

**Specification for the
Cured-In-Place Pipe Lining of Sewers**

Table of Contents

TS 4.10.01	Scope	3
TS 4.10.02	Information to be Reviewed Prior to Bid Submission	3
TS 4.10.03	Information to be Submitted with Bid.....	3
TS 4.10.04	Notification to Public	4
TS 4.10.05	Site Investigation	4
TS 4.10.06	Existing Video Inspection Records and Drawings	5
TS 4.10.07	Excavations for Retrieval of Equipment or Other Purposes.....	5
TS 4.10.08	Weather Conditions	5
TS 4.10.09	Flow Control and Bypass	6
TS 4.10.10	CCTV Inspections and Reports.....	7
TS 4.10.11	CCTV Truck Units	10
TS 4.10.12	Preliminary CCTV Inspection – V1.....	10
TS 4.10.13	Field Measurement of Sewers and Liner Sizing.....	11
TS 4.10.14	Service Connection Statement	11
TS 4.10.15	Service Connection Investigation.....	11
TS 4.10.16	Service Connection Investigation Procedure	11
TS 4.10.17	Sewer Cleaning and Preparation for Lining	13
TS 4.10.18	Sewer Reaming, Cutting and Grinding.....	13
TS 4.10.19	Filling of Voids	14
TS 4.10.20	Post Cleaning and Preparation CCTV Inspection – V2.....	15
TS 4.10.21	Materials and Standards.....	15
TS 4.10.22	Design Requirements for CIPP Liner.....	16

TS 4.10.23	Fit, Finish and Properties Requirements	18
TS 4.10.24	Installation of CIPP Liner	19
TS 4.10.25	CCTV Inspection of Completed Rehabilitation – V3.....	20
TS 4.10.26	Samples of Resin and Cured Rehabilitations.....	20
TS 4.10.27	Testing of Samples of Cured Liner.....	21
TS 4.10.28	Reinstatement of Sewer Service Connections	22
TS 4.10.29	Liner Sample Test Results – Reconciliation and Deficiency	23
TS 4.10.30	Deficiencies	26
TS 4.10.31	Payment	26

TS 4.10.01 Scope

This specification is for Cured-in-Place Pipe (CIPP) lining of various maintenance hole to maintenance hole sections of sewers in the city of Toronto. The sewers may include sanitary sewers, storm sewers and combined sewers.

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

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

TS 4.10.02 Information to be Reviewed Prior to Bid Submission

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

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

TS 4.10.03 Information to be Submitted with Bid

The Tender Call requires the following information to be submitted with the Bid for the review and approval of the Contract Administrator. Further information could be required to be submitted elsewhere in the Tender Call other than in TS 4.10 herein.

Submit with Bid:

- 1) The name of a professional engineer 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).
- 2) CIPP liner design for all sewer sections identified in the Tender Call: The liner design shall be according to TS 4.10 herein. The designs shall bear the seal and signature of an Engineer.
- 3) A CIPP liner design example if no sewer sections are identified in the Tender Call: The liner design example shall be submitted according to TS 4.10 herein. The example designs shall be illustrative of future designs that shall be submitted during the Contract. As sewer sections are identified during the contract, the designs submitted shall bear the seal and signature of an Engineer.

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- 4) Material specifications and structural details of the proposed sewer liner in sufficient detail to enable confirmation by the Contract Administrator 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.
 - 5) A complete list of equipment including CCTV cameras, robotic service connection cutters, reamers and other necessary major items to be dedicated to the work. The list of equipment shall specify type, manufacture and quantity of equipment.
 - 6) 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.
 - 7) A certified original copy complete with supporting literature from the resin manufacturer of the Infrared Spectrograph of the catalyzed resin mixture proposed for this Contract.

TS 4.10.04 Notification to Public

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

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

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

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

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

TS 4.10.05 Site Investigation

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

TS 4.10.06**Existing Video Inspection Records and Drawings**

The Contract Administrator 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 monthly basis during the contract. The method of provision either in full or incrementally will depend on the structure of the specific contract tender including the structure of schedule of unit prices and quantities.

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

TS 4.10.07**Excavations for Retrieval of Equipment or Other Purposes**

Where the retrieval of lodged equipment is required by open-cut excavation, the Contractor shall provide for retrieval including any excavation, maintenance of flow, repair, backfill and restoration. However, if the equipment became lodged in a portion of a sewer section for which no previous CCTV inspection or other advice 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. However, the City will not entertain any other associated cost related to this work.

All such work shall be performed by an approved sub-contractor and shall be completed according to City standards and specifications.

If it is necessary to excavate for any reason such as repair of defective liner, reinstatement of service connections or bypass of flow, the Contractor shall provide such excavation, repair, backfill and restoration as required. However, dependent on the reason why an excavation is required and at the discretion of the Contract Administrator, additional payment for such work may be negotiated with the Contractor. In such case where the work is determined by the Contract Administrator to be an extra to the Contract, the work shall not proceed without the approval of the Contract Administrator prior to the work.

All such work shall be performed by an approved sub-contractor and shall be completed according to City standards and specifications.

TS 4.10.08**Weather Conditions**

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 blocked laterals due to the liner, commencement of construction shall be delayed until favourable weather is forecast.

This applies to all storm, sanitary and combined sewers to be lined.

TS 4.10.09 Flow Control and Bypass

When interruption of sewer line 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. Where bypass pumping is used, flow control shall be according to TS 4.01 – *Construction Specification for Temporary Sewer Bypass System*.

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

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

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

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

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

Flow Control Included Limit Provision

The Contractor shall provide for all bypass capacity up to and including 150 mm pump configurations where a 150 mm pump shall have a minimum capacity of 4540 L/min (1200 USGPM). The Contractor shall be responsible for determining the bypass capacity. Where the Contractor has determined that the bypass requires capacities exceeding 4540 L/min, the Contractor shall advise the Contract Administrator of the requirement and any additional cost for the higher bypass capacity. The Contract Administrator shall provide further instruction to the Contractor as needed including, as required, negotiation of additional payment for the bypass capacities exceeding 4540 L/min.

Sufficient Capacity for Flow Control

No flow control or bypass pumping shall be employed that has insufficient capacity to maintain flow in the sewer system. It is the Contractor's responsibility to employ 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*.

TS 4.10.10**CCTV Inspections and Reports**

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

CCTV Equipment

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

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

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

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

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

Sewer Conditions for CCTV Inspections

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

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

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

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

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

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

Notice to City of Inspections

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

CCTV Screen Information

The sewer section video inspection shall include the Title Screen in the format indicated below, clearly displayed for a minimum of 30 seconds at the start of all video inspection recordings. Inspection of the sewer section shall not proceed while the information screen is being displayed:

Line Number	TITLE SCREEN
1	CITY OF TORONTO CONTRACT No. 12345
2	SL – 9 STREET: NIAGARA ST.
3	PRELIMINARY / POST-PREPARATION VIDEO
4	DATE: 21 MAR/99 TIME: 11:55 AM
5	SURFACE DISTANCE: 112.0 M
6	START MH No: 23 2ND S/O WELLINGTON
7	END MH No: 22 1ST S/O WELLINGTON
8	WEATHER: DRY / RAIN / MELTING SNOW / etc.
9	FLOW DIRECTION: N TO S
10	CAMERA DIRECTION: S TO N
11	START & S/C REFERENCE POINT: CAMERA PANNED 90°
12	SIZE: 305 mm TYPE: CLAY DUTY: COMBINED
13	CONTRACTOR: ACME LINERS INC.

Upon commencement of, and throughout the inspection, the following information shall be continuously displayed on-screen and captured on the recording: start and ending maintenance hole numbers, street name, continuous chainage, and feature/defect coding.

Sewer Condition and Defect Coding

The CCTV inspection shall include condition, feature and defect classification coding according to the Water Research Council (WRc) *Manual of Sewer Condition and Classification* Third Edition.

CCTV inspection and defect coding shall be carried out by former North American Association of Pipeline Inspectors (NAAPI) certified operators. New operators and operators with an expired NAAPI certification over three years must provide sufficient evidence of training by an approved entity such as an individual or association that has been approved by the Contract Administrator.

The Contract Administrator may at any time during this contract specify a form of training or certification to be undertaken by inspection operators based on the current standard or any other industry standard the City adopts in the future.

Inspection Information Recorded as Sewer.dat File

The CCTV inspection equipment and software shall make and record a WRc sewer.dat file of the inspection. The sewer.dat file shall capture all the information required to describe the main liner sewer or service pipeline. However defect coding in accordance with the required WRc sewer condition classifications is not required for either the main line sewer or the service pipeline. The sewer.dat file shall be according to the City's requirements for such files. Prior to the regular contract required submissions of CCTV inspections/reports, the Contractor shall submit a trial sewer.dat file of an inspection for approval by the Contract Administrator.

CCTV Video Recording File Format and Conventions

The required video recordings of CCTV inspections shall be provided to the Contract Administrator on Digital Video Disc (DVD) or approved alternate media.

The video file format shall be MPEG-1 or MPEG-2. The MPEG files shall be of a minimum video size resolution of 320 x 240 and encoded at a rate of no less than 750 kb/s

The MPEG file naming convention shall be:
startmaintenancehole_finishmaintenancehole_direction_MMDDYY.mpg
where direction is either "U" for upstream or "D" for downstream

The CCTV video recording must be indexed to the textual data. The field survey must record the time index on the video, which shows the image(s) corresponding to the text record. The indexing must include the start time of the entire survey and the exact time number for each pipe feature/defect recorded in the data. This indexing will permit the user to view a particular sewer pipe or a particular feature/defect in a pipe, after inserting the appropriate DVD, and then advance to the stored time index in the MPEG file, then display the image(s):

A DVD referencing ID shall be created using the following format.
YYYYMMDDCCCCTT (year, month, day, contractor, disk number) and clearly labeled.

CCTV Inspection Video Player Requirements

CCTV inspection video files shall play properly and completely on commonly used video file playing software applications. The video files must play properly and completely on correctly configured, up to date versions of Microsoft Windows Media Player, VideoLAN VLC Player and Apple QuickTime Player. Video files that do not play properly and completely on all these three players will be rejected. The Contractor is advised that playback problems often can be traced back to the software or equipment that was used to generate the MPEG files. Playback problems often also can be traced back to DVD burning software and equipment that may compress (or otherwise corrupt) files resulting in a file that will only play properly on a specific video player.

Inspection Reports

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

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

CCTV Inspection Submission

When a required CCTV inspection has been completed, it shall be submitted to the Contract Administrator on a properly identified DVD or other media approved by the Contract Administrator. The submission for a sewer service shall include the video file, the sewer.dat file and the PDF report file. These three files shall be grouped together on the DVD along with any other information relevant to the specific CCTV inspection such as images from the inspection. The grouping shall be identified by the street number corresponding to the sewer service inspected.

A single DVD may include CCTV inspections for more than one sewer service. In this case, the DVD shall be properly organized with each CCTV inspection submission in its own folder. Such folders shall be clearly and properly identified in regard to the sewer service to which it pertains by the street number corresponding to the sewer service inspected.

The reports shall be in a format that will enable direct down loading of the data into a data management system.

CCTV Inspections Submission Schedule

The Contractor shall submit the CCTV inspection DVD(s) to the Contract Administrator every 14 Days or as agreed with the Contract Administrator.

TS 4.10.11 CCTV Truck Units

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

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

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

TS 4.10.12 Preliminary CCTV Inspection – V1

The Contractor shall make a preliminary CCTV inspection—called the V1—of the sewer section before undertaking any work required for the 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 Contract Administrator. Significant changed condition means a condition that will prevent lining of the section, require an unexpected excavated repair before lining, require a change in the liner design resulting in an increased liner thickness to deal with the changed condition or any other situation, which in the Contract Administrator's opinion, is a significant changed condition.

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

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

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

Sewer defect coding is not required for the V1.

The V1 CCTV inspections shall be submitted to the Contract Administrator according to the requirements of TS 4.10 herein.

TS 4.10.13 Field Measurement of Sewers and Liner Sizing

The Contractor shall measure the internal diameters of the sewer sections to be lined and the length of the sections to be lined. The measurements taken shall be suitable for proper sizing of the liners to be installed. Refer to requirements for CIPP Liners in TS 4.10 herein. The Contractor shall not rely on dimensions provided by the City. Measurements shall be provided to the Contract Administrator on request.

TS 4.10.14 Service Connection Statement

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

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

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

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

TS 4.10.15 Service Connection Investigation

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

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

TS 4.10.16 Service Connection Investigation Procedure

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

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

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

- property serviced by the drain
- location of drain relative to reference maintenance holes
- result of dye testing—live or dead drain
- size of drain

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

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

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

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

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

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

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

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

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

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

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

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

TS 4.10.17 Sewer Cleaning and Preparation for Lining

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

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

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

Disposal of Materials

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

The Contractor shall submit its MOE license with the Bid.

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

TS 4.10.18 Sewer Reaming, Cutting and Grinding

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

Reaming Tolerances

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.

Protruding Service Connections

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

Precaution to Prevent Damage to the Sewer Section

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

TS 4.10.19 Filling of Voids

Voids Identified for Filling in the Contract

The Contractor shall fill voids as specified for filling in the Contract Documents. Void filling shall ensure structural integrity of the lined sewer and prevent bridging by the liner. The Contractor shall submit for the approval of the Contract Administrator a detailed method statement outlining the procedures and materials to be used in filling the voids. The method statement shall correspond with requirements that may be specified for void filling such as in the Contract's Sewer Section Lining Summary Table.

Voids Requiring Filling Not Identified in the Contract

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

TS 4.10.20**Post Cleaning and Preparation CCTV Inspection – V2**

After completion of the cleaning and preparation of the sewer section including all reaming, cutting, grinding 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.

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

On its discretion, the Contract Administrator may waive the requirement for the V2 to be submitted for approval 2 Days prior to lining, such as when approval for lining was provided at a live viewing of the V2 by a City representative. However, in such cases the V2 submission shall always be submitted at a later time.

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

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

TS 4.10.21**Materials and Standards**

The sewer lining shall be cured-in-place-pipe (CIPP) according to the requirements of ASTM F1216-09 for inverted liners or ASTM F1743-08 for pulled in place liners or ASTM F2019-03(2009) for reinforced pulled in place liners and ASTM D5813-04(2008).

The lining system shall be capable of receiving Ontario Ministry of Environment approval and of carrying effluent within the limits of the current Toronto Municipal Code, Chapter 681 Sewers, without adverse effect on the lining or the effluent.

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.

The quantity of resin used in the liners and its impregnation shall meet with the requirements of the applicable ASTM standard such as ASTM F1216-09, section 7.2.

The CIPP liners shall be according to the CIPP liner design specified in TS 4.10, herein.

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 Contract Administrator prior to use.

TS 4.10.22**Design Requirements for CIPP Liner**

The lining design shall be according to ASTM F1216-07-a Appendix X1, Design Considerations for the fully deteriorated pipe condition. The liner design shall determine the liner thickness required for the liner installation location. The design shall be in accordance with the design parameters shown in the table below. The thickness determined by the liner wall thickness design shall be the required wall thickness of the completed liner.

The Contract Administrator reserves the right to reject the design method used, if in the Contract Administrator's opinion, is not consistent with the requirements of TS 4.10 herein.

Engineered designs for each sewer section to be lined shall be approved by an Engineer bearing the seal and signature of an Engineer authorized to perform such work by Professional Engineers Ontario (PEO).

Designs shall be submitted to the Contract Administrator for approval. No lining shall be installed without an approved design.

Designs Correct for Field Conditions

The Contractor shall check and determine that actual field conditions for any liner installation sewer section correspond with the liner design for that installation. The field conditions to be checked shall include deepest depth to invert, ovality of the existing sewer and live load situation. Where the existing liner design is not appropriate for the field conditions, the Contractor shall adjust the liner design accordingly and the liner installed shall meet the requirements of the adjusted design. The adjusted liner design shall be submitted to the Contract Administrator for approval.

Where a liner design previously approved by the Contract Administrator is found needing adjustment due to determined actual field conditions, the Contractor shall advise the Contract Administrator within 48 hours and wait for the Contract Administrator's instructions. Where the adjusted design results in a thicker liner to be installed, any additional cost involved shall be determined according to the Contract Price and if Contract Prices are not applicable, then shall be negotiated with the Contract Administrator.

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

Installed Liner Thickness for Comparison with Design Thickness

The wall thickness of the in place, completed liner shall meet or exceed the design thickness. Liner wall thickness measurements and determination of the actual effective thickness shall be according to ASTM D5813-04(2008). Measurements of the actual installed liner wall thickness shall not include the thickness of any non-structural components.

When actual line thickness or liner properties appear to be deficient, design reconciliation based on test result values shall be permitted. Such reconciliation may or may not resolve the deficiency. Refer to design reconciliation procedure in TS 4.10 herein.

Table 1: Design parameters for CIPP liners

Parameter	Requirement
Design Method	ASTM F1216-07a, Appendix X1, Design Considerations X1.2 Gravity Pipe. X1.2.2 Fully Deteriorated Gravity Pipe Condition
Design Life	50 years
Safety Factor	2.0 for all equations
Ovality	3% or the actual ovality of the sewer section, whichever is greater.
External Hydrostatic Pressure	Corresponding to ground water table at 2.0 m below ground surface.
External Earth Load	Based on 2.0 m over top of pipe or the actual height of cover that exists at the liner location, whichever is greater.
Live Load	AASHTO HS-20 or the actual live load that exists at the liner location, whichever is greater.
Soil Weight	18.85 KN/m ³ (1922 Kg/m ³)
Soil Modulus	6.89 MPa
CIPP Liner Flexural Modulus used for design	The flexural modulus used for design shall be the long-term flexural modulus for the design life. The long-term flexural modulus shall be the amount of short-term flexural modulus (according to ASTM D790) retained for the design life. The short-term flexural modulus used shall be the value that will be reliably and repeatedly achieved in liner installations. The retention factor shall be derived from long-term testing and be appropriate for stress and stress duration in the installed liner. Independent third party test data is required (submit with tender) to substantiate the short-term and long-term values used in design. The design must identify the short-term and long-term values. Minimum short-term value shall be in accordance with the minimum requirement in ASTM F1216-07a (1724 MPa).
CIPP Liner Flexural Strength used for design	The flexural strength used for design shall be the long-term flexural strength for the design life. The long-term flexural strength shall be the amount of short-term flexural strength (according to ASTM D790) retained for the design life. The short-term flexural strength used shall be the value that will be reliably and repeatedly achieved in liner installations. The retention factor shall be derived from long-term testing and be appropriate for stress and stress duration in the installed liner. Independent third party test data is required (submit with tender) to substantiate the short-term and long-term values used in design. The design must identify the short-term and long-term values. Minimum short-term value shall be in accordance with the minimum requirement in ASTM F1216-07a (31 MPa).

Short-term Flexural Modulus and Short-term Flexural Strength

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

TS 4.10.23 Fit, Finish and Properties Requirements

The completed installed liner shall conform to the properties in Tables 2.

Table 2: Fit, finish and property requirements

Item	Requirement for Liner
Continuity of Liner	The finished liner shall be continuous over the entire length of the liner installation from maintenance hole to maintenance hole without any breaks, separations or joints.
Liner Fit to Existing Sewer Liner	<p>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 or 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.</p> <p>The liner should also be able to negotiate vertical/horizontal elbows and bends with various degrees (angles ranging from 0 to 90 degrees).</p>
Exception to Liner Fit at Existing Sewer Line Irregularities	<p>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 ovalisation 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 ¼ of the liner inside diameter in any direction from the irregularity as measured along the inside surface of the liner.</p> <p>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.</p>
Liner Shape	The liner shape will be as defined by liner fit to existing sewer line. In general the liner shape shall conform to the shape of the existing sewer line inside surface after its cleaning and preparation in accordance with requirements. 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 – subject to the requirements for void filling in TS 4.10. 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.

Liner Wall Thickness and Tolerance

The liner's finished wall thickness shall be as specified in the liner design submitted by the Contractor meeting the requirements of the Contract.

The liner wall thickness shall be determined according to ASTM D5813-04(2008) which specifies a minimum of eight equally spaced thickness measurements around the circumference of the liner including maximum and minimum thicknesses with the effective liner thickness being the average of the measurements. Regardless of the average thickness result, the ASTM D5813 also requires that the minimum thickness at any point shall not be less than 87.5 per cent of the specified thickness. Measurements liner wall thickness shall not include the thickness of any non-structural components.

The wall thickness tolerance is:

- Minus 0%
- Plus 25%

Installed CIPP Liner Physical Properties Requirements

The complete installed liner shall have the following required physical properties:

- Flexural Modulus: Shall meet or exceed the short-term value used in the liner design or the minimum value in the ASTM F1216, whichever is greater.
- Flexural Strength: Shall meet or exceed the short-term value used in the liner design or the minimum value in the ASTM F1216, whichever is greater.

In the case of long-term values of flexural modulus and flexural strength used in design, the liner shall possess the required long-term retention characteristics such that the long-term values used in design will be met by the liner over its design life.

TS 4.10.24 Installation of CIPP Liner

Installation Procedure

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

The liner and its resin should be protected during the installation into the sewer. No significant amount of resin shall be lost by contact with maintenance hole walls or the sewer pipe during the installation. The liner should not be contaminated or diluted by exposure to dirt, debris, or water during the pull.

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

Odour Control

The Contractor shall provide notice to the affected residents indicating possible odour resulting from sewer lining and curing process. The notice shall indicate to the residents what to expect and typical procedures to alleviate odour and include advising residents to ensure all plumbing drain traps are full of water.

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

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

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

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

Cool Down: 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 4.10.25 CCTV Inspection of Completed Rehabilitation – V3

After completion of all work in the lining of the sewer section including reinstatement of service connections and maintenance hole benching, a CCTV inspection—called the V3—of the full length of the sewer section lined shall be done and submitted to the Contract Administrator. The V3 shall be done according to the requirements for CCTV inspection and reports in TS 4.10 herein. The Contract Administrator will review the V3 as part of its approval process for the lined sewer.

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

TS 4.10.26 Samples of Resin and Cured Rehabilitations

Resin Samples – Field

When required, the Contract Administrator will take a sample of resin from an on site wet-out liner tube. The Contractor shall provide necessary assistance in the taking of this sample. The Contract Administrator may have this resin sample tested by infrared (IR) 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.

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

Cured Liner Samples – Field

When required for a liner installation, the Contractor shall make a sample of liner for testing. Requests for samples by the Contract Administrator will be at random and at the discretion of the Contract Administrator. The number of samples required and when samples are required will be at the discretion of the Contract Administrator. The Contractor shall be given 24 hours notice by the Contract Administrator of when a sample is required and must be equipped at all times to make the sample upon this notice

For sewer sizes up to 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 maintenance hole. 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 processing. 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.

For sewer sizes greater than 450 mm, the Contractor shall provide a plate type sample.

For further information on sampling methodology, refer to ASTM F1216-09 Section 8.

The length and size of any sample shall be sufficient to obtain at least five test specimens for ASTM D790 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 and 32 times thickness for reinforced CIPP 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 $16 \times 6 = 96 \text{ mm} + 100 \text{ mm} = 196 \text{ mm}$ long.

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 Contract Administrator. Where plate samples are provided, the Contractor shall provide just the plate to the Contract Administrator. The Contractor shall identify on the sample by permanent marker the contract number, lining section number, maintenance hole number, sewer size and date of removal.

Samples shall be taken into custody by the Contract Administrator immediately and delivered to the testing agency by the Contract Administrator.

TS 4.10.27 Testing of Samples of Cured Liner

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 approval of the Contract Administrator. The Contractor shall authorize the testing agency to forward the test reports to the Contract Administrator and communicate with the Contract Administrator concerning the testing and results. The Contract Administrator will arrange for delivery of the samples in custody to the testing agency. Samples shall be tested for flexural modulus and flexural strength according to ASTM D790 and thickness according to ASTM D5813-04 (2008). 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.

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

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

- flexural strength short-term
- flexural modulus short-term
- required liner thickness

These values shall have been identified in the Contractor's liner design. The testing agency's report shall reference these values as the specified values.

TS 4.10.28 Reinstatement of Sewer Service Connections

Reinstatement of the service connections shall be carried out according to the approved method statement.

All live service connections shall be reopened to their full diameter, and the interface with the liner made leak tight by remote means.

Service connections must be reinstated to the entire opening of the service connection or service connection pipe, whichever is the greater. No sleeve or liner protrusions, sealer, grout or other foreign material is permitted into such area.

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

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

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

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

TS 4.10.29**Liner Sample Test Results – Reconciliation and Deficiency**

Where liner samples are tested by the Contract Administrator , the tests shall include determination of sample flexural modulus, flexural strength and thickness according to ASTM D790, ASTM D790 and ASTM D5813, respectively. Testing will be done by an accredited third party testing agency knowledgeable in the testing of CIPP and approved by the Contract Administrator. Where the test results do not meet or exceed the required physical properties, the liner shall be deemed deficient subject to reconciliation of the test results.

A liner deemed deficient based on sample test results shall be reconciled for true deficiency by repeating the design for the liner using the test results for flexural modulus and flexural strength while keeping all other design parameters the same.

Where the repeated design (the reconciliation) shows that the combination of test results (flexural modulus, flexural strength and thickness) provides a liner that meets the design requirements, the liner shall not be deemed deficient.

Such design reconciliation shall not be permitted when test results do not meet the minimum requirements for flexural modulus and flexural strength in the ASTM F1216 in which case the liner will be deficient.

The Contract Administrator shall make or otherwise approve any design reconciliation. Two examples of design reconciliations are shown below.

Reconciliation Example No. 1

For a 450 mm installation the required liner thickness is 7.6 mm designed at flexural modulus of 2413 MPa and flexural strength of 31 MPa. Tested results show thickness is 7.2 mm, flexural modulus is 2995 MPa and flexural strength is 38.9 MPa. There is an apparent deficiency in liner thickness. Reconciliation of apparent deficiency is shown below.

Design Parameter	As designed	Reconciliation
Design Condition	Fully Deteriorated	Fully Deteriorated
Sewer Size	450 mm	450 mm
Invert Depth	3.5 m	3.5 m
Water table below ground surface	2.0 m	2.0 m
Ovality	3 %	3 %
Soil Density	18.85 KN/m ³	18.85 KN/m ³
Soil Modulus	6.89 MPa	6.89 MPa
Live Load	HS-20	HS-20
Other Load	0	0
Flexural Modulus Short-term	2413 MPa	2995 MPa (Test result)
Long-term Retention for Flexural Modulus	50 %	50 %
Flexural Modulus Long-term for design	1206.5 MPa	1497 MPa
Flexural Strength Short-term	31 MPa	38.9 MPa (Test result)
Long-term Retention for Flexural Strength	50 %	50 %
Flexural Strength Long-term for design	15.5 MPa	19.45 MPa
Enhancement Factor	7	7
Poisson's Ratio	0.3	0.3
Safety Factor	2	2
Required Liner Thickness	7.6 mm	7.1 mm
Tested Thickness	7.2 mm	7.2 mm
Conclusion on Liner Thickness Deficiency	Thickness is deficient based on design properties	Thickness is not deficient based on test result properties

In this example, the reconciliation shows that the as tested thickness of 7.2 mm is sufficient when the tested properties are taken into account. Therefore, the liner would not be deficient based on test thickness.

Reconciliation Example No. 2

For a 600 mm installation, the required liner thickness is 9.6 mm designed at flexural modulus of 2758 MPa and flexural strength of 31 MPa. Tested results show thickness is 8.8 mm, flexural modulus is 2465 MPa and flexural strength is 35.6 MPa. There is an apparent deficiency in liner thickness. Reconciliation of apparent deficiency is shown below.

Design Parameter	As designed	Reconciliation
Design Condition	Fully Deteriorated	Fully Deteriorated
Sewer Size	450 mm	450 mm
Invert Depth	3.6 m	3.6 m
Water table below ground surface	2.0 m	2.0 m
Ovality	3 %	3 %
Soil Density	18.85 KN/m ³	18.85 KN/m ³
Soil Modulus	6.89 MPa	6.89 MPa
Live Load	HS-20	HS-20
Other Load	0	0
Flexural Modulus Short-term	2758 MPa	2465 MPa (Test result)
Long-term Retention for Flexural Modulus	50 %	50 %
Flexural Modulus Long-term for design	1379 MPa	1232 MPa
Flexural Strength Short-term	31 MPa	36.6 MPa (Test result)
Long-term Retention for Flexural Strength	50 %	50 %
Flexural Strength Long-term for design	15.5 MPa	18.3 MPa
Enhancement Factor	7	7
Poisson's Ratio	0.3	0.3
Safety Factor	2	2
Required Liner Thickness	9.6 mm	10.0 mm
Tested Thickness	8.8 mm	8.8 mm
Conclusion on Liner Thickness Deficiency	Thickness is deficient based on design properties	Thickness remains deficient based on test result properties

In this example the reconciliation shows that the as tested thickness of 8.8 mm is not sufficient when the tested properties are taken into account. Therefore, the liner is deficient based on test thickness. In fact even at the designed 9.6 mm the liner would be deficient because the design properties were not achieved.

TS 4.10.30 Deficiencies

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

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

Where in the Contract Administrator's opinion, there is no repair or correction that is satisfactory, the Contract Administrator may require removal and replacement of the sewer lateral rehabilitation or require an alternate resolution at the discretion of the Contract Administrator.

A deficiency will exist when the work or the results of the work is/are not according to Contract Documents.

TS 4.10.31 Payment

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

Appendixes

Appendix A: WRc Sewer Defect Classification Table

Appendix B: Service Connection Statement

Appendix A: WRc Sewer Defect Classification Table

Definitions

Clock References

Clock references must be given clockwise, i.e., from 10 o'clock to 2 o'clock = 1002. Thus, the upper half of a pipe is 0903 and the lower half 0309.

Structural Condition – Pipe Sewers

Cracked	Crack lines visible on the pipe wall, pieces all still in place.
Fractured	Cracks visibly open on the pipe wall, pieces all still in place.
Broken	Pipe cracked with pieces of pipe visible displaced, some pieces could be missing.

Cracked, fractured and broken can be further described as:

Longitudinal	Defect runs approximately along axis of sewer.
Circumferential	Defect runs approximately at right angles to axis of sewer.
Multiple	Combinations of both longitudinal and circumferential defects.
Deformed	Original cross-section of sewer altered, pipe probably extensively broken.
Collapsed	Complete loss of structural integrity. Most of cross-sectional area lost.
Joint Displaced	The spigot of a pipe is not concentric with the socket of the adjacent pipe.
Open Joint	Adjacent pipes are longitudinally displaced at the joint.
Dropped Invert	Invert section of pipe 'dropped' relative to sewer walls, with a pronounced gap between invert and wall.

Structural Condition – Brick Sewers

Mortar Missing	Mortar between brickwork missing to a degree varying from surface loss to medium or total loss. Bricks still in place.
Cracked	Crack lines visible in brickwork and/or mortar. Bricks still in place.
Fractured	Cracks visibly open in brickwork and/or mortar. Bricks have moved apart from one another.

It is often difficult to distinguish between mortar missing, cracked and fractured. Where possible, take a photograph of medium or total mortar loss, or where brickwork cracks or fractures are suspected.

Cracked and fractured can be further described as longitudinal, circumferential or multiple, as defined under pipe sewers.

Displaced Bricks	Single bricks, or areas of bricks, have moved from their original position.
Missing Bricks	Single bricks, or areas of bricks, are missing. (More than one ring may be affected).
Surface Damage	
- spalling	Surface splintered off.
- wear	Surface worn, e.g., by cleaning tools.
Deformed Sewer	
- vertical	Reduction in vertical dimension of sewer.
- horizontal	Reduction in horizontal dimension of sewer.
Collapsed	Complete loss of structural integrity. Most of cross-sectional area lost.
Dropped Invert	Invert section of brickwork 'dropped' relative to sewer walls, with a pronounced gap between invert and wall.

Service Condition – Pipe and Brick Sewers

Roots	The ingress of roots through defects in the sewer, connections or maintenance holes. Described as fine, mass or tap roots depending on severity. (See photographs) 'Tap' means that individual roots are over 10 mm thick.
Infiltration	The ingress of groundwater into the sewer through defects, joints or MH's. The four terms used in describing this are:
- Seeper	The slow ingress of water. The usual indication of this type of infiltration is that the joint or crack 'glistens' in the lights of the CCTV camera.
- Dripper	Water dripping in through a crack or faulty joint.
- Runner	Water running in through a crack or faulty joint.
- Gusher	Water entering pipe under pressure through crack or joint.
Encrustation	Deposits left by the partial evaporation of infiltrating groundwater containing dissolved salts. Classified into light, medium or heavy by percentage diameter lost.
Scale	Hard deposits, which cannot be, identified as encrustation, e.g., deposits resulting from corrosion of iron pipes, or hardened grout downstream of a ready mixed concrete plant.
Debris	Grease, organic or silty materials deposited in a sewer, which cause flow turbulence and a reduction in hydraulic efficiency. Examples of this are road grit, fatty deposits and soil washed in by infiltrating groundwater.
Obstruction	Solid material in a sewer, which impedes the inspection and/or causes a reduction in hydraulic efficiency., e.g., bricks rods or displaced sealing rings.
Water Level	The level of water at the observed point in the sewer.
Line	A visible divergence in the sewer alignment, left, front, up, down.

Construction Features – Pipe and Brick Sewers

Junction	A purpose made or preformed junction built in to the sewer during construction.
Connection	A lateral pipe which has been added to the sewer. Includes all 'saddle' connections.
Major Branch	(Applies only to sewers of diameter 900 mm and above.) Branch or similar feature of comparable size to the main sewer, e.g., drop shaft, air vent, and overflow.
Maintenance Hole	Any access point. May be direct or side entrance shaft, or lamphole. May be 'buried', i.e., covered over at some time since construction.
Defective Junction	The junction or the adjacent sewer have become damaged during or after construction, or the connection is incorrectly positioned or of poor workmanship.
Intruding Connection	The connection intrudes into the water.
Continuous Defect	
- Pipe Sewers	A defect, which extends or is repeated over two or more consecutive pipe lengths.
- Brick Sewers	A defect, which extends beyond the first metre visible in the TV monitor or photograph.

WRc Sewer Defect Classification Table

CLASS	CODE	TYPE	CODE	DESCRIPTION	CODE	J	%	CLOCK 1 2	SEE NOTE
Pipe	P	Cracked	C	Longitudinal	L	*		*	
		Fractured	F	Circumferential	C	*		*	
				Multiple	M	*		*	
		Broken	B			*		*	
		Deformed	D				*		
		Collapsed	X				*		
		Joint Displaced	JD	Slight under 't'	S)	
		Open Joint	OJ	Medium 1-1 ½ x't'	M) 1	
				Large over 1 ½ 't'	L)	
				't' = pipe wall thickness					
		Dropped Invert	DI						
Brick	K	Mortar Missing	M	Surface (1-15mm)	S			*	
				Medium(15-50mm)	M			*	
				Total (over 50mm)	T			*	
		Cracked	C	Longitudinal	L			*	
		Fractured	F	Circumferential	C			*	
				Multiple	M			*	
		Displaced Bricks	DB					* or t*	
		Missing Bricks	MB					* or *	
		Surface Damage	S	Spalling	S			* or *	
				Wear	W			* or *	
		Deformed Sewer	D	Vertical	V		*	2	
				Horizontal	H			3	
		Collapsed Sewer	X						
		Dropped Invert	DI					4	
KEY TO ADDITIONAL DETAILS					NOTES				
<p>An asterisk (*) in any column means further details should be given, if available, as follows:</p> <p>J if defect is at joint, add J to code</p> <p>% give percentage of diameter lost - to nearest 5%</p> <p>Clock 1 give one clock reference, e.g., 3 o'clock</p> <p>Clock 2 give two clock references, e.g., from 10 to 4</p> <p>Additional illustrations occur incidentally throughout</p> <p>In these cases give one clock reference, or two, depending on circumstances.</p>					<ol style="list-style-type: none"> 1. S, M, and L measure degree of displacement 2. Give % height loss 3. Give % width loss 4. Give wall, floor gap in mm 5. Depth of water, as % of height 6. Give junction diameter in mm 7. Give connection diameter in mm 8. Give length of intrusion in mm 9. Give pipe diameter in mm 				

WRc Sewer Defect Classification Table

CLASS	CODE	TYPE	CODE	DESCRIPTION	CODE	J	%	CLOCK		SEE NOTE																				
								1	2																					
Service Condition	S	Roots	R	Fine Mass Tap	F M T	*	*																							
											Infiltration	I	Seeper Dripper Runner Gusher	S D R G	*		*													
																			Encrustation Encrustation Scale	E ES	Heavy (over 20%) Medium (5-20%) Light (under 5%)	H M L	*	*	*					
		Debris	DE	Silt Grease	S G	*	*																							
									Obstruction Water Level Line		OB WL L	Give more details Deviates, L, R, U, D			*															
		L,R,U,D																5												
Construction Features	F								Junction Defective Junction Connection Defective Connections Major Branch Maintenance Hole	JN JX CN CX BR MH	Intruding give MH no.	1				*	6 7 8													
		Miscellaneous	M	Start of Survey Finish of Survey Survey Abandoned Diameter Checked General Condition Photo Camera Underwater	ST FH SA DC GP CU	give reason give photo no.														9										
																					KEY TO ADDITIONAL DETAILS					NOTES				
																					<p>An asterisk (*) in any column means further details should be given, if available, as follows:</p> <p>J if defect is at joint, add J to code</p> <p>% give percentage of diameter lost - to nearest 5%</p> <p>Clock 1 give one clock reference, e.g., 3 o'clock</p> <p>Clock 2 give two clock references, e.g., from 10 to 4</p> <p>Additional illustrations occur incidentally throughout</p> <p>In these cases give one clock reference, or two, depending on circumstances.</p>					<ol style="list-style-type: none"> 1. S, M, and L measure degree of displacement 2. Give % height loss 3. Give % width loss 4. Give wall, floor gap in mm 5. Depth of water, as % of height 6. Give junction diameter in mm 7. Give connection diameter in mm 8. Give length of intrusion in mm 9. Give pipe diameter in mm 				

SERVICE CONNECTION STATEMENT (SCS) – CONTRACT NO.

SL #

Date: Page # of

Street Name	Contractor's Name	Distance Between M.H. (camera)	Sewer Dia. (mm)	From M.H. #	To M.H. #	Camera Direction	Total # of S/C	Total # of Live S/C

S/C Address	Live (yes/no)	Visible Plug (yes/no)	Camera Distance from M.H. #	Clock Position	S/C Size	S/C Material	S/C (P//F/R)*	S/C Open (yes/no)	S/C Open (Date)	S/C Open (Time)	Comments

* P (protruding), F (flushed with the main sewer line), R (recessed)