is required the Contractor shall carry out the investigation. The service connection investigation, when required, shall be completed as part of the V1 and V2 work.

Whether or not a service investigation is carried out, the Contractor is always required to complete the Service Connection Statement.

#### **TS 4.14.16 SERVICE CONNECTION INVESTIGATION PROCEDURE**

Where a service connection investigation is required, the Contractor, in accordance with the approved procedure, shall do an investigation on the sewer sections. The investigation will require completion of two reports: *Master Service Connection Report* and *Dye Tester Drain Report*.

The drain locations (properties serviced) shall be identified for all service connections indicated on video inspection records, including the preliminary video inspection V1, except where the service connections are confirmed to be dead—not in use—either by visible plugs or by dye testing. There may be additional connections not shown on the records.

The Contractor shall submit to the Contract Administrator a *Drain Report* including the *Master Service Connection Report* and *Dye Tester Drain Report*. The *Drain Report* shall identify each drain on the sewer section and for each drain provide the following information:

- property serviced by the drain
- location of drain relative to reference maintenance holes
- result of dye testing—live or dead drain
- size of drain
- material of drain (e.g. clay, concrete, plastic, other material)
- colour of drainpipe as seen by CCTV camera
- clock position of drain as seen by CCTV camera
- drain entry type (e.g. protruding, flush, recessed, factory tee, other)
- drain end condition (e.g. smooth, ragged, broken, other)
- existence of a visible plug in the drain as seen by CCTV camera
- any other identifying information indicating live or dead drains

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The Contractor shall obtain an exact steel tape measurement to the centre line of each service, either by remote means in non-man entry sewers, or by hand in man entry sewers only for sewers 600 mm or larger.

In addition, the drain connection locations shall be confirmed using the electronic distance counter utilized in the CCTV recordings.

The reference point for all measurements shall be established and clearly marked at the intersection of the obvert of the sewer and the inside wall of the maintenance hole.

The Contractor shall carry out testing to the extent necessary to confirm whether or not each drain connection is live. Two different and distinct colours of dye, one colour being of a bright and fluorescent nature must be employed on an alternating basis during the course of the dye testing. If necessary to confirm the status of a particular drain, testing of the following shall be carried out:

- a) All sanitary drains and storm drains in the first four buildings located in either direction from the drain, on both sides of the street. For drains adjacent to intersections, the first four buildings in either direction on adjacent streets.
- b) Catch basins, hydro chambers and vaults and adjacent lane drains in the vicinity of the drain connection.
- c) Storm and sanitary maintenance holes in the general vicinity must be checked to confirm the discharge location for any drains not entering into the sewer to be lined. All observations and results must be clearly and accurately noted on the *Dye Tester Drain Report*.

In order to ensure accuracy of the investigation, constant electronic communication shall be maintained between members of the investigation crew.

During the course of the dye testing all information must be recorded in a continuous, ongoing basis as the work progresses. If this is not done, the Contractor shall be required to retest all locations

Once a specific investigation crew commences the service connection investigation at any site location the members of that crew shall remain the same until the service connection investigation is completed at that site location. All members of all service connection investigation crews must carry and clearly display a picture identification card, which clearly identifies them as being employees of the Contractor.

The Contractor shall submit the *Drain Report* including three copies of the *Master Service Connection Report* and *Dye Tester Drain Report* both typed along with copies of original field notes to the Contract Administrator for review and approval 2 Days prior to the on-site drain review and at least 5 Days prior to the scheduled lining installation. No on-site drain review will occur until the *Drain Report* is submitted.

The on-site drain review will require on site: all members of the dye testing crew, all drain investigation and dye testing reports, all drain investigation video recordings, a CCTV truck and any other information relating to the sewer section.

The on-site drain review will determine the service connections to be abandoned. No service connections shall be left abandoned without written approval from the Contract Administrator.

No lining installation work will be permitted without the final approved *Drain Reports* being on site.

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#### **TS 4.14.17 PIPELINE CLEANING AND PREPARATION FOR LINING**

The sewer section to be lined shall be cleaned to remove foreign materials prior to lining by means of a controlled hydro pressure sewer cleaner. Precautions shall be taken to ensure that no flooding of public or private property occurs during any phase of the cleaning and any reaming operations. Satisfactory precautions shall be taken to protect the sewer lines from damage that might be inflicted by the use of cleaning equipment.

All sludge, dirt, sand, rocks, grease and other solid or semi-solid material shall be cleaned from the sewer. Resulting debris from the cleaning operations shall be removed at the downstream MH of the pipeline section being cleaned. Passing material to other MH to section(s) shall not be permitted. The Contractor shall also install a screen in the downstream maintenance hole in order to catch any material, including cut outs from service connection openings, which might migrate downstream. Such material from the maintenance hole shall be removed and properly disposed.

Where the V1 or sewer cleaning operations indicate the presence of deposits, roots, protrusions or other foreign materials in the sewer that are resistant to sewer cleaning operations, these shall be removed by sewer reaming cutting or grinding.

##### **Disposal of Materials**

In accordance with the requirements of the *Environmental Protection Act*, R.S.O 1990, Section 27 and subject to all terms and conditions related to Waste Management, the Contractor will be responsible for the complete removal and disposal off site, of all foreign materials flushed, scraped, or cut out of the existing pipeline. Flushing and abandoning of debris in main sewers or sewer laterals is not permitted.

The Contractor shall submit its MOE license with the Bid.

Prior to commencement of the Contract, the Contractor shall notify the Contract Administrator of the disposal site(s). The Contractor shall also provide the Contract Administrator with documentation, such as weigh scale tickets, attached to all relevant invoices, indicating discharge quantities, pertinent dates and discharge location(s).

**Infiltration and Moisture Control:** Refer Section TS 4.14.20

#### **TS 4.14.18 PIPELINE REAMING, CUTTING AND GRINDING**

The sewer section to be lined shall be reamed to remove deposits and protrusions using an approved reaming method. Deposits and protrusions can include calcite build up, roots and protruding service connections. An acceptable CCTV camera must monitor reaming operations.

Where calcite is hard and firmly attached to the existing pipeline, full removal is not required as long as the remaining calcite does not reduce the existing pipeline inside diameter by more than specified below under Reaming Tolerances and the remaining calcite is not an impediment to the application of the SIP-TPFL.

##### **Reaming Tolerances**

All protrusions, deposits, build-ups and other foreign material in the pipeline section shall be removed such that the internal diameter of the pipeline pipe is not reduced by more than 20 mm by any material remaining after reaming. Any such remaining material must hard and firmly attached to the pipeline wall.

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### **Protruding Service Connections**

Service connections that protrude into the sewer section shall be cut or ground back prior to reaming of the sewer with any type of reaming device that may damage the service connection. Protruding service connections shall be cut back sufficiently to preclude damage from reaming operations and the extent of the protrusion left in place must not interfere with the installation or long-term performance of the SIP-TPFL liner. Cut back protruding service connections shall be smooth and even with no jagged edges. If the service lateral piping or service connection is damaged or broken by the Contractor, then the Contractor shall repair the damage by using excavation if necessary. The Contractor shall submit for approval, the proposed method of repair and reinstatement for damaged drain piping or service connections.

### **Precaution to Prevent Damage to the Sewer Section**

The Contractor shall plan and execute the reaming operation to prevent damage to the sewer section and any service connections in the sewer section. Proper precautions shall be taken by the Contractor to ensure that the reaming operation does not cut into the sewer itself, to ensure that the reaming tools do not become jammed in the sewer and that any areas of the sewer that are structurally unsound are not further damaged. Any extraction of reaming tools or other equipment, including extraction by excavation, is the responsibility of the Contractor.

## **TS 4.14.19 FILLING OF VOIDS**

### **Voids Identified for Filling in the Contract**

The Contractor shall fill voids through the pipe wall, behind the pipe wall or around the pipe wall outside of the pipe as specified for filling in the Contract Documents. Void filling shall ensure structural integrity of the lined sewer and prevent bridging by the liner. It shall also ensure there is adequate contact surface available for spray lining material to be applied. The Contractor shall submit for the approval of the Contract Administrator a detailed method statement outlining the procedures and materials to be used in filling the voids. The method statement shall correspond with requirements that may be specified for void filling such as in the Contract's Sewer Section Lining Summary Table.

### **Voids Requiring Filling Not Identified in the Contract**

If, during the course of the work such as during the V1, cleaning and preparation or V2, the Contractor identifies voids that require filling to ensure the structural integrity of the liner and to prevent bridging by the liner, the Contractor shall advise the Contract Administrator of these voids. Where the filling of such voids is required by the Contract Administrator, the Contractor shall submit a detailed method statement outlining the procedures and materials to be used in filling the voids. Where the Contract Administrator requires filling of the voids, the cost shall be negotiated. However, this provision shall not apply to any voids created as a result of the Contractor's work unless, and at the discretion of the Contract Administrator, the creation of such voids was an unavoidable repercussion of the work.

## **TS 4.14.20 INFILTRATION AND MOISTURE CONTROL FOR LINING INSTALLATION**

For the duration of lining installation within the pipeline there shall be no running or standing water in the pipeline and absolutely no infiltration of water into the pipeline. Moisture on the inside surface of the pipeline shall be limited to surface dampness only.

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The Contractor shall take the necessary measures to make sure that infiltration and moisture is controlled. These measures shall include (where necessary): Stopping infiltration by grouting, prevention of all flow into the pipeline by damming or blocking inlets, clearing of all standing and ponded water by pigging or swabbing and plugging all incoming lateral connections.

No lining shall take place when the pipeline is wet or moist beyond surface dampness.

The cost of moisture control shall be included in cleaning, preparation and lining items.

The cost of infiltration control shall be as per applicable pay item.

#### **TS 4.14.21 POST CLEANING AND PREPARATION CCTV INSPECTION – V2**

After completion of the cleaning and preparation of the sewer section including all reaming, cutting, grinding, void filling and infiltration/moisture control, a CCTV inspection—called the V2—of the full length of the sewer section shall be done. The V2 shall be according to the requirements of TS 4.14 herein.

The V2 complete with all reports shall be provided to the Contract Administrator at least 2 Days prior to lining for the Contract Administrator’s approval of the cleaning and preparation.

Lining shall not commence until approval of the cleaning and preparation has been provided by the Contract Administrator to the Contractor.

In the event that, after the V2, a deficiency in the cleaning and preparation (and specifically including moisture control) is identified that requires correction, the V2 shall be redone after the correction has been done and the redone V2 submitted to the Contract Administrator.

Submission of the V2 and/or the Contract Administrator’s approval of cleaning and preparation do not remove the Contractor’s responsibility for the cleaning and preparation of the pipeline in accordance with the requirements of TS 4.14 herein.

#### **TS 4.14.22 MATERIALS AND STANDARDS**

The sewer lining material shall be a thermoset plastic and shall be suitable for application to the full perimeter and area of the interior wall surface of a pipeline of conduit by a direct mix at the pressurized spray head process. Spin casting or other centrifugal methods of spray application shall not be used. The liner spraying shall be executed robotically with CCTV video recording of the lining process. The CCTV recording shall be submitted to the Contract Administrator upon request. Allowed exception to robotic spraying shall be made for surface preparation and on the terminations of the liner in the maintenance holes (or other termination structures) where hand spraying is acceptable.

The sewer liner is referred to as SIP-TPFL, Spray-in-Place Thermoset Plastic Flexible Liner or simply liner. The material shall be a polyurethane, a polyurea, a combination of both or other thermoset plastic material that meets the requirements of TS 4.14. When applied in multiple passes by robotic spray-on application equipment, the layers must bond to each other in a manner that the resulting thickness shall be constant and be fully homogenous and monolithic element without any structural weakness at the interfaces where successive layers have been applied to build up the required liner thickness.

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The in place SIP-TPFL shall be shall be capable of withstanding up to 15% deflection under external load without cracking or exhibiting other evidence of distress or failure.

Chemical resistance of the completed in-place liner shall meet the chemical resistance requirements in ASTM F1216-16 (including appendix X2) and ASTM D5813.

The material shall be 100% solids with zero VOC.

The in-place liner shall be suitable for the transport flow of municipal sewage and shall not degrade or erode when transporting municipal sewage at flow velocities normal for municipal sewer pipes.

The in-place liner shall have the following minimum properties:

Minimum Flexural Strength: 55 MPa (7,977 psi) by ASTM D790 test method  
Minimum Flexural Modulus: 1,724 MPa (250,045 psi) by ASTM D790 test method  
Minimum Hardness: 70 Shore D  
Minimum Structural Wall Thickness: As per approved liner design or other Contract specified requirement.

The wall thickness design of the liner may use properties greater than the minimums above in which case test results from liner samples shall meet the greater values.

The in-place liner shall meet or exceed the short-term properties and long-term design properties premised in the liner design for the required design life of 50 years (or number of years otherwise specified).

Where, in the course of work, the Contractor has reason to use equivalent materials that differ from the original proposed materials, either in general or for a specific installation, proposed alternate materials shall meet the above minimum properties and all performance requirements outlined in TS 4.14 and require the approval of the Contract Administrator prior to use.

#### **TS 4.14.23 LINER INTERIOR SURFACE FINISH AND FLOW REQUIREMENTS**

The finished liner within the host pipe shall provided a Manning flow coefficient of not greater than  $n = 0.012$  for host concrete pipe (or other similar surface finish host pipe) and not greater than  $n = 0.016$  for CSP (corrugated steel pipe). The higher Manning flow coefficient allowed for CSP is based on the expectation that the finished inside surface of the liner may reasonably have some reflection of the corrugations in the CSP.

The liner's surface finish shall be generally smooth and uniform so that there shall be no localized Manning flow coefficients greater than the above limits. The liner interior surface finish shall be free of ridges, high spots, hollows, valleys or depressions except in CSP where such ridges and hollows are a reflection of CSP corrugations ridges and valleys. There shall be no irregularities that may result in ponding or flow damming unless such irregularities are a reflection of the host pipe surface. This exception does not apply if irregularities in the interior surface grade of the host pipe are due to host pipe cleaning and preparation that does not conform the Contract requirements.

The liner interior shall provide for a continuous and uniform grade (slope) for gravity flow except in the case that the grade of the liner is a reflection of the grade of the host pipe. This exception does not apply if irregularities in the interior surface grade of the host pipe are due to host pipe cleaning and preparation that does not conform the Contract requirements.



When completed the lined pipeline's internal size and flow characteristics shall provide at least 90% of the flow capacity of the pre-lining pipeline based on a Manning flow comparison pre-lining to post-lining. For comparison, for CSP a pre-lining Manning number of 0.023 shall be used and for concrete a pre-lining Manning number of 0.014 shall be used.

**TS 4.14.24 DESIGN OF SIP-TPFL INSTALLATIONS FOR CIRCULAR PIPE**

The SIP-TPFL wall thickness shall be designed by the Contractor in accordance with Appendix X1 in ASTM F1216-07a subject to the parameters and modifications to the F1216 Appendix X1 design method described in Table 1 below.

Engineered designs for each sewer section to be lined with a SIP-TPFL shall be made and each design shall be stamped by a Professional Engineer licensed and authorized to perform such work by Professional Engineers Ontario (PEO).

Designs shall be submitted to the Contract Administrator for acceptance. No lining shall be installed without a design accepted by the Contract Administrator.

The Contract Administrator reserves the right to reject the design if, in the Contract Administrator's opinion, it is not consistent with the requirements in the specification.

**Table 1. Design Method and Design Parameters for SIP-TPFL in Circular Host Pipe**

<b>Parameter</b>	<b>Requirement</b>
Design Method	SIP-TPFL liners for sewer, storm and culvert shall be designed for wall thickness using the ASTM F1216-07a, Appendix X1, Design Considerations, X1.2 Gravity Pipe. X1.2.2 Fully Deteriorated Gravity Pipe Condition modified as follows:  1. See External Hydrostatic Pressure parameter below. 2. F1216-07a X1 Note X1.2 calling for a maximum DR of 100 is not applicable. 3. F1216-07a Equation X1.4 is not applicable.  Design by appendix X1 from ASTM F1216 versions later than F1216-07a is not permitted.
Design Life	50 years
Safety Factor	2.0 for all equations
External Hydrostatic Pressure	Corresponding to the greater of: 1) Ground water table at 1.2 m below ground surface or 2) A water head 1.5 m over invert or a water head of 0.2 m over top of pipe, whichever produces the most head.
External Earth Load	Based on 2 meters cover over top of host pipe or a cover over top of host pipe equal to 2 times host pipe outside diameter, whichever yields the greater cover.  The foregoing applies unless full cover loading is specified in the tender or RFP documents in which case the external earth load shall be based on 2 m cover over top of the pipe or the actual cover, whichever is greater
Live Load	CHBDC CL-625-ONT or the actual greater live load (such as a railway load) that exists at the liner location, whichever yields the greater live load. Live load shall be based on the actual cover over the top of the host pipe, which can differ from the cover used for External Earth Load.

Ovality	With the exception of CSP culverts, 3% or the actual ovality of the existing pipe section, whichever is greater. For CSP culverts, 4% or the ovality of the existing CSP culvert, whichever is greater.
Soil Weight	18.85 KN/m <sup>3</sup> (1922 Kg/m <sup>3</sup> )
Soil Modulus	6.9 MPa
Flexural Modulus Used in Design Equations	<p>The flexural modulus used in the design equations shall be the amount of the short-term test flexural modulus retained for the long-term design life. The retention factor shall be based on long-term testing (such as ASTM D2990). The long-term testing shall determine the retention factor, which shall account for the long-term creep behaviour of the liner material under the appropriate stress and stress duration conditions.</p> <p>The short-term test flexural modulus to be used as the starting value for determining the flexural modulus to be used in the design equations shall be the short-term test flexural modulus that is routinely and reliably obtained in tests of actual installed liners. The design shall identify the short-term test value and long-term design value. A required minimum short-term test flexural modulus may be specified in this specification or in applicable standards.</p> <p>Independent third party testing in accordance with ASTM D790 (or equivalent) is required to substantiate the short-term test flexural modulus used. Independent third party testing in accordance with ASTM D2990 (or equivalent) is required to substantiate the retention factor used for long-term design.</p> <p>When long-term testing to establish the long-term design retention factor is not available, a maximum retention factor of 50% shall be used.</p>
Flexural Strength Used in Design Equations	<p>The flexural strength used in the design equations shall be the amount of the short-term test flexural strength retained for the long-term design life. The retention factor shall be based on long-term testing (such as ASTM D2990). The long-term testing shall determine the retention factor, which shall account for the long-term creep behaviour of the liner material under the appropriate stress and stress duration conditions.</p> <p>The short-term test flexural strength to be used as the starting value for determining the flexural strength to be used in the design equations shall be the short-term test flexural strength that is routinely and reliably obtained in tests of actual installed liners. The design shall identify the short-term test value and long-term design value. A required minimum short-term test flexural strength may be specified in this specification or in applicable standards.</p> <p>Independent third party testing in accordance with ASTM D790 (or equivalent) is required to substantiate the short-term test flexural strength used. Independent third party testing in accordance with ASTM D2990 (or equivalent) is required to substantiate the retention factor used for long-term design.</p> <p>When long-term testing to establish the long-term design retention factor is not available, a maximum retention factor of 50% shall be used.</p>

### Short-term Test Flexural Modulus and Short-term Test Flexural Strength

The short-term test values of flexural modulus and flexural strength (as per ASTM D790) used as the starting values from which the long-term design values are derived shall be short-term test values that will be reliably and repeatedly obtained in the installed liners as substantiated by testing samples from installed liners. The starting short-term test values shall be identified in the liner design.

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### **Designs to Be Correct or Corrected for Field Conditions**

The Contractor shall check and determine that actual field conditions for any liner installation sewer pipeline section correspond with the liner design for that installation. The field conditions to be checked shall include deepest depth to invert, ovality of the existing sewer and live load situation. Where the existing liner design (such as the design submitted with tender or RFP or later time) is not appropriate for the field conditions, the Contractor shall adjust the liner design accordingly and the liner installed shall meet the requirements of the adjusted design. The adjusted liner design shall be submitted to the Contract Administrator for approval. The adjusted or new liner design shall be stamped by a Professional Engineer (as above) submitted to the Contract Administrator for approval.

Where a SIP-TPFL design previously approved by the Contract Administrator is found needing adjustment due to determined actual field design parameters, the Contractor shall advise the Contract Administrator within 48 hours and wait for the Contract Administrator's instructions. Where the adjusted design results in a thicker liner to be installed, any additional cost involved shall be determined in accordance with the Contract Unit prices where applicable and if Contract Unit prices are not applicable, then shall be negotiated with the Contract Administrator. An additional cost payment shall not be made if the originally approved design was in error due to the use of incorrect parameters versus parameters provided to the Contractor (such as in the tender or bid documents).

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

### **Design Thickness Versus Installed Liner Thickness**

Unless otherwise specified in the contract documents, the thickness determined in the accepted liner design shall be the required structural thickness of the in-place completed liner. Liner wall thickness measurements and determination of the actual effective thickness shall be according to ASTM D5813-04(2008). Measurements of the actual installed liner wall thickness shall not include the thickness of any non-structural components.

When actual line thickness or liner properties appear to be deficient, design reconciliation based on test result values may be permitted at the discretion of the Contract Administrator. Such reconciliation may or may not resolve the deficiency. Refer to design reconciliation procedure in TS 4.14 herein.

### **TS 4.14.25 DESIGN OF SIP-TPFL INSTALLATIONS FOR NON-CIRCULAR PIPE**

The design method specified in TS 4.14.24 is not applicable to lining for pipelines that are non-circular, such as oval, egg, elliptical, horseshoe or other non-circular shapes. For SIP-TPFL for non-circular host pipelines, the Contractor shall determine and propose a design method that is appropriate for the lining.

The Contract Administrator has the right to accept, reject or request clarification in regard to the Contractor's proposed design method. Among other considerations, the Contract Administrator will assess whether liner performance under bending or deflection should be or has been addressed in the design method.

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#### **TS 4.14.26 LINER APPLICATION TEMPERATURE**

Where the successful application of a specific SIP-TPFL is temperature dependent, such as minimum and maximum allowed temperatures for application and cure of the liner on to the inside of the host pipe, it is the Contractor's responsibility to review Environment Canada weather forecasts to make sure that temperatures for liner application are within allowable limits and will remain within the temperature limits during the application including any curing time required.

In submission with procurement document the Contractor shall have provided the application temperature limits. When in the opinion of the Contract Administrator, the temperature limits will not be met no liner shall be applied.

When in the opinion of the Contract Administrator the application temperature limits provided in the Contractor's submission with procurement document (or at a later date) require clarification or revision no liner shall be applied.

#### **TS 4.14.27 INSTALLATION OF SIP-TPFL**

##### **Installation Procedure**

The actual installation procedure shall be according to the submission with the Bid. Any proposed deviation from the submitted procedure shall be submitted, with explanation, to the Contract Administrator for approval and the submission shall include the approval of the lining manufacturer or senior licensor.

The Contractor shall ensure that all required equipment including as required by the Contract is on site and in satisfactory working order prior to commencing the installation of any sewer lateral rehabilitation.

The Contractor shall ensure that the existing host pipeline is completely free of all water and infiltration and has limited moisture (surface dampness only) that will not negatively affect the SIP-TPFL during its application onto the existing host pipeline. The Contractor shall ensure that, when several sequential spray passes of the SIP-TPFL are required to build up the required thickness, there is no surface contamination or moisture build up on the material applied in the previous SIP-TPFL pass.

Liner terminations shall be in key cuts in the concrete of the manhole (or other termination structure) approximately 5 mm wide by 5 mm deep.

##### **Time Between Successive Liner Spray Passes**

The spray application of the SIP-TPFL shall consist of continuous passes of the spray head with each pass applying a thickness of the liner on top of the preceding pass until the required thickness has been applied. There shall be no contamination of the preceding pass surface before the succeeding pass, where contamination means any dirt, dust, debris or moisture that will negatively impact the bonding of the succeeding layer to the preceding layer of SIP-TPFL material. Where the surface has become contaminated (for any reason), the succeeding pass shall not take place until the surface has been cleaned and dried (where required).

Where a delay is encountered between successive passes that exceeds 12 hours, the next pass shall not take place until the surface is cleaned, dried and primed with the required primer for the SIP-TPFL. In its submissions the Contractor shall identify the required primer to use in this situation.

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### **Odour Control When Required**

In the case that a disturbing odour is generated by the application of the SIP-TPFL the Contractor shall provide notice to the affected residents indicating possible odour resulting from sewer lining and curing process. The notice shall indicate to the residents what to expect and typical procedures to alleviate odour and include advising residents to ensure all plumbing drain traps are full of water.

The Contractor is responsible to respond, investigate and act immediately on any odour complaint that may occur. Actions to be taken by the Contractor to alleviate an odour problem within a property shall include:

- seeking permission to enter the property;
- filling of any dry traps;
- preventing air flow from any traps which do not function properly: will not water seal;
- ventilating the property via open window and doors;
- ventilating the property with fans/blowers; and
- other actions that are useful in alleviating the odour problem.

The Contractor shall provide adequate sewer ventilation and odour mitigation during the sewer lining process. The following steps shall be taken:

Exhaust Fans for Sewer When Required: When required to control odour two maintenance hole exhaust fans with a minimum capacity of 2100 cfm each shall be used to exhaust air from the sewer via maintenance holes. One fan shall be located at an adjacent maintenance hole immediately downstream of the sewer section being lined. The second fan shall be employed at the tail end maintenance holes as soon as access for the fan is available following removal of the liner tail. If the second fan cannot be readily employed at the tail end maintenance hole, it shall be employed at the closest possible adjacent maintenance hole that will permit air to be exhausted from the sewer being lined. In the event that odour control becomes a problem, the Contractor shall provide additional exhaust ventilation of the sewer to alleviate odour.

### **Installation to Include Making of Liner Test Samples**

As part of the installation, the Contractor shall make the required test samples. Refer TS 4.14.28.

### **TS 4.14.28 SAMPLES FROM SIP-TPFL INSTALLATION**

Samples of the SIP-TPFL shall include flat plate samples and full cylindrical samples. Plate samples shall be tested for flexural strength and flexural modulus. Cylindrical samples shall be tested for deflection capacity.

#### **Flat Plate Samples**

Contractor shall provide a plate type sample, fabricated at site, made by applying the SIP-TPFL material onto a flat plate and building it up to the required thickness. Plate samples shall be made by spraying the liner materials on to a flat plate using the same materials to be used in the pipe. The plate samples shall be representative of the lining installed in the pipeline. A release agent shall be used to allow for easy separation of the sample from the plate. The plate sample size (length and width) shall be determined by the requirements for obtaining sufficient test specimens and the Contractor shall obtain the plate size requirements from the testing agency to be used.

For each pipeline segment installation, two flat plate samples shall be made. One immediately before the start of lining the pipeline (start sample) and the other immediately after completion of the last spray pass in the pipeline (finish sample).

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The samples shall be clearly and indelibly identified with Contract number, location, size of the pipeline being lined, date and whether the start sample or the finish sample.

The Contractor shall have the samples tested at a testing agency approved by the Contract Administrator and shall arrange for the Contract Administrator to receive the test results directly from the test agency and shall provide the test agency with the Contractor's permission to communicate directly with the Contract Administrator.

### **Full Cylindrical Samples**

For each pipeline being lined the Contractor shall make a full cylindrical sample in an appropriate cylindrical form. The form shall be a close approximation of the size of the pipeline and the thickness applied the same as the required liner thickness in the pipeline. For pipeline sizes greater than 1200 mm diameter, a 1200 mm diameter form shall be used and the thickness of the cylindrical sample shall result in the same DR as the DR of required thickness liner in the pipeline. (DR = Dimension Ratio =  $t/OD$ ). For example a 50 mm thick liner in an 1800 mm pipeline results in a liner DR of  $1800/50 = 36$ . Therefore the 1200 mm cylindrical sample thickness would be  $1200/36 = 33$  mm.

For non-circular pipelines, the cylindrical sample form diameter shall be the average of the height and width of the non-circular pipeline to a maximum 1200 mm diameter cylindrical sample. For sample cylindrical form diameters up to 1200 mm the sample thickness shall be the same thickness as required in the pipeline. Where the average of the pipeline height and width is greater than 1200 mm, a 1200 mm diameter form shall be used and the sample thickness shall be based on an equivalent DR, where the DR of the non-circular pipeline shall be considered to be the average of the height and width divided by the required liner thickness.

Cylindrical sample may be fabricated in a location off site as long as the conditions of spraying are similar to the on-site conditions and the identical material is sprayed in to the cylindrical sample. The Contractor shall provide the Contract Administrator with 5 days advance notice of the fabrication so that the Contract Administrator can attend the fabrication.

The samples shall be clearly and indelibly identified with Contract number, location, size of the pipeline being lined, date and location where the sample was made.

The Contractor shall have the samples tested at a testing agency approved by the Contract Administrator and shall arrange for the Contract Administrator to receive the test results directly from the test agency and shall provide the test agency with the Contractor's permission to communicate directly with the Contract Administrator.

### **Core Sample from Wall of Installed Liner**

When in the opinion of the Contract Administrator a further sample from the actual installed liner is required to clarify information obtained from other sampling, a core sample shall be extracted from the installed liner within the conduit that was lined. The core sample shall be 75 -100 mm in diameter or, if cut from the mouth of the lined conduit, 75-100 mm wide by 75-100 mm long. The depth of the sample shall be at least 90% of the wall thickness of the installed liner. When and where a core sample is extracted, the liner shall be repaired using a suitable method.

### **Sample Audit Trail and Chain of Custody**

The Contractor shall have a verifiable process for documenting the chain of custody of all samples so that the Contract Administrator can verify the origin and history of all the samples tested.

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## **TS 4.14.29 TESTING OF LINER SAMPLES**

The Contractor shall provide for testing and inspection of samples of liner at an independent testing agency. The testing agency shall be subject to the approval of the Contract Administrator. The Contractor shall authorize the testing agency to forward the test reports to the Contract Administrator and communicate with the Contract Administrator concerning the testing and results. The Contractor shall arrange for delivery of the samples to the testing agency.

### **Testing of Flat Plate Samples**

Flat plate samples of installed liner shall be tested for flexural modulus and flexural strength as per ASTM D790 and thickness as per ASTM D5813-04(2008). 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.

The Contractor shall provide for the testing agency to forward test reports by email to the Contract Administrator.

The Contractor shall provide the test agency with the design parameters for the liner corresponding with the sample as follows:

- Flexural Strength Short-term test used in design
- Flexural Modulus Short-term test used in design
- Required Liner Thickness determined by design

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.

The test results will determine whether the required physical properties and required thickness have been met. However in regard to thickness, the Contract Administrator reserves the right to have the actual installed thickness verified by field measurement, either at the accessible ends of the liner or by a sample removed from the liner itself or by drilling into the liner to determine the thickness.

### **Testing of Full Cylindrical Samples**

Full cylindrical samples shall be tested as per ASTM D2412, Standard Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading. A full report shall be provided including photographs and video recording of the test. The test shall be limited by occurrence of a crack (deflection to be recorded) or when the cylindrical sample has reached 20% deflection. The Contractor shall provide the Contract Administrator with 5 days advance notice of the test so that the Contract Administrator can attend the test.

The test results will determine whether the SIP-TPFL meets the requirement for a minimum 15% deflection without any visible deterioration including cracking, crazing or other indications of failure stress. For example a 1200 mm diameter cylindrical sample shall ovalize under parallel plate loading to a vertical diameter of 1050 mm, which corresponds with 15% deflection.

### **Visual Inspection of Samples**

Samples shall be inspected visually (by the naked eye) to confirm that the liner wall is homogeneous and monolithic. Specifically there shall be no sign of an interface characteristic between thicknesses layers applied laid by passes of the spray on application that would or could compromise the structural performance of the liner over the design life. While it is understood that this is a qualitative judgment rather than a quantitative judgment, any inspection finding suggesting that the wall is not homogeneous and is not monolithic will require further discussion and may result in the Contract Administrator deeming the liner/lining unacceptable.

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### **TS 4.14.30 SERVICE CONNECTION REINSTATEMENT**

Any service connection incoming to the existing pipeline shall be reinstated into the lined pipeline unless the Contract Administrator has directed otherwise. Reinstatements shall be made immediately on completion of the lining so that that service is restored with minimal delay to the affected property.

In the making of the V2 CCTV inspection, the Contractor shall have recorded the quantity, locations and positions of all the service connections.

Although the installation of the SIP-TPFL may not have completely blocked off the existing service connection, however it may have reduced the opening size due to spray into the service connection. In which case any excess material limiting the size of the service connection pipe shall be removed.

Reinstatement of the service connections shall be carried out according to the approved method statement. All live service connections shall be reopened to their full diameter, and the interface with the liner made leak tight.

Immediately following any SIPP-TPFL installation that covers a live service connection the Contractor must open each service connection to a minimum of 75 per cent within 18 hours. All service connections must be entirely opened by no later than the next day.

When live in use service connections are to be covered or blocked off, the Contractor must provide a 48-hour *Service Disruption Notice* to all affected parties. Such notice must be typed on the Contractor's letterhead and clearly indicate both daytime and after hours local contact telephone numbers. The Contractor must schedule the liner installation accordingly. No service disruption will be allowed without such 48-hour notification. In the event that the Contractor is unable to install the liner on the date stated in the *Service Disruption Notice* the Contractor must immediately provide written notification of the change of date including the new date for the liner installation. After the service connection has been reinstated the Contractor must provide written notification to all affected parties that their service connection is again in service. The notification format must be submitted to the Contract Administrator for approval prior to the commencement of work on this Contract.

The 48-hour *Service Disruption Notice* shall contemplate providing residents, upon request of the resident, the supply of a clean, properly functioning portable chemical toilet for the entire time that such resident's service connection is blocked at the sewer. Such toilets shall be delivered prior to any service connections being blocked in the sewer and shall be promptly retrieved by the Contractor upon service connection reinstatement.

The Contractor shall maintain a detailed record of the time at which the reinstatement of each service connection is completed and this record shall be entered on the *Service Connection Statement*.

### **TS 4.14.31 LINER WALL THICKNESS VERIFICATION**

Liner wall thickness means the structural wall thickness of the completed in-place SIP-TPFL and this thickness shall not include any layers or thickness that do not add to the liner's structural resistance to external loads. On completion the in-place liner shall meet or exceed (within limit below) the required liner wall thickness. The required liner thickness shall be the greater of:

- (1) The wall thickness determined by the SIP-TPFL design accepted by the Contract Administrator (Refer TS 4.14.24 and TS 4.14.25)
- (2) A minimum thickness specified in the Contract documents.



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The liner wall thickness shall not exceed more than 25% of the required thickness.

The Contractor shall verify the in-place lining thickness using one of the following methods.

#### **Thickness Measurement by Ultrasonic Measuring Device**

The liner thickness at the liner obvert (inside top of liner) shall be measured at 2 m intervals along the full length of the installed liner. Suitable ultrasonic thickness measuring devices are an acceptable method of determining the thickness. The device shall be calibrated as required to assure correct reading for the lined pipeline. A written record of the thickness measurements shall be provided to the Contract Administrator. On the Contract Administrator's request, the Contractor shall additionally measure liner thickness at locations (such as at invert) directed by the Contract Administrator when, in the Contract Administrator's opinion further thickness verification is warranted.

When required by the CA, the contractor shall accommodate City Inspection staff participation in the thickness measurement activity.

#### **A Method Proposed by the Contractor and Acceptable to the CA**

The Contractor may propose to the CA a different method for verifying in-place liner thickness. At the discretion of the CA the proposed method may be accepted or rejected.

#### **Provision for Thickness Coverage in CSP Pipelines**

For a CSP, the finished liner surface may also have a corrugated profile. The thickness of the liner at the bottom of the corrugation valley shall meet or exceed the design thickness and the thickness at the corrugation peak shall meet or exceed the design thickness accepted by the CA. At all locations between the bottom of the valley and the peak the thickness of the liner measured perpendicular to the CSP steel surface shall meet or exceed the design thickness accepted by the CA.

### **TS 4.14.32 LINER PHYSICAL PROPERTIES VERIFICATION**

#### **Required In-Place Physical Properties for SIP-TPFL**

The completed in place SIP-TPFL wall properties shall meet or exceed the required properties. The required liner properties shall be the greater of:

1. The liner properties used in the liner design accepted by the Contract Administrator (see TS 4.14.24 and TS 4.14.25), or
2. Any minimum liner properties required by this specification (see TS 4.14.22)

When a liner property appears to be deficient compared to the required property, a design reconciliation based on test results for liner properties shall be permitted at the discretion of the Contract Administrator. Design reconciliation determines the revised required thickness by substituting, in the original design, the actual as-tested properties in place of the original design properties while all other parameters remain the same. Where the actual tested liner thickness meets or exceeds the reconciled design thickness, the liner shall not be deemed deficient based on properties or thickness. Design reconciliation is not permitted when any liner material property or the liner wall thickness is below the minimum requirements in this specification (see TS 4.14.22) or in an applicable standard. Any such design reconciliation and the results from it are subject to the approval of the Contract Administrator.

The long-term design performance for the liner properties shall meet or exceed the long-term design performance assumed in the accepted liner design.

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### Required Homogeneous and Monolithic Wall

The wall of the SIP-TPFL shall be homogeneous and monolithic throughout. There shall be no visible (to the naked eye) layering or other signs of interface between material layers applied by subsequent passes of the spray-on application that would or could compromise the structural performance of the liner over its design life.

### Additional Samples & Testing When Required by Contract Administrator

When the CA has reason to believe that additional samples and testing is required to verify liner properties this shall be provided by the Contractor. When testing shows that the samples meet requirements, the additional samples and testing shall be paid under the applicable tender item. No payment shall be made if test results do not meet requirements. Such additional sampling and testing applies only for Type 1 and Type 3 samples and testing and does not apply for Type 2 samples and testing.

### TS 4.14.33 REQUIRED FIT AND FINISH PARAMETERS FOR SIP-TPFL

The in place and completed SIP-TPFL shall meet or exceed the following parameters in Table 2.

**Table 2: Required Liner Fit and Finish Requirements**

<b>Continuity of Liner</b>	The finished liner shall be continuous over the entire length of the liner installation from MH to MH (or inlet to outlet) without any breaks or separations.
<b>Liner Fit to Existing Sewer</b>	The outside surface of the finished liner shall be in contact with the inside surface of the existing sewer. The inside surface of the existing sewer is the surface after the sewer has been cleaned and prepared for lining in accordance with the cleaning and preparation requirements.
<b>Liner Shape</b>	The liner shape will be as defined by liner fit to existing sewer line. In general the liner shape shall conform to the shape of the existing sewer line inside surface after its cleaning and preparation in accordance with requirements.
<b>Liner Wall</b>	The liner wall shall be free of any interior bulges, ribs, ripples, folds or other irregularities except where any irregularity results from fitting the shape of the sewer after cleaning and preparation. The wall of the liner shall be free of any voids, cavities or bubbles. The liner wall material shall be homogeneous.
<b>Liner Surface</b>	The interior surface of the liner shall be free of any bumps, protrusions or irregularities that will be an impediment to flow. The interior surface finish shall provide for a Manning Number of not greater than 0.011 flow coefficient.
<b>Liner Terminations</b>	The ends of the finished liner shall be neat and smooth. Terminations at MHs shall be flush or extend slightly beyond the MH wall/sewer interface by only a sufficient extension to allow for any longitudinal shrinkage. Terminations shall be neatly keyed into the MH of other terminating structure.
<b>Service Connection Reinstatements</b>	Reinstatements shall be clean and without ragged edges or discontinuities. The inside size of the service pipe shall not be reduced more than 5% by liner spray reaching up into the service connection pipe.

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#### **TS 4.14.34 CCTV INSPECTION OF COMPLETED REHABILITATION – V3**

After completion of all work in the lining of the sewer section including reinstatement of service connections and maintenance hole benching, a CCTV inspection—called the V3—of the full length of the sewer section lined shall be done and submitted to the Contract Administrator. The V3 shall be done according to the requirements for CCTV inspection and reports in TS 4.14 herein. The Contract Administrator will review the V3 as part of its approval process for the lined sewer.

In the event that, after the V3, a deficiency in the lined sewer section is identified that requires repair or remediation, the V3 shall be redone after the repairs or remedial action have taken place and the redone V3 submitted to the Contract Administrator.

The V3 shall be coded in accordance with requirements in TS 4.14.10.

#### **TS 4.14.35 LINER THICKNESS/PROPERTY DEFICIENCIES AND DESIGN RECONCILIATION**

When liner wall thickness and/or sample test result properties are deficient compared to the requirements, a design reconciliation based on test results for liner properties shall be permitted subject to exception below. Such design reconciliation may or may not resolve the deficiency.

Design reconciliation determines a revised required thickness by substituting, in the original design, the actual as-tested properties for the original design properties while all other parameters remain the same. Where the in-place liner thickness meets or exceeds the reconciled design thickness (revised required thickness), the liner shall not be deemed deficient based on properties or thickness. The Contract Administrator shall make or otherwise approve any design reconciliation. Any design reconciliation and the results from it are subject to the acceptance of the Contract Administrator.

Exception to Design Reconciliation: Design reconciliation is not permitted when any liner material property or the liner wall thickness is below the minimum requirements in this specification (refer TS 4.14.22), in the procurement documents or in an applicable standard.

#### **TS 4.14.36 DEFICIENCIES**

A deficiency will exist when the work or the results of the work is/are not according to Contract Documents. Deficiencies include (but are not limited to) liners that do not meet the required physical properties, liners that do not meet the required thickness and liners that do not meet the fit and finish requirements. Further, when the SIPCL does not achieve the lining objectives set out in TS 4.15.02 it shall be deemed deficient.

When the Contractor is aware of any deficiencies in the Work or in the results of the work, the Contractor shall advise the Contract Administrator of these deficiencies within 48-hours including situations where the deficiency has already been rectified.

Where deficiencies have been identified, either by the Contract Administrator or the Contractor, the Contractor shall resolve, correct or rectify the deficiencies to the satisfaction of the Contract Administrator. Depending on the nature of the deficiency, the Contract Administrator may request that the Contractor provide the Contract Administrator with a method statement, subject to the Contract Administrator's approval, for the repair of the deficiency.

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Where in the Contract Administrator's opinion, there is no repair or correction that is satisfactory, the Contract Administrator may require removal of the deficiency and replacement with a non-deficient liner or require an alternate resolution at the discretion of the Contract Administrator.

**TS 4.14.37 PAYMENT**

Payment at the Contract Price shall be full compensation for all labour, Equipment and Material to do the Work.

**APPENDIXES**

Appendix A: Service Connection Statement

