TS 4.10: SPECIFICATION FOR CURED-IN-PLACE PIPE (CIPP) FOR THE LINING OF SEWERS AND CULVERTS

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TS 4.10.1 Scope

1. This specification is for Cured-in-Place Pipe (CIPP) lining of sewers in the City of Toronto, which are under the jurisdiction of Toronto Water. The sewers may include sanitary sewers, storm sewers and combined sewers but do not include sewer services, which are governed by a different Toronto Water standard specification. This specification also applies to the CIPP lining of City of Toronto culverts per the culvert definition of and culvert design parameters contained herein.

2. This specification is not applicable for CIPP liners installed in pressurised pipelines or intended for pressure service.

3. Sewers or sewer services on private property or where the Ontario Building Code has jurisdiction are not within the scope of this specification.

4. The Work shall include performing the following operations: notification of public, various CCTV inspections, determining sewer and liner dimensions, determining any changed design parameters for CIPP liners, design of CIPP liners, flow control and bypass pumping, cleaning and preparation of the sewers to be lined, Service Connection (SC) investigation with related work (when required), provision and installation and curing of the CIPP liners, reinstatement of sewer SCs, return of the lined sewer to regular service plus any other work required for and incidental to the foregoing.

5. The work involved requires special equipment to be handled by persons experienced in all phases of the Work.

6. This specification is for standard CIPP (CIPP-S) and reinforced CIPP (CIPP-R) using hot water, steam or ultraviolet light cure methods. No other curing method is applicable.

7. In the context of this specification culvert means a pipeline to convey surface water with both ends open to surface water. When this specification is applied for a culvert(s), the term “sewer” used in this specification shall be considered synonymous with culvert unless noted otherwise.

8. When referenced in a tender, RFP or contract, TS 4.10 shall be part of the Procurement Documents (PD).

TS 4.10.2 Terminology and Abbreviations

1. The following list of terminology and abbreviation used in this document is provided for convenience and may not be a complete list of terms and abbreviations used. Where terms or abbreviations are not on this list or known/understood/apparent, the Contractor shall contact the CA for further clarification(s).

Asset	A sewer or section of sewer or a culvert or section of a culvert, which is identified in the Contract by physical location
Asset Specific	Whereby the PD may supersede, modify, or add to this standard specification
ASTM	American Society for Testing and Materials
CA	Contract Administrator
CCTV	Closed Circuit Television

CIPP	Cured-in-Place Pipe
CIPP-R	Reinforced CIPP (Reinforced felt carrier tube plus resin)
CIPP-S	Standard CIPP (Felt carrier tube plus resin)
CRF	Creep Retention Factor
DSMH	Downstream Maintenance Hole
H2S	Hydrogen Sulphide
ISO	International Organization for Standards
LDPR	Liner Design Parameter Record
MH	Maintenance Hole
MH-MH	Maintenance Hole to Maintenance Hole
MCRF	Modulus Creep Reduction Factor
OTM	Ontario Traffic Manual
PD	Procurement Documents
PEO	Professional Engineers Ontario
RFI	Request for Information
RFP	Request for Proposal
RFT	Request for Tender
SC	Service Connection
SCR	Service Connection Record
SCRRF	Strength Creep Rupture Reduction Factor
SDMP	Styrene Discharge Management Plan
SLD	Standard Liner Design: The liner design for each liner (specific to each sewer asset) or liner diameter on the contract type as defined in the Contract.
SP, SPs	Special Provision(s) or Special Specification(s) of Contract
SSLD	Site-Specific Liner Design: A revision of a Standard Liner Design (SLD) for a specific liner site due to field determined/verified design parameters that are different (typically more onerous) than the standard design parameters used in the corresponding SLD.
USB	Universal Serial Bus
USMH	Upstream Maintenance Hole
UV	Ultraviolet Light
UVC	Ultraviolet Light Cured
UVC-CIPP	Ultraviolet Light Cured Cured-in-Place Pipe
V1	Preliminary CCTV inspection prior to cleaning and preparation
V2	Post Cleaning and preparation CCTV inspection before lining
V3	Final CCTV inspection of the completed lining installation
V4	Warranty CCTV inspection
WRc SRM	Water Research Center Sewerage Rehabilitation Manual

TS 4.10.3 Reference Standards

1. This specification references the following standards, specifications, or publications. Unless noted otherwise in this specification, the most up to date version applies.

ASTM	**ASTM**
D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D5813	Standard Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems
D2990	Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
F1216	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube. Except for Design appendix

F2019	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP)
F1743	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pull in Place Installation and curing of a Resin- Impregnated Tube
F2994	Standard Practice for Utilization of Mobile, Automated Cured-in-Place Pipe (CIPP) Impregnation Systems
ISO	**ISO**
ISO 11296-4	Test method for short-term Flexural Modulus and Flexural Strength
ISO 7685	Method for determining structural thickness of reinforced liners
ASCE	**ASCE**
MOP145	Practise No. 145. Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes

TS 4.10.4 Information to Be Reviewed Prior to Bid Submission

1. Where the sewer section(s) for CIPP lining have been identified in the PD, all bidders prior to submission of bid, shall review the City CCTV inspection records of these sections that may be available. Arrangements for viewing these records shall be made according to the instructions in the PD.

TS 4.10.5 Information to Be Submitted with Bid

1. For submissions to be included with bid, refer to the PD (Procurement Documents).

TS 4.10.6 Information to be Submitted Prior to Commencement of the Work

1. The information listed below shall be submitted to the CA a minimum of 10 days before commencement of the Work. The Contractor shall check the PD for any revisions, additions, deletions, or additional information regarding information to be submitted prior to the commencement of the Work.

    a. The name of a professional engineer(s) licensed in the province of Ontario who will provide the CIPP liner engineering designs required according to the liner design requirements in TS 4.10 herein. The professional engineer shall be authorized to perform such work by Professional Engineers Ontario (PEO).

    b. CIPP liner design(s) as proscribed in TS 410.25, Design Requirements for CIPP Liners.

    c. Material specifications and structural details of the proposed sewer liner in sufficient detail to enable confirmation by the CA that the CIPP liner proposed will meet the design requirements in TS 4.10 herein. Include the proposed resin manufacturer, resin type and manufacturer's resin identification number. Include the proposed liner tube manufacturer and type of tube.

    d. A summary of the Contractor's proposed CIPP liner procedure. Include one example of the liner wet-out process sheet and one example of the liner curing process summary sheet to be used, for each liner, for the work.

    e. A certified original copy from the resin manufacturer of the Infrared Spectrograph of the catalyzed resin mixture proposed for this Contract.

TS 4.10.7 Notification to Public

1. 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 CA and the Contractor, and both must be delivered at the same time.

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

3. 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 CA for approval prior to notice delivery.

4. 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.

5. The Contractor shall provide the CA with a copy of such notice for review.

6. The above requirements for notification to the public may be modified or superseded by the PD. The Contractor shall verify notice requirements with the CA.

TS 4.10.8 Site Investigation

1. 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 4.10.9 Existing Video Inspection Records and Drawings

1. The CA shall provide the Contractor with a list of sewer sections for CIPP 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 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.

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

TS 4.10.10 Excavations for Retrieval of Equipment of for Other Purposes

TS 4.10.10.1 Situation A. No CCTV or Advice Provided to the Contractor by the City

1. Where the retrieval of stuck or lodged equipment is required by open-cut excavation, the Contractor shall provide for retrieval including any excavation, maintenance of flow, repair, backfill and restoration at the Contractor's expense. However, if the equipment became stuck or lodged in a portion of a sewer section for which no previous CCTV inspection or no direction for working in the zone with no previous CCTV inspection was provided to the Contractor by the City, then the City will pay the Contractor for 75 per cent of the total above noted cost only if such cost occurs during the preliminary V1 CCTV inspection or during preliminary cleaning operations for the V1. The City will not entertain any other associated cost related to this work.

2. All such work shall be completed according to City standards and specifications and any sub-contractors used shall be City approved and acceptable to the CA.

TS 4.10.10.2 Situation B. All Other Excavations

1. If it is necessary to excavate for any reason such as repair of defective liner, reinstatement of SC or bypass of flow, the Contractor shall provide such excavation, repair, backfill and restoration as required at the Contractor's expense. However, dependent on the reason why an excavation is required and at the discretion of the CA, then the City will pay the Contractor 40% of the total of the cost of the excavation and related work. The remaining 60% of the cost shall be borne by the Contractor. Such payment by the City shall only be made when the CA has granted approval for the work prior to the work taking place.

2. All such work shall be completed according to City standards and specifications and any sub-contractors used shall be City approved and acceptable to the CA.

TS 4.10.11 Weather Conditions

1. The Contractor shall review the Environment Canada weather forecast prior to commencement of lining operations. Where the anticipated weather conditions are such that anticipated sewer/drain flows may exceed the Contractor's bypass pumping capacity or may cause potential basement flooding such as due to blocked laterals due to the liner installation, commencement of construction shall be delayed until favourable weather is forecast.

2. Sewer and culvert flows are significantly and readily boosted by wet weather and snow melt events. When there exists a reasonable potential that a detrimental rain or snow melt event will occur which could cause unacceptable surcharge in the sewer/culvert due to liner installation activities, the Contractor shall notify the CA and reschedule the liner installation at no cost to the City.

3. A liner installation shall not be started when rain or snowmelt is forecast within the predicted time period of the liner installation. Liner installation is defined as the beginning of the insertion of a liner tube until the time that all SCs and sewer inlets are reinstated. Liner installation time period does not include sewer cleaning and preparation.

TS 4.10.12 Flow Control

TS 4.10.12.1 General

1. The Contractor shall provide control of sewer flows (flow control) as necessary to properly conduct the work. Flow control is required for CCTV inspection and CIPP lining operations and may be required for other phases of the work. The Contractor shall use a flow control method that is acceptable to the CA. Flow control may require the use of temporary bypass pumping by the Contractor.

2. The cost of flow control shall be included in the lining price up to and including the Flow Control Included – Limit Provision.

3. Refer to the PD for any further requirements applicable to flow control including any requirements for Asset Specific Items.

TS 4.10.12.2 Flow Control Included - Limit Provision

1. Standard flow control shall be included as part of the lining items up to and including a capacity of 4,540 L/min (1200 USGPM). Standard flow control and pumping/by-passing should include all necessary piping/fitting, fuel, traffic protection, road crossing devices and monitoring. The Contractor shall be responsible for determining the bypass capacity.

2. Where the Contractor has determined that the bypass requires capacities exceeding 4,540 L/min (1200 USGPM), the Contractor shall advise the CA of the requirement and submit a flow bypass plan in accordance with TS 4.01, Section G5 and as modified herein.

TS 4.10.12.3 Flow Control Requirements

    1. No flow control (including bypass pumping) shall be employed that has insufficient capacity to maintain required flow in the sewer system. It is the Contractor's responsibility to employ flow control of sufficient capacity. No work requiring flow control shall proceed until flow control arrangements are in place that provide sufficient flow control capacity including for situations that exceed the Flow Control Included Limit Provision (see below).

    2. When interruption of sewer flows is necessary to properly conduct the work including such as CCTV inspection and CIPP lining operations, acceptable methods of flow control shall be provided by the Contractor.

    3. The degree of flow control shall be suitable for the work to be undertaken during flow control including that, for CTV inspection purposes (except for V1), flow control shall be sufficient to allow all surfaces of the pipe (or liner) to be clearly seen including the invert.

4. The Contractor is to make all necessary arrangements with the owners/occupants of each building. The Contractor shall contact all property owners or tenants or both to coordinate the repair work to the sewer and minimize any impact on residents, businesses or both.

5. On all liner installation dates when bypass pumping is used, the Contractor must maintain on site both a primary and standby 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 downstream sewer section. The standby 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 SCs have been reinstated and the Contractor has recorded the post- installation video.

6. All flow control shall be in place and operation prior to the final pre-installation inspection. All bypass pumping capacities and configurations must be submitted and reviewed by the CA prior to the actual liner installation date. For the standard flow control, the Contractor only requires completing a form, which indicates date, time and location of when flow control starts and ends. The form must be emailed to the CA for logging and recording purposes as per regulatory guidelines on a daily basis.

TS 4.10.13 CCTV Inspections of Pipelines

TS 4.10.13.1 General

1. The following applies to CCTV inspections for submission to the CA. Some CCTV inspections submitted to the CA may not require all of the requirements described in this section. Refer to specific requirements for V1, V2, V3 and V4 CCTV inspections for whether defect coding and reports are required.

2. CCTV inspections shall be undertaken in accordance with TS 409 except as modified herein.

TS 4.10.13.2 Pipeline Conditions for CCTV Inspections

1. The sewer section under inspection shall be sufficiently dry so that any remaining fluid 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 entire sewer length and perimeter.

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

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

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

5. When required for a specific inspection, the CCTV camera shall stop and view each defect and/or SC clearly and completely for at least five (5) seconds, before centring the camera to the perspective view.

6. SC (or tap) observation distances must occur at the centre of the tap and the side periphery. To determine use and deficiencies of the tap, the camera must continue to travel, camera centred in the perspective view (to capture other observations), to stop perpendicular to the tap and pan so that the camera can view directly into the barrel of the lateral, to enable the inspector to apply modification and descriptor codes to the tap as necessary.

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

TS 4.10.13.3 Required Notification for CCTV Inspections

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

TS 4.10.13.4 Sewer Condition and Defect Coding

1. When required, CCTV inspection shall include condition and defect classification coding in accordance with NASSCO PACP (Current Version). CCTV operators for CCTV inspections requiring PACP coding shall be trained and certified in PACP requirements. CCTV will be rejected if all the requirements are not met.

2. Inspection operators failing to provide copies of their NASSCO certification and / or meet the accuracy requirements on two occasions will not be permitted to code on the remainder of the Contract until they can demonstrate to the CA that they can code in accordance with the requirements of the NASSCO PACP and MACP, in their current versions.

TS 4.10.13.5 Additional Notifications Required

1. The City's CA shall be notified for further action when the following situations are encountered during CCTV:

    a) Cross bores
    b) Pitch fibre mains or laterals (black pipes)
    c) Corrugated metal pipe.
    d) Clay tile pipe

TS 4.10.13.6 Focal Length Correction

1. The focal length is the intersection point between the camera lenses widest horizontal viewing angle and the pipe's side periphery (03 or 90 o'clock) when the camera is level and looking forward. The rear of the camera must be positioned at the start of the pipe where the camera's physical distance is added to the focal length. This total distance is known as the cable calibration distance. Record the distance from the manhole to pipe interface to the cable calibration distance at the start of the inspection and adjust the distance reading so that zero is at the manhole to start of pipe interface.

TS 4.10.13.7 Pan and Tilt and Zoom

1. Panning, tilting and zoom are required at all defects and lateral connections to clearly show the feature.

TS 4.10.13.8 CCTV Truck Units

1. 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.

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

3. CCTV truck units shall be equipped with suitable sewer de-fogging/de-misting equipment (such as ventilating fans) so that the CCTV view shall not be degraded by fog or mist in the sewer.

TS 4.10.14 Preliminary CCTV Inspection – V1

1. The Contractor shall make a preliminary CCTV inspection—called the V1—of the sewer section before undertaking any work required for the CIPP 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 CA. 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 CA's opinion, is a significant changed condition.

2. Where a significant changed condition is encountered, the Contractor shall immediately inform the CA.

3. 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 SCs. Such preliminary cleaning does not have to meet the requirements for cleaning and preparation for lining under TS 4.10.18.

4. Flow control for the sewer shall be sufficient for V1 inspection purposes and bypassing of the sewer flow shall be done where the sewer is not sufficiently clear for V1 inspection purposes.

5. Sewer defect coding is not required for the V1.

6. CCTV inspection shall include pan and tilt capabilities at all SCs.

7. The contractor shall confirm liner design conditions as per TS 4.10.15.

8. In confirming the design parameters as part of the V1 inspection, the Contractor shall prioritize preparation work and V2 inspections for assets with ovality greater than identified Tender ovality in order to facilitate finalization of a liner design.

9. The contractor shall provide the CA with a V1 along with the Liner Design Parameter Record (LDPR) (see TS 4.10.15.3) of verified field conditions prior to the ordering and installation of any liners. When the V1 and LDPR submission by the Contractor includes a determination of a significant changed condition or the necessity for an SSLD and this requires instruction by the CA back to the Contractor, the CA shall provide this instruction to the Contractor.

TS 4.10.15 Field Verification of Liner Design Parameters & LDPR

TS 4.10.15.1 Contractor Responsible for Liner Design Parameters

1. The Contractor shall be responsible for correctly determining and/or verifying the existing sewer liner design parameters and in a timely manner. This responsibility includes the correctness of the information in the Liner Design Parameter Record (see TS 4.10.15.3).

2. Where it may be determined later that existing sewer liner design parameters determined and verified by the Contractor were not correct, any costs associated in correcting a liner installation, including associated work, shall be the responsibility of the Contractor.

TS 4.10.15.2 Field Verification of Existing Sewer Diameter, Length and Other Parameters

1. The Contractor shall measure the internal diameter of the sewer section and the length of the sections to be lined. The measurements taken shall be suitable for proper sizing of the liners to be installed. Refer to requirements for CIPP Liners in this specification. The Contractor shall not rely on dimensions provided in the PD or other City inspections.

2. The Contractor shall, in the field, obtain the following parameters so that any existing values can be either verified or changed to match existing conditions in the field. Where there were no existing values, the field obtained parameters shall become the parameters.

    a. Sewer Diameter US
    b. Sewer Diameter DS
    c. Sewer Invert depth at USMH
    d. Sewer Invert depth at DSMH
    e. Sewer length to be lined
    f. Sewer Ovality – maximum
    g. Live Load design requirement (either Truck or Railway loading)

3. The Contractor shall compare the field obtained parameters to the parameters used in the Standard Liner Designs (SLD) for the sewer section. Where the field obtained design parameters will result in an increased liner thickness versus the standard design, the Contractor shall use the field obtained design parameters to prepare a Site-Specific Liner Design (SSLD).

TS 4.10.15.3 Liner Design Parameter Record - LDPR

1. The Contractor shall produce and maintain a Liner Design Parameter Record (LDPR) in which shall be recorded the field obtained design parameters for each MH-MH sewer section of lining or partial section of lining. The LDPR shall be updated regularly as existing sewer design parameters are obtained.

2. The LDPR shall be provided to the CA on a weekly basis or as requested.

3. For each MH-MH sewer section or partial section the LDPR shall show when the Standard Liner Design (SLD) is adequate or alternatively when a Site-Specific Liner Design (SSLD) is required.

4. When an SSLD is required, the LDPR shall show which field obtained design parameter(s) necessitated the SSLD in place of the SLD.

5. In the case where a field obtained sewer size is different from the size previously assigned to the sewer (such as in the PD), the changed size shall be identified on the LDPR.

6. The LDPR shall be in electronic format (such as an Excel spreadsheet).

7. At the time of V2 submission the Contractor shall submit the current LDPR that also includes:

    a. Date of the V2
    b. Cleaning and preparation have been done meeting Contract requirements is confirmed by the Contractor
    c. Whether a SSLD is required, and if so, whether it has been submitted to the CA

TS 4.10.16 Service Connections Record (SCR)

1. The Contractor shall record details of all SCs on a sewer section on a Service Connections Record (SCR). The form shall be fully completed identifying all SCs 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.

2. The SCR shall be updated during SCs reinstatement to show which SCs have been reinstated with date and time of reinstatement.

3. Upon request, the SCR shall be provided to the CA prior to lining and additionally provided with updates post-lining.

4. For a sample of the SCR, see Appendix A

TS 4.10.17 Service Connection Investigation

1. Where, in the Contractor's opinion, service investigation is required the Contractor shall carry out the investigation in accordance with Appendix B. When a SC investigation is required, it shall be completed as part of the V1 and V2 work.

2. Service investigations, when required, shall be at the Contractor's expense.

TS 4.10.18 Sewer Cleaning and Preparation for Lining

TS 4.10.18.1 General

1. The sewer section(s) to be lined shall be cleaned to remove foreign materials prior to lining by means of a controlled hydro pressure sewer cleaner. When and where required, more resistant foreign material deposits and debris shall be removed by reaming, cutting and grinding as needed.

2. 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. Any claims for the flooding and related damage to private or public property that occur due to the contractor's sewer cleaning and/or reaming operations shall be the responsibility of the Contractor.

3. Satisfactory precautions shall be taken to protect the sewer lines from damage that might be inflicted by the use of cleaning and reaming equipment.

4. 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 DSMH of the section being cleaned. Passing material to another sewer section shall not be permitted. The Contractor shall also install a screen in the DSMH in order to catch any material, including cut outs from SC openings, which might migrate downstream. Such material from the MH shall be removed and properly disposed.

5. 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.

TS 4.10.18.2 Flushing and Debris Removal

1. For all sewers in the contract (unless otherwise excluded) the Contractor shall clean the MH-MH sewer section to remove and dispose of foreign materials by means of a controlled hydro pressure sewer cleaner, in accordance with the PD.

2. The sewer section to be cleaned shall include the full length of MH-MH sewer section.

3. Precautions shall be taken to ensure that no flooding of public or private property occurs during any phase of cleaning and preparation.

4. Satisfactory precautions shall be taken to protect the sewer lines from damage that might be inflicted by the use of cleaning equipment.

5. Wherever possible, flushing shall be completed from the upstream MH in the same direction as the sewer flow.

6. Cleaning and flushing shall continue for each section of pipe sewer until no further debris is flushed from the pipe, and the pipe sewer section is free of impediments to flow. A minimum of 90% of the pipe sewer circumference shall be free of debris. Additional cleaning as specified herein may be required prior to the installation of CIPP liners.

7. Any debris resulting from the work shall be removed at the nearest downstream maintenance hole. Passing material from maintenance hole section to maintenance hole section shall not be permitted. The Contractor shall employ a screen and a vacuum unit in the nearest downstream maintenance hole in order to prevent any debris or other material from migrating downstream. Such debris or material from the maintenance hole shall be removed and properly disposed.

TS 4.10.18.3 Sewer Reaming, Cutting and Grinding

1. The sewer section shall be reamed using an acceptable reaming method to remove deposits and foreign materials that are resistant to removal by flushing.

2. Such deposits and foreign materials may include calcite build up, encrustations, hard debris, tree roots or other obstructions within the pipe or affixed to the pipe wall. Hard and firmly

attached deposits may be left in place provided that the inside diameter of the existing sewer is not reduced by more than 5%.

3. An acceptable CCTV camera must monitor mechanical cleaning operations.

4. Any extraction of mechanical cleaning tools or other equipment, including extraction by excavation, is the responsibility of the Contractor at the Contractor's expense.

5. Where the Contractor determines that the type of hard foreign material encountered is concrete, the Contractor shall advise the CA of this finding and wait for instruction from the CA. The CA shall advise the Contractor on a course of action to be taken regarding the concrete, including payment for concrete removal if so required.

TS 4.10.18.4 Reaming Tolerances

1. All protrusions, deposits, build-ups, and other foreign material in the sewer section shall be removed such that the internal diameter of the sewer pipe is not reduced by more than 13 mm by any material remaining after reaming providing that such material is hard and firmly attached to the sewer wall.

TS 4.10.18.5 Protruding Service Connections

1. SCs that protrude into the sewer section must be cut or ground back prior to reaming of the sewer with any type of reaming device that may damage the SC. Protruding SCs 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 CIPP liner. Cut back protruding SCs shall be smooth and even with no jagged edges. If the service lateral piping or SC is damaged or broken by the Contractor, then the Contractor shall repair the damage by using excavation if necessary. The Contractor shall submit for acceptance, the proposed method of repair and reinstatement for damaged drain piping or SCs.

2. Any SC protruding more than 13 mm into the mainline sewer shall be cut back sufficiently to preclude interference with the installation or long-term performance of a CIPP liner as specified herein. This includes at all locations identified in the PD or by the CA.

3. All protruding laterals shall be trimmed smoothly and uniformly to within 13 mm of the inside wall of the mainline sewer, with no sharp or jagged edges.

TS 4.10.18.6 Precaution to Prevent Damage to the Sewer Section During Cleaning & Preparation Operations

1. The Contractor shall plan and execute their cleaning and preparation operations to prevent damage to the sewer section and any SCs in the sewer section being cleaned and prepared. Proper precautions shall be taken by the Contractor to ensure that: cleaning and preparation operations do not cut into the sewer itself, cleaning and preparation tools/equipment used 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 cleaning and preparation tools/equipment or other equipment, including extraction by excavation, is the responsibility of the Contractor at the Contractor's expense.

2. If the service lateral piping or SC is damaged or broken by the Contractor, then the Contractor shall repair the damage by using excavation, installing a SC/lateral piping CIPP liner if

necessary. The Contractor shall submit for acceptance, the proposed method of repair and reinstatement for damaged drain piping or SCs.

TS 4.10.18.7 Contractor Confirmation of Cleaning and Preparation

1. The contractor shall confirm to the CA that all cleaning and preparation (including any reaming, cutting, grinding, protruding SCs and void filling) of the sewer has been completed in accordance with the above requirements and any requirements specified elsewhere in the PD. This confirmation shall be provided to the CA with the V2 submission prior to any lining work proceeding. Refer to V2 section for submission requirement.

2. Refer to V2 section for further related confirmation requirement.

TS 4.10.19 Filling of Voids

1. A void is a volume of space starting at the outside wall surface of the existing sewer where there is an absence of soil or ground material. Depending on its size and geometry the void may represent a structural weakness in the pipe/soil system that may continue after lining of the sewer. A void will often be evidenced by missing sewer pipe wall that has allowed the ground material to escape into the sewer, exacerbated by ground water infiltration. Where a void is deemed to create a significant structural weakness in the lined pipe, the void requires filling to re- establish the soil/ground support around the sewer.

2. The Contractor shall fill voids as specified for filling in the PD. Void filling shall ensure structural integrity of the lined sewer and prevent bridging by the liner. The Contractor shall submit for the acceptance of the CA a detailed method statement outlining the procedures and materials to be used in filling the voids.

3. During the course of the work such as V1, cleaning and preparation, if the Contactor identifies voids that are not identified in the PD then the Contractor shall advise the CA of these voids. Where the CA requires filling of these 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 CA, the creation of such voids was an unavoidable repercussion of the work.

4. Void filling in small diameter (non-entry) sewers may be undertaken using remote technology from within the sewer or require external soil grouting techniques.

5. Any pressure grouting shall be done in accordance with the manufacturer's printed instructions.

6. If large voids are encountered, these voids shall be reported immediately to the CA for further instruction from the CA.

TS 4.10.20 Post Cleaning and Preparation CCTV Inspection – V2

1. After completion of the cleaning and preparation of the sewer section including all reaming, cutting, grinding, SC trimming and void filling, 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 4.10 herein.

2. The V2 complete with all reports shall be provided to the CA at least 10 business days prior to lining for the CA's acceptance of the cleaning and preparation.

3. On its discretion, the CA may waive the requirement for the V2 to be submitted for acceptance 10 business days prior to lining, such as when acceptance for lining was provided at a live viewing of the V2 by a City representative or when liner installation scheduling would be set back. However, in such cases the V2 submission shall still be submitted to the CA prior to liner installation.

4. The contractor shall review the V2 CCTV Inspection prior to submission to the CA. The Contractor shall confirm to the CA that the cleaning and preparation (including any reaming, cutting, grinding, protruding SCs and void filling) has been completed in accordance with contract requirements. This confirmation shall be provided to the CA with the V2 submission.

5. Lining shall not commence until acceptance of the cleaning and preparation (including as indicated in the V2 and V2 submission) has been provided by the CA to the Contractor. Acceptance of the cleaning and preparation by the CA does not relieve the contractor from its responsibility to complete the cleaning and preparation in accordance with contract requirements. The CA shall respond to the Contractor within 48 hours of V2 submission or as agreed by both the Contractor and the CA.

6. If, after the V2, a deficiency in the cleaning and preparation is identified that requires correction, the V2 shall be redone after the correction has been done and the redone V2 submitted to the CA 10 business days prior to liner installation.

TS 4.10.21 Pre-Design Inspection for 1200 and Larger Pipelines

1. A pre-design dimensional inspection shall be carried out for all host pipes 1200 mm and larger. The pre-design dimensional inspection shall obtain detailed dimensional data.

2. The inspection may be carried out in conjunction with V1 with the proviso that the magnitude of debris present does not compromise the ability to obtain dimensions of the host pipe with sufficient accuracy to size the liner.

3. Dimensional data shall be obtained in a continuous or discontinuous mode. Where discontinuous methods are used, frequency of measurement shall not be less than every 5 metres capturing the height and width of the host pipe along its entire length.

4. The following methods may be employed:

    a. By direct entry with hand measurements
    b. By remote survey using laser profiling techniques as specified herein.

5. CCTV inspections involving hand measurements shall clearly show the dimensional measurements and distance of the measurement from the upstream manhole on the video. Distances based on CCTV cable measurement will be permitted.

6. Laser profiling technology must have sufficient accuracy and reliability as specified herein.

7. No coding of the submission will be required.

8. Laser profiling equipment shall meet the following minimum requirements:

    a. "Three Dimensional (3D) Laser Scanning" to determine the surface profile of mainline pipes using a three dimensional (3D) laser on the entire circumference of the pipe. 3D LASER scanning equipment shall provide an accurate determination of pipe geometry (features and defects).

    b. Minimum equipment requirements are:

        i. The laser shall be Class 1; eye-safe for operator safety.

        ii. Surface measurements accurate to 5 mm at 3 metres in 1200 mm pipes and larger.

        iii. Precision ovality / deflection detailed range laser measurement scans accurate to ±1%.

        iv. Laser scans shall produce a point cloud with a maximum distance between points of 10 mm in the transverse direction and 40 mm in the longitudinal direction.

        v. The rate of scan shall not exceed 9 m / minute.

9. The pre-design inspection, complete with all reports and dimensions shall be provided to the CA prior to or in conjunction with the liner design submission.

TS 4.10.22 Materials and Standards

1. The sewer lining shall be cured-in-place-pipe (CIPP) according to the requirements of ASTM F1216 for inverted liners or ASTM F1743 for pulled in place liners or ASTM F2019-20 for UVC reinforced pulled in place liners and ASTM D5813. The most current version of the above standards shall apply. For requirements applicable to liner design refer TS 4.10.25, Design Requirements for CIPP Liners.

2. The CIPP may either standard CIPP (CIPP-S) or Reinforced CIPP (CIPP-R). CIPP-S consists of a plain felt carrier tube plus resin. CIPP-R consists of a reinforced felt carrier tube plus resin. UVC CIPP is normally CIPP-R.

3. All liner materials shall have a substantial history of successful use as CIPP liner materials in municipal sewer application in the province of Ontario. Material properties shall meet the requirements of referenced standards, or the properties used in the liner designs, whichever are greater.

4. The quantity of resin used in the liners and its impregnation shall meet with the requirements of the applicable ASTM standard such as ASTM F1216.

5. The CIPP liners shall be designed according to the requirements in this specification. Refer to TS 4.10.25.

6. Where, in the course of work, the Contractor has reason to use materials that differ from the original proposed materials, either in general or for a specific installation, proposed alternate materials shall meet the above standards and require the approval of the CA prior to use.

TS 4.10.23 Minimum Physical Properties for CIPP

1. The minimum in-place physical properties for the installed CIPP liners shall be as shown in Table 1 below:

2. The in-place physical properties are evidenced by test results on samples from the installed CIPP liner or on samples that are representative of the installed CIPP liner.

3. The Contractor may provide CIPP liners with in-place properties greater than the required minimum values in Table 1. If such greater properties are used as a basis for CIPP liner design, these greater properties must be attained in liner sample test results (subject to design reconciliation where appropriate).

Table 1: Minimum Physical Properties Required for Installed & Finished CIPP Liners

CIPP Property	All CIPP Except UVC CIPP	UVC CIPP	Test Method
Flexural Modulus	2,400 MPa Minimum	8,000 MPa Minimum	ASTM D790 or ISO 11296-4
Flexural Strength	31 MPa Minimum	150 MPa Minimum	ASTM D790 or ISO 11296-4

TS 4.10.24 Sewer Sizes and CIPP Lining Sizing

TS 4.10.24.1 Nominal Sewer Size Tolerances

1. Sewer sizes shown in the PD are nominal designated metric sizes. For the purpose of the contract, a nominal sewer size shall include actual sizes within the range shown below in Table 2.

Table 2: Nominal Sewer Size Tolerances

Nominal Sewer Size (mm)	Lower Limit of Actual ID (mm)	Upper Limit of Actual ID (mm)
200	> 178	≤ 216
225	> 216	≤ 241
250	> 241	≤ 279
300	> 279	≤ 343
375	> 343	≤ 419
450	> 419	≤ 483
500	> 483	≤ 521
525	> 521	≤ 572

600	> 572	≤ 648
675	> 648	≤ 724
750	> 724	≤ 800
825	> 800	≤ 876

2. Where the inside diameter fits within the range for a nominal size, the sewer shall be deemed to be that nominal size for payment purposes. For example, a sewer identified in the PD as a 750 mm that has an actual inside diameter of 775 mm shall be deemed to be a 750 mm sewer whereas a sewer identified in the PD as a 750 mm that has an actual inside diameter of 810 mm shall be deemed to be an 825 mm sewer.

3. For sizes greater than those identified in Table 2, actual inside sewer dimensions may be up to 75 mm greater on average than the nominal sewer dimensions identified in the tender for payment purposes. Where actual sewer dimensions are greater than 75 mm on average, payment will be made at the next larger nominal sewer size.

4. Where payment for CIPP lining is identified on an asset-by-asset basis, any increases in the liner thickness resulting from an increase in the internal dimensions of the existing sewer greater than 75 mm on average will be paid in accordance with the applicable CIPP thickness increase pay item.

TS 4.10.24.2 Liner Sizing Measurements Made Prior to Cleaning and Preparation

1. Where the sewer inside diameter is measured for sizing the CIPP liner prior to cleaning and preparation, the measurement method shall employ the use of sizing rods, mandrels or other device that can penetrate through or scrape away corroded layers or material to obtain the inside diameter that is expected to occur after cleaning and lining. Measurement by tape measure shall not be acceptable.

2. For the measurements, the sewer shall be flow controlled so that any flow remaining in the sewer is minimal and does not degrade the accuracy of the measurements. At a minimum, measurements shall be taken at both ends of all MH-MH sewer sections to be CIPP lined.

TS 4.10.24.3 Impact of H2S Corrosion on Inside Diameter

1. Sewers with significant H2S corrosion will have an enlarged inside diameter after cleaning and preparation for lining. The sewer inside diameter after cleaning and preparation shall be the diameter used for sizing and design of the CIPP liner.

2. Payment for CIPP lining shall be based on the nominal size with a size range that includes the inside diameter after cleaning and preparation.

TS 4.10.24.4 Variable Sewer Inside Diameter for Lining

1. If an inside diameter variance exists along the same sewer section to be lined, the liner may be oversized or undersized for zones of the lining run. There will be excess material in the form of wrinkles and fines in the finished liner (i.e., oversized) or the finished liner may stretch out resulting in a decrease in wall thickness (i.e., undersized). The Contractor shall present the liner sizing situation and anticipated lining results (regarding fit and finish) along with a recommendation for liner sizing for the MH-MH section to the CA. This submission

shall be made on the V1 or V2 LDPR. The CA shall discuss the situation with the Contractor and in conjunction with the Contractor determine and accept the sizing of the liner for the installation.

2. The determination of the sewer sizing for lining will consider the best compromise between zones of excess liner material and zones where the liner could be thinned out by stretching or where the stretch may not be sufficient resulting in a liner that is not tight fitting.

TS 4.10.25 Design Requirements for CIPP Liners

TS 4.10.25.1 General

1. The required design method for a CIPP liner depends on the existing sewer size, geometric shape and significance of imperfections in the existing sewer.

2. Originally circular shapes may have some out-of-roundness (ovality) due to deflection but are not considered non-circular for design. Non-circular shapes include eggs, ovals, arch pipes, dished bottom ellipses and other non-circular shapes.

3. The required design method shall be according to the following table.

Sewer Shape and Conditions	CIPP Liner Design Method	Standard Design Parameters	Notes
Circular. With ovality up to 10%.	ASTM F1216-22 Appendix X1	Table 3A	1
Circular With ovality more than 10%	ASCE MOP 145	Table 3B	
Non-circular. All sizes and shapes	ASCE MOP 145	Table 3B	Eggs and vertical ovals meeting the WRc SRM design criteria may, at the Contractor's option, be designed by the WRc SRM Type II design until December 31, 2026.
Eggs and Vertical Ovals Meeting WRc SRM criteria for Type II design	WRc SRM Type II design	Table 3C	As of January 1, 2027, MOP 145 design will be required for these eggs and vertical ovals.

Note 1: Imperfections in Circular Sewers:
Imperfections of significance include ovality > 10%, flat zones (D shaped pipe), inward protrusions and other significant irregularities in the sewer geometry. The Contractor shall note any such imperfections that are identifiable in the V1 or V2 and they shall be recorded by the Contractor in the LDPR. The Contractor shall advise the CA of such imperfections. Where the CA deems that the imperfection(s) must be accounted for in design then the ASCE MOP 145 design method shall be used in place of ASTM F1216 X1 design method.

4. CIPP liners shall be designed for the fully deteriorated condition of the existing pipe (F1216 X1 design) or the equivalent condition in ASCE MOP 145 design or the equivalent condition in WRc SRM Type II design unless otherwise noted in the PD. The liner design shall determine the required thickness for the liner.

5. The thickness for the liner (the required thickness) means the structural liner thickness, in place in the lined sewer, after all CIPP liner processing has been completed within the lined sewer. Thickness of the liner does not mean the nominal liner tube thickness, either pre or post wet-out tube thickness. Liner thickness is subject to minimum thickness requirements in this specification. Refer section TS 4.10.25.11.

6. The Contractor shall provide a Standard Liner Design (SLD) or, where required, a Site-Specific Liner Design (SSLD) for each liner to be installed on the contract. SLDs shall use the standard design parameters listed in either Table 3A (for ASTM F1216 design) or Table 3B (for ASCE MOP 145 design) where applicable to the existing pipe shape, size and imperfections. The SSLDs shall use the design parameters listed in Table 3A or 3B (as applicable) except for parameters that are verified in the field and that will result in an increased liner thickness versus the SLD. Also see the following clause 6 for exception(s) to Table 3A and 3B parameters.

7. All CIPP liner designs provided by the Contractor shall bear the seal and signature of a professional engineer who must be authorized to perform such work by Professional Engineers Ontario (PEO).

8. Some contracts may specify, or be based on, sewer asset specific requirements in the PD. The design parameters and design check requirements for asset specific items may differ from TS 4.10's requirements. Pipeline asset specific requirements may be in place for larger size pipelines and for pipelines that have non-circular shapes including eggs, ovals, and other non-circular shapes. For items with pipeline asset specific design requirements refer to the PD that modify, over-ride or add to TS 4.10's design requirements.

9. Designs shall be submitted to the CA for acceptance. No liner shall be installed without an accepted design.

10. The minimum required thicknesses in TS 4.10.25.11 shall over-ride thicknesses determined by design when the design thickness is less than the minimum thickness unless specified otherwise in the PD.

11. All designs shall have a unique and clearly identifiable reference number along with a revision number where multiple design submissions are required for the same sewer section to be lined. This tracking number shall be utilized on all applicable submissions and correspondence and specifically on the LDPR.

12. SLDs shall be submitted within 30 Calendar Days of award, or a minimum of 14 Calendar Days prior to commencement of work on the Contract, whichever should come first.

TS 4.10.25.2 Regular Design Versus Asset Specific Design

1. Where applicable, Asset Specific design requirements will be provided in the PD.

TS 4.10.25.3 Standard Liner Design (SLD)

1. An SLD, based on the Standard Design Parameters listed in Table 3A or 3B (as applicable) below, shall be prepared and submitted by the Contractor for each sewer size in the Contract with the exception of Assert Specific items.

2. For Asset Specific items, an SLD shall be prepared and submitted by the Contractor whereby the SLD shall be based on specific information (which may differ from this specification) provided within the PD. This specific information may include modifications to Table 3A or 3B parameters as applicable to the Asset Specific design.

3. For Asset Specific items, there is normally one SLD for each liner to be installed (each sewer asset). Where liners of the same size and similar depth and live load are to be installed common SLDs may be developed as long as the applicable sewer asset(s) are clearly identified on the design.

4. Revision of SLD to SSLD: During the course of the work the Contractor shall field determine/verify where the design parameters applicable to the existing sewer design differ from the Standard Design Parameters or asset specific parameters provided in the PD. Field determined/verified design parameters that are more onerous for design than the SLD parameters shall necessitate a revision to a SLD for specific liner installations. The revision is called a SSLD (Site Specific Liner Design).

5. SLDs and SSLDs will be considered incidental to the CIPP liner installation and will not be measured for payment unless otherwise is specified in the PD.

TS 4.10.25.4 Site-Specific Liner Design (SSLD)

1. An SSLD differs from an SLD only in one or more of certain design parameters that have been obtained in the field, which are more onerous for design than the Standard Design Parameters listed in Table 3A or 3B (as applicable). More onerous for design means that the field obtained parameters will result in a thicker liner (or an equivalent to thicker liner) than the corresponding SLD. All other corresponding SLD parameters apply unchanged in a corresponding SSLD. Refer to TS 4.10.15 Field Verification of Liner design Parameters & LDPR.

2. Where the field obtained design parameters do not result in a thicker liner (or an equivalent to thicker liner), then an SSLD is not required.

3. An SSLD accepted by the CA takes precedence over an accepted SLD.

TS 4.10.25.5 Standard Design Parameters

Table 3A: Standard Design Parameters for CIPP Liners Using ASTM F1216-22 Appendix X1 Design

Parameter	Requirement
Host Pipe Shape & Limits	For originally circular host pipe with ovality for liner design not exceeding 10%.
Design Method	ASTM F1216-22 Appendix X1
Design Life	50 years
Pipe Condition for Liner Design	Fully Deteriorated Gravity Pipe Condition (unless otherwise specified in the PD)
Size	As identified for lining in the PD. Use Nominal size for bid or preliminary designs,
Invert Depth	Based on 3.0 meters over top of the pipe. For Asset Specific items or Contracts refer to the PD.
Water Table Location & Hydrostatic Load	A water table location at 1.2 m below ground surface or a minimum hydrostatic head of 1.5 m over invert or a minimum hydrostatic head of 0.1 m over crown, whichever of the three yields the greatest hydrostatic head for design. For culverts refer TS 4.10.25.7.
Ovality	3%. For Asset Specific items or Contracts refer to the PD. If actual ovality exceeds 10%, design by MOP 145 must be used instead of design by ASTM F1216.
Soil Density	18.83 kN/m^3 (1920 kg/m^3)
Soil Modulus	6.9 MPa unless PD indicates lower values present
Traffic Live Loading	Minimum of CHBDC CL-625-ONT for vehicular loads and Cooper E80 loading for train crossings
Enhancement Factor	7.0 for CIPP liners that are tight fitting to existing sewer.
Factor of Safety	2.0
Flexural Modulus. Value to be used in design equations	The liner flexural modulus is determined by ASTM D790 (or ISO equivalent). For design, the flexural modulus shall be reduced by a Creep Reduction Factor (CRF). The CRF shall account for the effect of creep over the design life of the liner. The CRF shall be derived from long-term testing according to ASTM 2990 (or ISO equivalent). A minimum test duration of 10,000 hrs is required. The long-term testing to determine the CRF shall be done on a composite consisting of all the components of the CIPP system (resin, felt, any reinforcing etc.). The flexural modulus to be reduced by the CRF shall be the flexural modulus that is routinely and repeatably obtained in testing (ASTM D790 or ISO equivalent) of actual installed liners. A required minimum flexural modulus may be specified in this specification or in applicable standards. Independent third-party test data shall be available to substantiate the values of the flexural modulus and CRF used in the design(s). Liner designs shall identify the flexural modulus, the CRF and the value of the flexural modulus used in the design equations. If these values are not clearly identified the designs shall be rejected by the CA. ***Refer Appendix C for anticipated changes in the above requirement for future years.***
Flexural Strength. Value to be used in design equations	The liner flexural strength is determined by ASTM D790 (or ISO equivalent). For design, the flexural strength shall be reduced by a Flexural Strength Reduction Factor (FSRF). The FSRF shall account for the effect of stress over the design life of the liner. The FSRF shall be derived from long-term testing according to ASTM 2990 (or ISO equivalent). The long-term testing to determine the FSRF shall be done on a composite consisting of all the components of the CIPP system (resin, felt, any reinforcing etc.). The flexural strength to be reduced by the CRRF shall be the flexural strength that is routinely and repeatably obtained in testing (ASTM D790 or ISO equivalent) of actual installed liners. A required minimum flexural strength may be specified in this specification or in applicable standards. Independent third-party test data shall be available to substantiate the values of the flexural strength and CRRF used in the design(s). Liner designs shall identify the flexural strength, the CRRF and the value of the flexural strength used in the design equations. If these values are not clearly identified the designs shall be rejected by the CA. ***Refer Appendix C for anticipated changes in the above requirement for future years.***

Table 3B: Standard Design Parameters for CIPP Liners Using ASCE MOP 145 Design

<table>
<tr><th>Parameter</th><th>Requirement</th></tr>
<tr><td>Host Pipe Shape & Limits</td><td>For originally circular host pipe with ovality for liner design greater than 10%.
For non-circular host pipe of all sizes and shapes.</td></tr>
<tr><td>Design Method</td><td>ASCE MOP 145</td></tr>
<tr><td>Type Testing Load duration</td><td>Live loads
Shall be based on short-term flexural modulus and flexural strength material properties.
Sustained loads
Shall be based on anticipated or apparent properties after 50 years of sustained load application</td></tr>
<tr><td>Host pipe design condition</td><td>Design for State III unless otherwise noted in the PD.</td></tr>
<tr><td>Size</td><td>Base design for Bid Purposes on the dimensions identified for each specific lining section noted in the PD.
Carry out dimensional review in V1 and/or V2 Inspection to confirm it matches Asset Specific Design assumptions</td></tr>
<tr><td>Invert Depth</td><td>As per Table 3A</td></tr>
<tr><td>Water Table Location & Hydrostatic Load</td><td>As per Table 3A</td></tr>
<tr><td>Soil Density</td><td>18.83 kN/m3 (1920 kg/m3)</td></tr>
<tr><td>Constrained Soil Modulus</td><td>6.9 MPa unless PD indicates lower values present.</td></tr>
<tr><td>Traffic Live Loading</td><td>Minimum of CHBDC CL-625-ONT for vehicular loads and Cooper E80 loading for train crossings</td></tr>
<tr><td>Load and Resistance Factors</td><td>Unless otherwise specified in the Asset Specific requirement use ASCE MOP 145 Load and Resistance Factors as follows:

<u>Load Factors</u>

<table>
<tr><th>Applies To</th><th>Symbol</th><th>Recommended Value</th></tr>
<tr><td>Groundwater pressure</td><td>γ_{GW}</td><td>1.6 (ASCE)</td></tr>
<tr><td>Dead load</td><td>γ_{DL}</td><td>1.2 (ASCE)</td></tr>
<tr><td>Live load</td><td>γ_{LL}</td><td>1.6 (ASCE)</td></tr>
</table>
Dead load: soil overburden pressure, surface static load
Live load: highway traffic, railway traffic, aircraft

<u>Resistance Factors</u>

<table>
<tr><th>Applies To</th><th>Symbol</th><th colspan="2">Recommended Value</th></tr>
<tr><td rowspan="3">Long-term flexural strength, $\sigma_{50,F}$</td><td rowspan="3">Φ_{LF}</td><td>0.8</td><td>for CIP liners impregnated and cured on site.</td></tr>
<tr><td>0.85</td><td>for CIP liners resin impregnated off-site and cured on site.</td></tr>
<tr><td>1.0</td><td>for factory manufactured thermoplastics (PVC, PE), installed fold-and-form</td></tr>
<tr><td>Long-term flexural modulus, E_{50}</td><td>Φ_{LM}</td><td>0.8</td><td></td></tr>
<tr><td>Long-term buckling stability</td><td>Φ_{LM}</td><td>0.8</td><td></td></tr>
<tr><td rowspan="2">Corrosion strain, ε_L</td><td rowspan="2">$\Phi_{L\varepsilon}$</td><td>0.9</td><td>For in-situ manufactured GRP liners.</td></tr>
<tr><td>1.0</td><td>For factory manufactured GRP liners.</td></tr>
<tr><td>Constrained modulus of the backfill soil</td><td>Φ_S</td><td>0.8</td><td></td></tr>
</table>
</td></tr>
</table>

Imperfections	Maximum Annular Gap (g) = 1 mm Where present, design requirements for imperfection will be noted in the asset specific requirements for: - Hinge Rotational Angle – minimum 2.54 mm crack where noted - Cracking pattern (e.g. 2 hinge, 4 hinge, etc.) - Whether hinge is across governing buckling arc - Intrusions Flattening
Ovality	Ovality parameter applies only liner design for originally circular host pipe and does not apply to originally non-circular host pipe. Minimum of 3% or the actual host pipe ovality, whichever is greater. See Note 3B-1.
Deferred Ovality	Deferred Ovality parameter applies only liner design for originally circular host pipe and does not apply to originally non-circular host pipe. Minimum of 6% or the actual ovality plus 3%, whichever is greater. See Note 3B-1.
Flexural Modulus Used in Design Equations	As per Table 3A, with the exception that the applied stress level for the ASTM 2990 or equivalent) test shall be at 75% of the yield strength of the material and projected to the Load Duration noted herein.
Long term flexural strength	As per Table 3A based on Creep Rupture Testing carried out in an ASTM D2990 Creep Rupture Test and projected to establish the Load duration noted herein.

Note 3B-1: Regarding Ovality and Deferred Ovality. In the context of TS 4.10, MOP 145 design is only used for originally circular pipe when the actual (or specified) ovality exceeds 10%. Therefore, the minimums of 3% (ovality) and 6% (deferred ovality) will never be applicable as actual ovality and deferred ovality will exceed 10% and 13%.

Table 3C: Standard Design Parameters for CIPP Liners Using WRc SRM Type II Design

Parameter	Requirement
Host Pipe Shape & Limits	For egg shape and vertical oval shape pipes meeting the shape criteria in the WRc SRM Type II design parameters. WRc SRM Type II design for these egg and vertical oval shapes will be acceptable until December 1, 2026. After which date, MOP 145 design will be required.
Design Method	WRC SRM Type II design
Design Life	50 years
Pipe Condition for Liner Design	Equivalent to ASTM F1216 Appendix X1 Fully Deteriorated Gravity Pipe Condition (unless specified otherwise in the PD).
Size	As per Table 3A
Invert Depth	As per Table 3A. See Note 3C1 below.
Water Table Location & Hydrostatic Load	As per Table 3A
Soil Density	As per Table 3A
Soil Modulus	As per Table 3A
Traffic Live Loading	As per Table 3A
Vertical Soil Pressure	Soil pressure for use in design shall be based on the soil prism load. The qt method given in ASTM F1216 Appendix X1 is not applicable.
Vertical to Horizontal Soil Pressure Ratio	0.4 unless specified otherwise in the PD.
Profile factor (R) for Deflection Equations	0.5
Factor of Safety	2.0
Flexural Modulus Used in Design Equations	As per Table 3A
Flexural Strength Used in Design Equations	As per Table 3A

TS 4.10.25.6 Starting Values of Liner Material Properties Used in Design

1. The starting values for flexural modulus, flexural strength, and other applicable design properties, shall be values that will be routinely and repeatedly obtained by the Contractor in installations of the same liner material and be substantiated by a history of regular testing of samples from installed liners. Regular testing means the standard testing that determines the property, such as ASTM D790 for flexural modulus. The starting values shall be clearly identified in the liner design. The 50 year retention (creep retention) used to reduce the starting values to long-term design values shall be based on ASTM 2990 testing (or equivalent testing as acceptable to the CA) for the liner and substantiates the 50 year retention used. The long-term design values used in the design shall be clearly identified in the liner design.

TS 4.10.25.7 Hydrostatic Load for Culverts

1. The water table location in Tables 3 shall not be used for culvert design. Instead, culverts shall be designed for a long-term hydrostatic head based on groundwater level assumed to be

at the top of the culvert and a short-term hydrostatic head based on groundwater level assumed to be 1.0 m above top of culvert.

2. In the context of this specification, culvert means a pipe or conduit for the drainage or transport of land surface water and with both ends open to surface water.

TS 4.10.25.8 Traffic Live Loading for Design

1. Liner locations subject to surface truck loads shall have the CHBDC CL-625-ONT loading, estimated for the depth of cover over the pipeline, applied in the design of the liner. The Live Load Distribution Factor (LLDF) and other methodology used in the estimate of live loading at pipe depth shall be as specified in the Canadian Highway Bridge Design Code, CHBDC S6-19.

2. Liner locations subject to surface railway line loads shall have Cooper E80 rail loading, estimated for the depth of cover over the pipeline, applied in the design of the liner. Rail loads shall include a track allowance dead load of 297 kg/m. Applied rail loads at depth shall be calculated using the Boussinesq solution for distribution of soil stresses from surface point loads. Impact factors for rail loads shall be calculated in accordance with the AREMA Manual for Railway Engineering.

3. For liner locations subject to railed streetcar or LRT live loads refer to the PD for further information. If no further information is available, apply Cooper E80 rail loading as above.

TS 4.10.25.9 Unusual/Indeterminate Cover Situations

1. An unusual/indeterminate cover situation may exist when the invert depths determined at MHs at each end of the lining run may not provide sufficient information for design of the liner. This could include significantly higher or lower cover over the sewer between the MHs compared to the cover at the MHs. Significant means covers that are at least 1 m higher or lower than the covers determined at the MHs.

2. Where the Contractor can reasonably identify this situation (such as at time of field verification of liner design parameters) or otherwise suspects this situation to exist the Contractor shall report such a ground cover situation to the CA. The Contractor shall report this situation on the LDPR. Within 48 hours the CA shall provide instruction to the Contractor regarding how to proceed in this situation.

TS 4.10.25.10 Shallow Cover with Live Load Situations

1. The situation can exist when a design based on the maximum MH depth can result in the actual minimum cover elsewhere requiring a thicker liner due to the effect of live load at the shallower depth. This situation, when evident, requires a design check for both maximum and minimum cover situations.

2. When the CHBDC CL-625-ONT live load is being applied and the maximum design cover is less than 2.2 m then both maximum and minimum cover situations shall be checked in liner design. The required liner thickness shall be the greater of the 2 thicknesses.

3. When a Cooper E80 railway live load is being applied and the maximum design cover is less than 10 m then both the minimum and maximum cover situations must be checked in design. The required liner thickness shall be the greater of the 2 thicknesses.

TS 4.10.25.11 Minimum Liner Thickness

1. All CIPP liners shall achieve a minimum thickness of 5.0 mm except for UVC CIPP liners that shall achieve a minimum thickness of 4.0 mm.

2. Liner thickness is defined in 4.10.25.1, Clause 5.

3. Where a design thickness is lower than the applicable minimum thickness in clause 1 above, the design shall show this and indicate that the minimum thickness is the required liner thickness for the liner installation covered by the design.

4. A design reconciliation based on installed liner as-test properties (such as from testing field samples of liners) shall not overrule the minimum liner thickness requirement herein.

TS 4.10.25.12 Designs to Be Correct for Field Conditions

1. Where the SLD is not sufficient for the field conditions, the Contractor shall provide a SSLD in accordance with the actual field conditions. The SSLD shall be submitted to the CA for acceptance.

2. Where the liner thickness as per the SLD is sufficient for or exceeds requirements for the field conditions, a SSLD is not required, and no adjustment shall be made to the SLD liner thickness.

3. Where a SLD liner thickness is found insufficient due to actual field conditions, the Contractor shall advise the CA within 48 hours of the reasons for insufficiency and wait for the CA's instructions. Where an SSLD by the Contractor for actual field conditions 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 CA.

4. No liner shall be installed that does not meet or exceed the requirements for actual field conditions, including liner thickness sufficient for actual field conditions.

5. A thickness increment pay item only applies when the Contractor was required to increase the nominal liner tube thickness applicable to the SLD liner thickness.

6. Where the Contractor considers that the increased in-place thickness necessitated by a SSLD can be achieved without increasing the nominal tube thickness over the applicable SLD nominal tube thickness, then the installation may be made with the specific nominal tube thickness at the Contractor's discretion. However, regardless of the nominal tube used, the in-place liner thickness shall meet the requirements of the SSLD. In the case where the Contractor opts to use the Tender SLD nominal tube thickness, there will not be a thickness increment for the nominal tube thickness and no increased thickness payment will apply.

7. Where the SSLD has been accepted by the CA, the Contractor will be paid for the liner thickness increase in accordance with the appropriate item in the Schedule of Quantities and Prices. Compensation for extra thickness will not be applicable in cases where liners are installed without prior acceptance by the CA of an SSLD showing the liner thickness increase versus a previous SLD or SSLD.

TS 4.10.26 CIPP Lining – Resin Impregnation

TS 4.10.26.1 General Requirements

1. The CIPP liner tube shall be wet-out with resin (impregnated) in accordance with ASTM F1216, F1743, F2019 or F2994 as applicable to the type of liner. The resin quantity placed into the liner tube shall be in accordance with the applicable ASTM standard. A minimum of 5% excess resin shall be used. The resin quantity required is the quantity that shall fill all voids in the liner tube at the nominal thickness and diameter plus an additional minimum of 5% excess resin.

2. Liner tubes that are not wet-out with resin in accordance with the above requirements will not be accepted by the CA. If required by the CA, the Contractor shall provide wet-out resin quantity calculations to the CA one week prior to the wet-out commencing. These calculations shall identify the resin, the resin specific gravity, the nominal tube thickness, the sewer inside diameter and the resin quantity to be used in liters per meter of tube and how this quantity was calculated. Where, in the CA's opinion, the calculations provided do not show the proper quantity of resin, the Contractor shall revise and re-submit the calculations until they are acceptable to the CA. The resin quantity used in the liner tube shall be in accordance with the calculations that have been accepted by the CA.

3. The CA shall have the right to inspect the Contractor's wet-out facility at any time during the wet-out of a liner tube for this contract. As part of such inspection and if requested by the CA, the Contractor shall weigh a sample of dry felt and a corresponding sample of wet-out felt from any tube being wet-out for this contract. Where the results of this sampling do not verify that sufficient resin was placed in the liner tube, the liner will not be acceptable to the CA and shall not be used for the work.

TS 4.10.26.2 Additional Requirements for UVC Liners

1. The resin impregnated liner shall be stored and shipped in a UV light proof container.

2. The resin impregnation shall comply with ASTM F2019-20.

3. The Contractor shall not install any liner that has exceeded the Manufacturer's warranty period for installation, normally 6 months from date of resin impregnation.

TS 4.10.27 Liner Thickness, Properties and Fit/Finish

TS 4.10.27.1 General

1. The installed and completed liner shall conform to the following requirements.

TS 4.10.27.2 Required Liner Thickness

1. The completed in place liner wall thickness shall meet or exceed the required wall thickness. The required liner thickness shall be the greater of:

    a. The wall thickness determined by the final accepted liner design, or

b. The minimum wall thickness required in this specification.

2. The final accepted liner design may be either a SLD or a SSLD as accepted by the CA.

3. Liner wall thickness measurements and determination of the actual effective thickness shall be in accordance with ASTM D5813 or for UV Cure only ISO 7685. Measurements of the actual installed liner wall thickness shall not include the thickness of any non-structural components. The effective wall thickness shall be either the minimum thickness divided by 0.875 or the average thickness whichever is less. Refer ASTM D5813.

4. Where plate samples or other factors prevent the determination of actual installed liner thickness, the CA may require the contractor to obtain (cut out) a small liner specimen from inside of the lined pipe with in 1 m of a MH or other access location.

5. The liner wall thickness shall not exceed more than 25% of the required thickness except where a liner thickness was increased to reduce installation risk and such increase was approved in advance by the CA.

6. When actual liner wall thickness appears to be deficient compared to the required thickness, a design reconciliation based on test results for liner properties shall be permitted. Design reconciliation determines a required liner thickness based on as-tested liner properties. For a design reconciliation, the as-tested properties are substituted for the originally used liner properties in the final CA accepted design while all other parameters remain the same. The thickness yielded by the design reconciliation becomes the required liner thickness. 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. A design reconciliation is not applicable when as-tested properties do not meet the minimum requirements in this specification unless an exception is granted by the CA.

TS 4.10.27.3 In Place Liner Properties

1. The physical properties used in the design of the liner shall be determined by testing of samples from the in-place liners. The samples must be representative of the installed liner regarding properties and thickness. Samples from the in-place liner shall be prepared and provided by the Contractor.

2. The completed in place CIPP liner sample wall properties shall meet or exceed the required properties. The required liner properties shall be the greater of:

    a. The liner properties used in the final accepted liner design, or
    b. Any minimum liner properties required in this specification.

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

TS 4.10.27.4 Required Liner Fit and Finish

Table 4: Fit & Finish Requirements for CIPP Liners

Item	Liner Requirement
Continuity of Liner	The finished liner shall be continuous over the entire length of the liner installation from MH to MH without any breaks, separations, or joints.
Liner Fit to Existing Sewer Liner	The outside surface of the finished liner shall be in contact with the inside surface of the existing sewer subject to the contact tolerance. 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. The contact tolerance is 1.0 mm. Where any space of gap between the outside surface of the liner and the inside surface of the existing sewer line exceeds 1.0 mm, the liner fit will be deficient, subject to exceptions noted below. The liner should also be able to negotiate vertical/horizontal elbows and bends with various degrees (angles ranging from 0 to 45 degrees). The liner shall extend into each MH a minimum of 12 mm and a maximum of 25 mm, such that a MH liner material application can be applied to the back (outer surface) of the liner, creating a seal around the CIPP liner, pipe and MH interface.
Exception to Liner Fit at Existing Sewer Line Irregularities	Existing sewer line irregularities include off set joints, protrusions, bumps, or other similar situations in the existing sewer that remain after the sewer has been prepared in accordance with the cleaning and preparation requirements. Neither ovalization of the existing sewer nor curves made by joint deflection are irregularities in this context. Where an irregularity exists, exception to the liner contact tolerance requirements will be allowed in the irregularity zone. The irregularity zone is defined as a zone extending a distance of up to 25% of the liner inside diameter in any direction from the irregularity as measured along the inside surface of the liner. A liner fit exception at an existing sewer irregularity shall not present an obstruction to sewage flow whether or not it complies with the allowed exceptions.
Liner Shape	The liner shape shall 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. However, where the existing sewer line shape is not defined (missing pieces of sewer line) the liner may either bridge the missing wall section or indent into the missing wall section. Where the liner bridges, the shape of the liner shall match the shape of adjacent sewer line and the inside diameter of the liner shall be as required for Contact Tolerance for the adjacent sewer line. Where the liner indents, the depth of the indent shall not reduce the liner wall thickness below the Wall Thickness Tolerance.
Liner Wall	The liner wall shall be free of any interior bulges, ribs, ripples, folds, or other irregularities except where these irregularities comply with the Liner Wall Thickness Tolerance, fit, shape and wall thickness given above. The wall of the liner shall be free of any voids, cavities, or bubbles.
Liner Terminations	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 only a sufficient extension to allow for any longitudinal shrinkage.

Bulges, including Lifts and Sags	There shall be no bulges in the liner that are not consistent with the surface profile of the existing sewer before lining. Such bulges will be considered an indication of a major structural deficiency in the liner and will require major remedial action. Where bulges are suspected or proven to contain internal separations within the wall of the liner, remedial action up to and including removal and replacement of the liner will be required. This applies to bulges that may be called lifts or sags.
Separation and Delamination	There shall be no separation or delamination within the liner wall. A type of separation or delamination may be evident when a lift or bulge in the liner is formed by an interior layer of the liner have separated and lifted away from the remaining liner that remains in place against the pipe wall. Such situations will be considered an indication of a major structural deficiency in the liner and will require major remedial action up to and including removal and replacement of the liner.

TS 4.10.28 Installation of CIPP Liner

TS 4.10.28.1 General

1. The installation methodology shall conform to the requirements of ASTM F1216, ASTM F1743 or ASTM F2019 as applicable to the type of liner. Where Bid or later submissions included a method statement with additional procedures, such additional procedures shall be followed. The specific details and execution of the installation are the responsibility of the Contractor.

2. The Contractor shall provide a minimum of 48 hours advanced notice to the CA of any CIPP liner installation.

3. All affected property occupants shall receive written notice 48 hours in advance of any work that will interfere with sewer use for that property.

4. 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 a CIPP liner section.

1. The contractor shall ensure that all MH’s used for insertion of liners are adequate in size as not to impact the required finished liner quality. Where the contractor identifies a MH opening size to be inadequate, the MH shall be modified appropriately. The CA, at its discretion, may also require the Contractor to make adjustments to the manhole opening prior to the insertion of the liner. Any additional costs associated with modifying the manhole opening and repairing the manhole after installation of the liner shall be paid under the appropriate pay item.

TS 4.10.28.2 MH Access

1. Modifications, removal (partial or complete), and reconstruction of existing MH’s may be required to facilitate installation of CIPP liners and other works included in the Contract. The Contractor shall complete an investigation of each site to determine the extent of the modifications to the existing MH’s required to complete the work. This should be completed in conjunction with the V1 CCTV inspection. The required MH work shall be submitted to the CA for review and acceptance prior to undertaking the work and will be paid under the applicable provisional item.

TS 4.10.28.3 Odour Control

1. 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.

2. When it is available from the CA the Contractor shall use the City's current Odour Notice.

3. 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:
    a. seeking permission to enter the property and undertake odour control activity;
    b. entering the property in the company of a city representative
    c. filling of any dry traps;
    d. preventing air flow from any traps which to do not seal properly with water but only if this is readily and easily done;
    e. ventilating the property via open window and doors;
    f. ventilating the property with fans/blowers; and
    g. other actions that are useful in alleviating the odour problem.

4. Whenever a styrene odour complaint occurs the Contractor shall document the complaint including address, date, time and all actions undertaken to mitigate the problem causing the complaint. Upon request of the CA, the Contractor shall provide the documentation (for any or all complaints) to the CA.

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

6. If a troublesome styrene odour occurs, then two MH exhaust fans with a minimum capacity of 2100 cfm each shall be used to exhaust air from the sewer via MHs. One fan shall be located at an adjacent MH immediately downstream of the sewer section being lined. The second fan shall be employed at the tail end MHs 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 MH, it shall be employed at the closest possible adjacent MH that will permit air to be exhausted from the sewer being lined. If odour control becomes a problem, the Contractor shall provide additional exhaust ventilation of the sewer to alleviate odour. This requirement for MH exhaust fans is more likely to be applicable with inverted CIPP lining products than with encapsulated pulled in place lining products (such as UVC CIPP).

TS 4.10.28.4 Styrene Discharge Management Plan (SDMP)

1. Under no circumstances shall cure water or condensate containing styrene be discharged into a storm sewer, outfalls or any other direct connection to surficial drainage courses or facilities.

2. If stated as a requirement in the PD (either for lining specific sites or all lining sites), the Contractor shall provide and execute a Styrene Discharge Management Plan (SDMP). However, if the Contractor is using (or opts to use) either a styrene free liner resin or an encapsulated UVC liner at the lining sites identified in the PD for SDMP then no provision or execution of a SDMP shall be required.

3. Where the PD contains the requirement for an SDMP and the Contractor is using (or opts to use) either a styrene free resin or an encapsulated UVC liner, the Contractor shall advise the CA accordingly at least 2 weeks before lining is to take place.

4. If an encapsulated UVC liner is used at a lining site identified in the PD for an SDMP, the Contractor shall perform on-site monitoring to verify that there is no residual styrene discharged to the environment.

5. The Contractor shall submit any required SDMP at the request of the CA, or a minimum of five (5) days prior to lining.

6. The Contractor's SDMP shall, where applicable, include:

    a. Use of on-site treatment systems where hot water curing is utilized.
    b. 100% condensate capture and the off-site disposal location where steam curing is utilized.

7. The SDMP shall include sufficient details on:

    a. Regulatory compliance considerations for discharge based on the Contractor's proposed resin selection, curing method, and discharge location for steam condensate or cure water, first flush, etc.

    b. The means, methods, and techniques employed to mitigate styrene levels to within acceptable limits for the site-specific application, including:

        i. Cure considerations to mitigate excessive styrene volatilization.
        ii. Handling considerations, post cure to mitigate levels discharged to aquatic or other environments that may be deleteriously impacted by excessive styrene levels.

8. Where the PD requires an SDMP and, if requested by the CA, the Contractor shall be responsible to undertake sufficient monitoring to confirm and demonstrate that discharge levels are consistent with the SDMP's stated discharge limit objectives. If requested by the CA, the Contractor shall provide a report on styrene monitoring results upon completion of liner installation.

TS 4.10.28.5 Cool Down for Thermal Cure CIPP Liners

1. A sufficient liner cool down period, under continuous cure head or pressure, shall be allowed to minimize shrinkage and thermal stresses in the liner.

2. In the case of hot water curing, prior to release into the sewer, the cure water shall be cooled to the ambient temperature of the sewer into which it will drain.

TS 4.10.28.6 UVC CIPP Liners Curing Method

1. All steps, processes and duration of the cure shall be in complete accordance with the UVC CIPP manufacturer's recommended process and procedures.

2. UV curing of CIPP liners shall include a monitoring system capable of recording the duration of the liners' exposure to UV light to ensure satisfactory curing of the resin. The system shall be capable of recording the light train speed throughout the entire duration of the installation. All UV cure technology shall be operated in accordance with the manufacture's requirements and recommendations.

3. Prior to installing the liner in the host pipe, the UV cure monitoring system's proper functioning shall be confirmed by hooking it up to the computer and ensuring that the sensors are reporting the UV light output. No more than two sensors in sequence can be found faulty during this test. If three or more sensors in sequence are discovered faulty, a new sensor array shall be pulled into the host pipe replacing the previously installed array; and the new array shall be again tested for its proper functioning.

4. The sensor array's computer database shall have an output report that identifies each sensor by its station over the length of the UV-CIPP installation. The maximum temperature achieved during the curing process and the time sustained at or above the required curing temperature shall be recorded and submitted for each sensor. If requested by the CA, the Contractor shall provide the curing output report for each sewer section lined.

5. On completion of the UV curing the liner shall be cooled down in accordance with the manufacturer's instructions prior to releasing the internal air pressure.

TS 4.10.28.7 Continuous Temperature Monitoring

1. In addition to temperature sensors being placed at the upstream and downstream MHs during the curing of the CIPP liner, the following CIPP installations shall include a monitoring system capable of continuously monitoring and recording temperatures along the entire length of the CIPP installation to verify proper curing temperatures unless otherwise is stated in the PD.

    a. Steam cured CIPP liners in sewers 450 mm in diameter or greater.
    b. All CIPP liners in sewers 1200 mm in diameter or greater for both steam, hot water, and optical cures (such as UVC).

2. The continuous temperature sensors shall be placed between the host pipe and the liner within the invert (bottom) of the host pipe throughout the full length of the liner installation. The system shall be capable of recording the temperature at the invert throughout the entire length of the installation. The sensors shall be spaced apart at intervals no greater than 3 meters apart. Additionally, sensors shall be strategically placed at points where a significant heat sink is likely to be anticipated (e.g., sag in the host pipe, active infiltration, high water table, etc.).

3. The monitoring and recording of these sensors shall be by a computer that can record the temperatures throughout the processing of the CIPP and be available for viewing on site by the CA during the cure process. Upon completion of the liner installation, the temperature data shall be submitted to the CA as part of the overall final QA/QC submittal requirement.

4. Acceptable temperature sensor monitoring systems include:

    a. ZIA Systems (www.ziasystems.com/) or
    b. CA approved equivalent.

5. Prior to installing the liner in the host pipe, the temperature monitoring system's proper functioning shall be confirmed by hooking it up to the computer and ensuring that the sensors are reporting the ambient sewer temperatures. No more than two sensors in sequence can be found faulty during this test. If three or more sensors in sequence are discovered faulty, a new sensor array shall be pulled into the host pipe replacing the previously installed array; and the new array shall be again tested for its proper functioning.

6. The sensor array's computer database shall have an output report that identifies each sensor by its station over the length of the CIPP installation. The maximum temperature achieved during the steam cure process and the time sustained at or above the required curing temperature shall be recorded and submitted for each sensor. If requested by the CA, the Contractor shall provide the temperature output report for each sewer section lined.

TS 4.10.28.8 CIPP Lining Termination Requirements at MHs

1. Where a liner has been placed continuously through a MH, the upper portion of the liner shall be cut out over the full length within the MH from the existing sewer pipe entrance to exit so that the top edges of the remaining liner are level with the existing MH benching. Where the existing benching does not fit tightly to the portion of the liner left in place, any gaps or misfits shall be filled with a suitable concrete patching compound. The liner ends at the MH walls, above the location where the liner is cut out, shall be trimmed as close as practical to the MH walls considering any thermal contraction to occur, along with common industry best practices, to allow a slight outward flare on the liner ends.

2. Where a liner is not placed continuously through a MH, the liner ends shall be trimmed as close as practical to the MH walls considering any thermal contraction to occur, along with common industry best practices, to allow a slight outwards flare on the liner ends. The MH trough shall be adjusted so that a smooth and uniform flow path at liner interface within the MH is maintained. If a liner is placed at the US and DS of a MH, and does not continuously extend through the MH, the trough shall be adjusted to provide a smooth and uniform flow path between both liner ends.

3. Material for adjusting the MH trough shall be Speedcrete, 20 MPa, or an approved equivalent product. Submission of data/specification sheets for request made for alternate product must be provided a minimum of 2 weeks prior to use.

TS 4.10.28.9 MH Benching and Restoration

1. All affected MHs shall be re-benched, where required, to conform to the new dimensions and positions of liners.

2. Where a liner has been placed continuously through a MH, the benching shall be made to conform to the exterior of the liner. The liner shall be opened the full width of the MH (from pipe entrance to exit) for the upper part of the liner to be made level with the top of the benching. Finished liner and benching in MH shall provide a smooth, uniform flow path from entrance to exit at constant slope.

3. Where lining work necessitated or resulted in damage to the MH or the MH benching, it shall be restored to equal or better than original condition and shall meet the requirements for benching as previously specified.

4. Material for benching work shall be Speedcrete, 20 MPa or an approved equivalent product.

TS 4.10.29 CCTV Inspection of Completed Rehabilitation – V3

1. After completion of all work in the lining of the sewer section including reinstatement of SCs and MH benching, a CCTV inspection—called the V3—of the full length of the sewer section lined shall be done and submitted to the CA. The V3 shall be done according to the requirements for CCTV inspection and reports in this specification. The CA will review the V3 as part of its acceptance process for the lined sewer.

2. If, 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 CA.

3. Sewer defect coding is required for the V3.

TS 4.10.30 Samples of CIPP Liner and CIPP Liner Resin

TS 4.10.30.1 Resin Samples

1. Resin sample shall come from liners to be installed and shall be provided to the CA. The sample should be marked with the following:

    a. Contract Number
    b. Date
    c. MH to MH reference of CIPP liner where resin was used.

2. The CA may arrange for the resin sample to be tested by infrared (lR) analysis and compare the resulting spectrograph to the reference spectrograph provided in the tender submission for the resin identified for use by the Contractor for the CIPP lining work.

3. All field resin samples supplied for this Contract shall produce IR spectrographs that correspond to the reference IR spectrograph.

TS 4.10.30.2 CIPP Liner Samples – General

1. The Contractor shall provide a field cured cylindrical liner sample for each liner installation for sewer sizes up to and including 450 mm. A liner installation can be one or multiple sewer sections installed continuously at once.

2. Contractor shall produce the sample on site at the time of liner installation and ensure its delivery to the agreed upon CA approved third party testing agency within 1 week of production.

3. The Contractor shall be completely responsible for all activities pertaining to all sampling and testing efforts, including:

    a. Preparation of samples
    b. Delivery to testing agency
    c. Testing of samples
    d. Storage of samples
    e. Reporting of results directly to the CA
    f. Disposal of samples

g. Maintaining chain of custody

~~4.~~ Plate type samples will only be considered for sewer sizes greater than nominal 450 mm. The CA will not accept plate type samples unless the Contractor can demonstrate to the satisfaction of the CA that a restrained pipe samples cannot be done for a specific installation.

5. Direct cut samples from installed CIPP liners may be required due to the size of the liner, curing method, or concerns over the sampling methods employed by the Contractor. Where directed, the Contractor shall obtain a sample of the installed CIPP liner from within the host pipe.

6. The length and size of any sample shall be sufficient to obtain at least five (5) test specimens for testing. The sample from which the test specimens are cut shall be sufficiently large so that sample edge effects can be eliminated from the test specimens. Sample size shall allow test specimen length of 16 times liner thickness for non-reinforced CIPP (CIPP-S) and 32 times liner thickness for reinforced CIPP (CIPP-R), plus at least 100 mm additional sample length to eliminate edge effects. For example, a sample for a 300 mm by 6 mm thick non-reinforced liner shall be at least 16 x 6 mm = 96 mm + 100 mm = 196 mm long.

7. For further information on sampling methodology, refer to ASTM F1216 Section 8.

TS 4.10.30.3 Sample Identification

1. The Contractor shall identify each sample by permanent marker with the following identifying information: Contract number, lining section number, MH number (or other removal location ID), sewer type (sanitary, storm, combined, culvert), sewer size and date of sample removal.

TS 4.10.30.4 Hot Water or Steam Cured CIPP Liners - Confined Pipe Samples

1. For sewer sizes up to and including 450 mm the sample shall be a restrained sample made by extending the liner installation through a cylindrical form. The sample form shall be located at an intermediate or end MH. The inside diameter of the form shall closely approximate the inside diameter of the sewer being lined. The form shall not expand or otherwise distort during sample forming or curing.

2. Provide necessary forms of the same diameter as the host pipe and secure a minimum 200 mm long full diameter confined test sample from each CIPP liner installation. Large diameter CIPP liners utilizing reinforcing may require a longer sample length; confirm with the testing agency.

3. The Contractor shall make sure that the environmental conditions under which the sample is made result in a cured sample that has properties representative of the cured liner within the sewer being lined. Confined test sample forms shall be completely encased in sandbags or a similar medium to form a heat sink and replicate the install conditions of the CIPP liner.

TS 4.10.30.5 Hot Water or Steam Cured CIPP Liners – Plate Samples

1. Plate type samples will only be considered for sewer sizes greater than nominal 450 mm. The Contractor shall provide a plate type sample for each liner inversion over 450 mm. An inversion can be one or multiple sewer sections installed continuously at once.

2. Test plate samples shall be produced from a full thickness portion of the liner (where possible), shall contain the same resin and hardener ratios and volumes used in the CIPP liner wet-out. Ensure the test plate is clamped as close to the final installation thickness of the CIPP liner as possible.

3. For unreinforced liners the minimum dimension of test plate sample shall be 300 mm x 300 mm.

4. For reinforced liners the test plate sample shall be sized to accommodate a 32:1 span to depth (liner thickness) ratio. Circumferential reinforcing fibres shall be orientated in the long dimension of the test plate sample. Minimum dimensions for the test sample shall be as follows. Confirm the required test plate size for reinforced liners with the CA prior to installation of the CIPP liner.

    a. Width: 13 times the thickness of the liner
    b. Length: 35.2 times the thickness of the liner

5. Prepare test plate samples on-site from the actual CIPP and cure in the following manner:

    a. in a clamped mold placed in the downtube or manhole for water-cured liners.
    b. In a clamped mold placed in a container filled with uniformly distributed steam from the installation manhole for steam-cured liners.

6. The Contractor shall remove the cured sample (in its form) from the cured liner and, after identifying the sample, provided the sample in its form to the CA. Where plate samples are provided, the Contractor shall provide just the plate to the CA.

7. The City reserves the right to change these requirements if deemed necessary or to request that samples by taken from any particular location at any time. The samples shall be used for inspection and testing purposes.

8. In instances, where plate type samples are accepted a de-rating of the measured material properties will be applied based on comparisons between plate and pipe samples on the project. A minimum of 3 prior installations with comparable results is required. Where comparable plate and pipe samples are not available, a de-rating percentage of 15% and 18% will be respectively applied to the flexural modulus and flexural strength values obtained from the sample test result(s), in accordance with the North American Society for Trenchless Technology (NASTT) Cured- In-Place Pipe (CIPP) Good Practices Guideline First Edition. The de-rated flexural modulus and flexural strength values will be used to verify the Contractor’s compliance with the contract specifications.

TS 4.10.30.6 UV Cured Liners - Sampling Methodology

1. The sample size shall be suitable to obtain sufficient test coupons for either ISO 11296-4 or ASTM D790 testing (as applicable to sample type) for flexural strength, flexural modulus and for measuring liner thickness around the circumference depending on the type of sample and how tested.

2. For sewer sizes up 375 mm the sample type shall be restrained cylindrical samples made in full circumference forms positioned in a MH, through which is run an extension of the liner being installed. The inside diameter of the forms shall be the same as the inside diameter of

the sewer being lined. The form shall have sufficient strength such that it does not expand under the heat and pressure of the liner installation and cure process. The length of the form shall be sufficient to provide a sample of liner 400 mm long. The forms shall be covered with material to maintain a cure heat environment similar to the cure heat environment for the liner within the sewer pipe.

3. For sewer sizes larger than 375 mm, if it is not possible or practical (due to space, access or safety limitations) to obtain formed cylindrical sample, then samples taken from pieces of cured liner removed in the liner opening process may be suitable for testing purposes.

4. When samples from pieces of cured liner are not suitable or are not representative of the liner within the sewer, then a sample shall be cut from the liner within the sewer.

TS 4.10.30.7 Direct Cut CIPP Samples

1. Where a test sample is required and there is no other method of obtaining it, a sufficiently large sample shall be cut out from the liner within the pipe (Direct Cut Sample). For reinforced liners, the configuration of the cut out sample shall allow for ISO 11296-4 test method (curved test coupons from around the circumference of the liner).

2. Direct samples of the CIPP liner shall be a minimum of 300 mm x 300 mm for unreinforced liners.

3. For reinforced liners the test plate sample shall be sized to accommodate a 32:1 span to depth (liner thickness) ratio. Circumferential reinforcing fibres shall be orientated in the long dimension of the test plate sample. Minimum dimensions for the test sample shall be as follows. Confirm the required test plate size for reinforced liners with the CA prior to installation of the CIPP liner.

    a. Width: 13 times the thickness of the liner
    b. Length: 35.2 times the thickness of the liner

4. Cut the test sample from a location where no defects were noted in the host pipe and at the 10:00 o'clock or 2:00 o'clock position in circular sewers. Direct samples from reinforced liners in non-circular sewers shall be oriented with the long dimension vertically in the straightest portion of the sewer. Confirm sampling locations with the CA prior to work.

5. Grout the area where test sample was taken with a resin-rich repair product such as an epoxy-based repair system that is compatible with the liner system and specifically designed for the nature, size and thickness of the patch being repaired to form a smooth watertight patch flush with liner. For liners thicker than 25 mm, a polymer concrete repair product or fibre reinforced cementitious rehabilitation product may be utilized.

6. Provide photographic evidence of the repair and ensure repairs at direct sampling locations are captured during subsequent CCTV inspections.

TS 4.10.30.8 Samples to be Representative of the Installed Liner

1. It is the Contractors responsibility that all samples shall be representative of the installed liner inside the pipeline in regard to properties and thickness.

2. When the CA or Contractor has reason to believe that the sample is not representative of the installed liner the sample shall not be used to develop test results that may be used to deem the liner either deficient or acceptable.

3. Where a sample is found to be not representative of the installed liner, either by the CA or the Contractor, the Contractor shall provide a sample that is representative in regard to properties and thickness of the installed liner.

4. If the CA requested that a replacement sample be obtained, and the replacement sample is not deficient in properties or thickness, the Contractor shall be paid for the replacement sample under the applicable pay item.

TS 4.10.31 Testing of Samples of Cured Liner

TS 4.10.31.1 General

1. The Contractor shall pay for the cost for testing of samples of cured liner at an independent testing agency. The testing agency shall be subject to the acceptance of the CA. The Contractor shall authorize the testing agency to forward the test reports to the CA and to communicate with the CA concerning the testing and results. The Contractor shall provide for and arrange for the delivery of the samples in custody to the testing agency unless stated otherwise in the PD.

2. Samples shall be tested for the CIPP liner properties used in the CIPP liner design and sample thickness. Typically, the properties tested will include flexural modulus and flexural strength for designs by the ASTM F1216 Appendix X1 and WRc SRM Type II methods. For designs by the ASCE MOP 145 method, testing may be required to include further properties. Testing of flexural properties shall use either ASTM D790 or the ISO 11296-4 as appropriate for the type of liner and type of sample. The provision of testing service shall allow for the obtaining of test reports within 7 Days of delivery of the sample to the testing agency.

3. The Contractor shall provide for the testing agency to forward test reports by e-mail to the CA.

4. The Contractor shall provide the test agency with the LDPR and the following design parameters for each liner:

    a. flexural strength
    b. reduction in flexural strength used for design life
    c. flexural modulus
    d. reduction in flexural modulus used for design life
    e. other properties as may be required for liner designs by ASCE MOP 145 method

5. The values of these properties shall have been identified in the Contactor's liner design. The testing agency's report shall reference these values as the specified values.

6. All test reports received shall at a minimum include the following:

    a. Header information identifying the sample "PASS" or "FAIL"
    b. Header information identifying the sample as described on the sample in addition to City contract number.

c. Date sample was received and date when sample was tested.
d. Photograph of the sample as received, both side and end profile
e. Identification of each test performed and its associated results
f. Graphical presentation of the flexural property test from beginning of applied loads to end of test.
g. Photograph of each broken specimen identified by the specimen number used to report the test result.
h. Signature of technician who completed the test and signature of report reviewer.
i. Copy of the Chain of Custody (COC) form.
j. Summary sheet of all samples taken and tests completed under the contract (referenced by the Contract Number) shall be provided with the final delivery of test reports.

TS 4.10.31.2 ISO Testing Methods

1. The ISO 11296-4 testing method shall be used for all restrained cylindrical samples from CIPP-R (such as UVC and other reinforced liners), and any curved samples cut out from a CIPP-R liner within the sewer.

2. At the Contractor's option the ISO 11296-4 can be used on cylindrical samples from CIPP-S.

3. The ISO 11296-4 method tests curved specimens that are cut out around the circumference of liner sample. This requires either a restrained cylindrical sample of liner, which is made in a cylindrical form with the form's inside diameter very similar to the inside diameter of the sewer being lined or a curved sample cut out of the liner within the sewer.

4. When the ISO 11296-4 test method is used ISO 7685 shall be used to determine liner structural thickness.

TS 4.10.31.3 ASTM Testing Methods

1. The ASTM D790 test method shall be used for straight and flat test specimens cut from the liner sample along its length. This type of specimen can be cut from a cylindrical restrained sample (of sufficient diameter), a flat plate sample or other available pieces of liner large enough for obtaining test coupons. When using the ASTM D790 method, a cylindrical restrained sample is the preferred sample as it better represents the liner inside the sewer than either random pieces of liner or formed flat plate samples. For CIPP-R cutting test specimens longitudinally from confined pipe cylindrical samples is not recommended, as test results will be suspect.

2. When the ASTM D790 test method is used ASTM 5813 shall be used to determine liner structural thickness.

TS 4.10.32 Reinstatement of Sewer Service Connections

1. Reinstatement of SCs shall be carried out according to the approved method statement.

2. All live SCs shall be opened to their full diameter, and the interface with the liner made leak tight by remote means. Where the pipeline size is suitable for person entry, remote means are not required. Person entry must conform to all confined space entry requirements.

3. SCs must be reinstated to the entire opening of the SC or SC pipe, whichever is the greater. No sleeve or liner protrusions, sealer, grout or other foreign material is permitted to remain within the service connection.

4. Following any liner installation that covers a live SC, the Contractor must open the SC to a minimum of 75 per cent to prevent any service backups. All SCs must be fully opened by no later than the next day. If there are any service backups prior to service connection being fully open, the Contractor will be responsible for service backup remediations.

5. Whenever live SCs are to be covered or blocked by a liner installation, the Contractor shall provide a 48-hour advance Service Disruption Notice to all affected parties. Such notice shall 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 advance notification.

6. If the Contractor is unable to install the liner on the date stated in the Service Disruption Notice the Contractor shall immediately provide written notification of the change of date including the new date for the liner installation. After the SC has been reinstated the Contractor shall provide written notification to all affected parties that their SC is again in service. The notification format shall be submitted to the CA for acceptance prior to the commencement of work on this Contract.

7. 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 SC is blocked at the sewer. When requested such toilets shall be delivered prior to any SCs being blocked in the sewer and shall be promptly retrieved by the Contractor upon SC reinstatement.

8. Any debris resulting from the work shall be removed at the nearest downstream maintenance hole. Passing material from sewer section to sewer section shall not be permitted. The Contractor shall employ a screen or some other suitable method in the nearest downstream maintenance hole in order to prevent any debris or other material from migrating downstream. Such debris or material from the maintenance hole shall be removed and properly disposed.

9. The Contractor shall maintain a detailed record of the date and time when the reinstatement of each SC was initially opened and when finally completed. This information shall be entered on the Service Connection Record.

TS 4.10.33 Test Results: Requirements, Deficiency & Reconciliation

TS 4.10.33.1 Test Result Requirements

1. The test results for all liner properties shall meet or exceed the required values. The required value for a property is the value used in the applicable final CA accepted design or the minimum value required by this specification, whichever is greater.

2. The test result for liner thickness shall meet or exceed the required thickness. The required thickness is the thickness determined by the final CA accepted liner design or the minimum thickness required by this specification, whichever is greater.

TS 4.10.33.2 Test Result Deficiency

1. When any test result for liner properties does not meet or exceed the required value, the liner will be deemed initially deficient and subject to a design reconciliation providing the criteria permitting design reconciliation are met. The design reconciliation, when permitted, may or may not clear the deficiency.

2. When the test result for liner thickness does not meet or exceed the required thickness, the liner will be deemed initially deficient and subject to a design reconciliation providing the criteria permitting design reconciliation are met. The design reconciliation, when permitted, may or may not clear the deficiency.

TS 4.10.33.3 Design Reconciliation

1. Design reconciliation determines the required liner thickness based on as-tested liner properties. For design reconciliation, the as-tested properties are substituted for the originally used liner properties in the final CA accepted design 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.

2. Design reconciliation is not permitted when as-tested properties or thickness do not meet the minimum requirements in this specification unless an exception is granted by the CA.

~~3.~~ The Design Reconciliation may be done by the Contractor and submitted to the CA for acceptance of the outcome. Alternately the CA may perform the Design Reconciliation and provide the results to the Contractor.

4. When the Design Reconciliation does not clear the deficiency, the liner remains deficient and the Contractor shall provide a plan for remedial action that is acceptable to the CA. The Contractor shall rectify the deficiency by whatever action is necessary.

TS 4.10.34 CCTV Inspection for Warranty – V4

1. Where required the Contractor shall complete a warranty (V4) inspection.

2. A full-length inspection section lined shall be done and submitted to the CA. The V4 shall be done according to the requirements for CCTV inspection and reports in this specification. The CA will review the V4 as part of its review for completion of the Warranty period.

3. If a deficiency that requires repair or remediation is identified in the lined sewer section after the V4, the V4 shall be redone and submitted to CA after the repairs or remedial action have taken place.

4. Sewer defect coding is required for the V4.

TS 4.10.35 Deficiencies

TS 4.10.35.1 General

1. A deficiency will exist when the work, or the results of the work, is/are not according to the PD.

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

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

4. Where in the CA's opinion, there is no repair or correction that is satisfactory for the installed CIPP liner, the CA may require removal and replacement of the CIPP liner or require an alternate resolution at the discretion of the CA.

5. The specific deficiencies addressed below are examples and do not represent all the deficiencies that may occur.

    a. Excessive Fining or Wrinkling

        i. Excessive liner material shall be removed to the acceptance of the CA at no cost to the City. Where excessive material cannot be removed without compromising the structural integrity of the liner, the Contractor shall take other remedial action as acceptable to the CA.

    b. Bulges, Lifts, Sags, Separations and Delaminations

        i. There shall be no bulges, lifts or sags in the liner that are not consistent with the surface profile of the existing sewer before lining. Such bulges, lifts or sags will be considered an indication of a structural deficiency in the liner and will require remedial action. Where bulges, lifts or sags are suspected or proven to contain internal separations or delaminations within the wall of the liner, remedial action up to and including removal and replacement of the liner will be required.

TS 4.10.35.2 Remedial Action

1. Where deficiencies are identified, the Contractor shall perform the remedial action that is acceptable to the CA in a timely manner without unreasonable delay.

2. Where a deficiency will seriously impact sewer or SC flow capacity and is considered likely to cause sewer back-ups onto properties or other overflows, the Contractor shall take immediate action to prevent such problems without waiting for acceptance of remedial method from the CA. In such case, the final resolution of a deficiency, if required, shall be by a method acceptable to the CA.

3. The cost of any work to rectify a deficiency is the responsibility of the Contractor.

TS 4.10.36 Payment

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

TS 4.10.37 List of Appendices

Appendix A: Service Connection Record (SCR)
Appendix B: Service Connection Investigation Procedure
Appendix C: Anticipated Changes to TS 4.10 for Future Years

TS 4.10 Appendix A: Service Connection Record

SL# _____ **Date _____ Page # ____ of ____**

Street Name	Contractor's Name	Distance Between MH (Camera)	Sewer Diameter (mm)	From MH ID	To MH ID	Camera Direction	Total No. SC	Total No. Live SC

SC Address	Live (Yes/No)	Visible Plug (Yes/No)	Camera Distance from MH ID	Clock Position	SC Size (mm)	SC Material	SC (P/F/R)	SC Open (Date)	SC Open (Time)	Comments

TS 4.10 APPENDIX B
Service Connection Investigation Procedure

Where a service connection investigation is required, the Contractor, in accordance with the approved procedure, shall investigate the sewer section(s). 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.

As per base scope, 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 (provisional item or additional cost) —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

The Contractor shall obtain an accurate measurement to the centre line of each service, either by remote means or physical measurement verified with the electronic distance counter utilized in the CCTV recordings.

The reference point for all measurements shall be at the intersection of the sewer obvert and the inside wall of the maintenance hole and mark the reference location with permanent marking where feasible.

The Contractor shall carry out testing to the extent necessary to confirm whether or not each drain connection is live. Use different and distinct colours of dye to determine the source when multiple locations are being dye tested at once. If necessary to confirm the status of a particular drain, testing of the following shall be carried out:

1) 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.

2) Catch basins, hydro chambers and vaults and adjacent lane drains in the vicinity of the drain connection.

3) 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.

TS 4.10 APPENDIX C
Anticipated Changes to TS 4.10 for Future Years

Changes Anticipated Starting January 1, 2027

To: TS 4.10.25 Design Requirements for CIPP Liners,
TS 4.10.25.5 Standard Design Parameters, Table 3A

Flexural Modulus Value to be used in design equations.
Change:
The long-term testing to determine the Creep Reduction Factor (CRF) shall be performed at a minimum applied stress level of 0.0025 times the liner's flexural modulus.

Flexural Strength Used in Design Equations
Change:
For design, the flexural strength shall be reduced by a Creep Rupture Reduction Factor (CRRF). The CRRF shall account for the effect of creep rupture over the design life of the liner. The CRRF shall be derived from long-term testing according to ASTM 2990 (or ISO equivalent).