

**Construction Specification for
the Installation of Chemical Grout in Sewers**

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TS 470.01 SCOPE

This specification covers the requirements for the testing of all joints/defects within a sewer section. The intent of testing is to identify those sewer joints/defects that are not watertight and that can be successfully sealed by packer injection grouting.

Packer injection grouting shall be accomplished by pressure injection of chemical grout into the soils encompassing the exterior of pipe joint/defect.

Chemical grouts shall be designed to be injected into the soil surrounding the pipe, which stabilizes the soil and forms a permanent impermeable seal called a grout/soil ring. Adequate amounts of grout are based generally upon pipe size and field conditions. This application will be through structurally sound joints/defects through penetrations from within the pipe by using the packer method in tandem with a closed-circuit television (CCTV) inspection system. In man entry cases, individuals may position the packer over the joint/defect.

The Work shall be completed without the use of an above ground temporary flow bypass and shall be conducted during periods of low flows and with the use of a flow through plug, or other similar method to reduce the flow to facilitate the rehabilitation of the affected sewer sections.

TS 470.02 REFERENCES

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

City of Toronto Standard Specifications

TS 409 Construction Specification for Closed-Circuit Television Inspection of Pipelines

American Society for Testing and Materials

F2304 Standard Practice for Rehabilitation of Sewers using Chemical Grouting

National Association of Sewer Service Companies (NASSCO)

Pipeline Assessment Certification Program (PACP)

TS 470.03 DEFINITIONS

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

CCTV means the televised inspection of sewers using closed circuit television.

Clean means the removal of all sand, grease and all other solid or semi-solid material from the designated sewer lines including calcite and/or exposed gaskets that may affect the rehabilitation operation.

Infiltration Point means a location where water was observed to be leaking into the sewer, active infiltration point. Typical locations are holes, pipe joints, and cracks.

Sewer Section means to the length of pipe connecting two maintenance holes.

Sealing of infiltration points by inflatable packer means the sealing of the infiltration points by an inflatable packer utilizing a chemical stabilization material in two parts, applied from the interior of the sewer pipe through a closed hydraulic system. The phrase "sealing of infiltration points by inflatable packer" as used in these specifications shall mean the pumping of chemical grout through any structurally sound sewer pipe.

TS 470.04 DESIGN AND SUBMISSION REQUIREMENTS

The Contractor shall prepare and submit the following:

- 1) The Contractor shall provide a minimum 48-hour advance written notice of proposed testing schedules and testing procedures for review by the Contract Administrator.
- 2) Equipment operating procedures and systems. An example could be the operating procedures for the use of a grout packer, grout injection systems, pressure testing requirements and so on for smaller sewer and procedures for the manual installation of grout for larger sewers
- 3) Chemical Grout information:
 - a) Description of chemical grout materials to be used according to clause TS 470.05.03.
 - b) Description of proposed additives to be used according to clause TS 470.05.04.
 - c) Manufacturers recommended procedures for storing, mixing, testing and handling of chemical grouts.
 - d) MSDS sheets for all materials to be used.
- 4) Indicate the manufacturer(s) and models of the packers and pumps to be used for the Contract.
- 5) Upon completion of each pipe section, submit to the Contract Administrator a CCTV report showing the following data for each identified joint/defect tested, grouted or attempted to be grouted.
 - a) Identification of the sewer pipe section tested by an assigned sewer ID (if available) and length.
 - b) Type of pipe material, diameter, and depth of pipe to the surface at maintenance holes.
 - c) Test pressure used and duration of test.
 - d) Pass/fail results for each identified joint/defect tested.
 - e) Location stationing of each identified joint/defect tested, and location of any joint/defect/connection not tested with an explanation for not testing.
 - f) Volume of grout material used on each identified joint/defect or connection.

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- g) Gel set time used.
 - h) Grout mix record of the batches mixed including amount of grout and catalyst, additives, temperature of the grout solution in tanks.
 - i) Operator conducting testing and sealing shall be noted on the reports.
 - j) Testing and Sealing Inspection Video:
 - i. Video recording shall include testing and sealing operations for each identified joint/defect including inflation and deflation over the joint/defect,
 - ii. Displaying the final air test of the joint/defect.
 - iii. Additional final recording, if specified, shall include inspection of the pipe after all grouting work is complete.

TS 470.05 MATERIALS

TS 470.05.01 Safe Handling

All safety considerations required to be met by the Contractor including safe handling, mixing, and transporting of chemical grouts should be provided by the grout manufacturer/supplier, and should include safe operating practices and procedures, appropriate personal protective equipment (PPE) for the various grouting operations, and proper storage, transportation, mixing, and disposal of grouts, additives, and their associated containers.

Ensure the required grout handling and mixing training certification from the grout manufacturer or supplier for personnel working with chemical grouts and additives is completed.

TS 470.05.02 Grout Material

All chemical sealing materials shall be subject to acceptance by the Contract Administrator. Manufacturer's specifications for the material and recommendations for its use shall be submitted to the Contract Administrator 20 Working Days prior to commencement of the Work. In every case, mixing and handling of chemical sealing materials shall be in strict accordance with the manufacturer's specifications, affecting the use and handling of the relevant materials.

After reviewing the existing conditions of each sewer section identified for rehabilitation, the Contractor has discretion to choose the appropriate chemical sealing materials which are best suited to the field conditions at the time of installation.

All chemical sealing materials used in the performance of the Work shall have the following properties and characteristics:

- 1) While being injected, the grout must be able to react or perform in the presence of groundwater.

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- 2) The ability to increase grout mix viscosity, density and gel strength by increased concentration of constituents or the use of approved additives.
 - 3) The cured grout must withstand submergence in water without degradation.
 - 4) The resultant grout formation must be homogeneous and prevent the passage of water infiltration through the pipe joint/defect.
 - 5) The grout must not be biodegradable.
 - 6) The cured grout shall be chemically stable and resistant to organics found in municipal sewage.
 - 7) Residual grout shall be easily removable from the sewer line to prevent blockage of the sewage flow.

TS 470.05.03 Chemical Grouts

Chemical sealant shall have a documented service of successful performance in similar usage, with a minimum of 12,000 successful joints/defects grouted.

TS 470.05.03.01 *Water Based Chemical Grout*

Water based chemical grout shall have the following characteristics:

- 1) A minimum of 12% acrylamide base material by weight in the total grout mix. A higher concentration of acrylamide base material is recommended to increase strength or offset dilution during injection.
- 2) The ability to tolerate some dilution and react in moving water during injection.
- 3) A viscosity of approximately 2 centipoise, which can be increased with approved additives.
- 4) A controllable reaction time from 10 seconds to 1 hour.
- 5) A curing reaction that produces a homogenous, chemically stable, non-biodegradable, firm and flexible gel.
- 6) The ability to increase mix viscosity, density and gel strength by increased concentrations of the mix constituents or by the use of approved additives.

TS 470.05.03.02 *Acrylate Base Grout*

Acrylate based grout shall have the following characteristics:

- 1) A minimum of 12% acrylate base material by weight in the total grout mix.
- 2) The ability to tolerate some dilution and react in moving water during injection.
- 3) A viscosity of approximately 1-3 centipoise, which can be increased with approved additives.

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- 4) A controllable reaction time from 10 seconds to 1 hour.
 - 5) A curing reaction that produces a homogenous, chemically stable, non-biodegradable, firm, flexible gel.
 - 6) The ability to increase mix viscosity, density and gel strength by the use of additives approved by the Contract Administrator.

TS 470.05.03.03 *Urethane Base Gel Chemical Sealing Material*

Urethane base gel chemical sealing material shall have the following characteristics:

- 1) One-part urethane pre-polymer thoroughly mixed with between five and ten parts of water weight. The recommended mix ratio is one-part urethane pre-polymer to eight parts of water (11% pre-polymer). When high flow rates from leaks are encountered, the ratio of water being pumped may be lowered.
- 2) A liquid pre-polymer having a solids content of 75% to 95% and a specific gravity of greater than 1.00.
- 3) A liquid pre-polymer having a viscosity of between 100 and 1500 centipoise at 21°C that can be pumped through 150 m of 12.7 mm hose with a 6900 kPa head at a flow rate of 30 mL/second.
- 4) The water used to react with the pre-polymer should have a pH of 5 to 9.
- 5) A cure time appropriate for the conditions encountered.
- 6) A relatively rapid viscosity increase of the pre-polymer/water mix. Viscosity should increase rapidly in the first minute for 1 to 8 pre-polymer/water ration at 10°C.
- 7) A curing reaction that produces a chemically stable and non-biodegradable, tough, flexible gel.
- 8) The ability to increase mix viscosity, density, gel strength, and resistance to shrinkage by the use of additives.

TS 470.05.04 *Additives*

At the Contractor's discretion and according to field conditions, additives may be selected and used within the manufacturers recommended quantities.

TS 470.05.04.01 *Strengthening Agents*

For joint/defect grouting, a latex or diatomaceous earth additive may be added to increase compressive and tensile strength. The quantity of strengthening agent additive shall be as recommended by the manufacturer and agreed to by the Contract Administrator.

TS 470.05.04.02 *Root Inhibitor*

When roots are present, for joint/defect grouting, a root deterrent chemical may be added to control root re-growth. The quantity of inhibitor shall be as recommended by the manufacturer and agreed to by the Contract Administrator.

- Dye – A manufacturer approved water soluble dye without trace metals may be added to the grout tank(s) for visual confirmation.
- Gel Time Modifier – A gel time extending agent may be used in accordance with the manufacturer's specification to extend gel time as necessary.
- Freeze/Thaw – In those lines where the grouting material may be exposed to a freeze-thaw cycle, ethylene glycol or other manufacturer approved additive shall be used to prevent chemical grout cracking once set.
- When using non-soluble additives, the grout tanks must have mechanical mixing devices to keep the additives in suspension and maintain a uniform solution of grout and additive.

TS 470.06 EQUIPMENT

TS 470.06.01 Sealing and Grouting Equipment

This equipment shall be an inflatable packer type or other suitable device which can be positioned to completely isolate each infiltration point. This device shall be an open-ended cylindrical casing of a size less than the pipe that is being repaired, with appropriate cables connected to either end to pull it through the line.

An air impervious, inflatable sleeve shall be mounted on the casing exterior, with the ends of the sleeve sealed to the ends of the casing. A conduit shall pass through the open end of the casing and shall be adapted to supply a polymerizing material, under pressure, to the space at the casing and the sleeve.

Expansion shall be regulated by precise pressure gauges and controls. No device which is expanded hydraulically or mechanically, and which could cause damage to the pipe will be allowed.

The equipment shall be constructed in such a way as to provide means for the introduction of air or water under pressure into a void created by the expanded ends of the testing device and shall have a means for continually measuring the actual static pressure of the air or water within the void area. The pressure data shall be transmitted from the void to appropriate monitoring equipment located to allow for simultaneous and continuous observation of the test monitoring equipment by the Contractor and the Contract Administrator.

The basic equipment used for mainline pipe joint/defect shall consist of a remotely operated colour television camera capable of pan and tilt, testing device (referred to hereafter as a packer), and test monitoring equipment. The equipment shall be constructed in such a way as to provide means for introducing air under pressure into the void area created by the expanded ends of the packer against the host pipe and a means for continuously measuring, viewing and recording the actual static pressure of the test medium and grout within the void area only. The packer shall be of a size less than the diameter of the host pipe, with the cables at either end used to pull it through the line and shall be constructed in such a manner as to allow a restricted amount of sewage to flow at all times. Packer shall be expanded by air pressure. Packers shall be of low void space construction with void volume given by the packer manufacturer.

Void pressure data shall be transmitted from the void area to the monitoring equipment or video picture of a pressure gauge mounted on the packer and connected to the void area. All test monitoring shall be above ground and, in a location, to allow for simultaneous and continuous observation of the televising monitor and test monitoring equipment.

Grouting equipment shall consist of the packer, appropriate pumping and hosing systems capable of supplying an uninterrupted flow of sealing materials to completely fill the voids. Grout pumping system shall be sized to deliver a mixed volume of grout at a minimum of 3 gpm and 30 gallons of uninterrupted flow within 10 minutes.

Volume of mixed grout pumped must be capable of being measured and recorded for each grouted joint/defect/connection. Generally, the equipment shall be capable of performing the specified operations in sewers where flows do not exceed 25 percent of pipe diameter unless permitted by the Contract Administrator.

TS 470.07 CONSTRUCTION

TS 470.07.01 Protect Sewer from Damage

The Contractor shall take satisfactory precautions to protect the sewer sections and appurtenances from damage that might be inflicted upon them by the use of cleaning and grouting equipment. Any damage inflicted upon a sewer section or other public or private property as a result of the Contractor's cleaning and grouting operations, regardless of the grouting method used and regardless of any other circumstance which may contribute to the damage, shall be repaired by the Contractor at no extra cost to the City.

TS 470.07.02 Pressure Testing and Grouting Using the Packer Method

TS 470.07.02.01 *Pipe Preparation*

Prior to the application of the chemical grouting materials, the Contractor shall thoroughly clean the sewer designated to receive the chemical grouting. Cleaning shall constitute removal of all loose debris and solids which inhibit proper seating of the packer. If mineral deposits or protruding taps are present, they shall be removed as part of the pipe preparation. Removal of other hardened materials such as concrete shall be considered beyond the scope of this work.

The Contractor shall have cleared the designated sewer line(s) of obstructions such as dropped joints, protruding lateral connections, and broken pipe / crushed pipe which will prevent the use of the grouting equipment. If the CCTV inspection reveals a condition for which an applicable pay item has not been included on the Pricing Form, the Contractor shall inform the Contract Administrator. The Contract Administrator may choose to make a point repair or will direct the Contractor to abandon the section of pipe scheduled for test and seal.

Sewer section cleaning shall be performed for each section in isolation until all sand, sludge, dirt, roots, debris or other foreign material has been removed from the sewer line and maintenance hole structure. Cleaning equipment shall be moved through the sewer at an appropriate operating speed and all foreign material from the cleaning process shall be retained in the downstream maintenance hole structure through the use of appropriate screen type devices placed in the opening of the downstream pipe. Passing of accumulated material—which could cause line stoppages, deposits or damage to equipment—from maintenance hole section to maintenance hole section shall not be permitted and all such material will immediately be removed from the maintenance hole structure immediately downstream of the sewer section being cleaned. This cleaning process shall be repeated for a minimum of two passes of the sewer section or until deemed satisfactorily cleaned by the Contract Administrator.

Each section of pipe identified for sewer line testing and sealing shall be thoroughly cleaned of all debris, calcite, roots, exposed gaskets or other foreign material that could affect the testing and sealing process. No additional payment will be made where additional cleaning is required to sufficiently test and seal the defect. The Contractor should review any previous CCTV records available at the pre-construction meeting for these pipes to help identify any unusual cleaning requirements.

In addition to the normal cleaning practice, where calcite build-ups are visible, the Contractor shall remove the build-up to provide for a clean, smooth surface to apply the sealant and the removal of calcite is considered part of the cleaning process. The Contractor should review the available CCTV videos to familiarize itself with the extent of calcite to be removed. In man entry cases with the inflatable packers it may be necessary to prepare some joints/defects with a quick set hydraulic cement so that the bladders may seat and seal against imperfections, for example concrete pipes with chips cracks and or visible aggregate.

Satisfactory precautions shall be taken at all times to ensure protection of the sewer against damage inflicted by the equipment in use. Additional precautions shall be taken to ensure the use of equipment and the cleaning operation itself does not create an environment conducive to the flooding or damage to public or private property serviced by the sewer section being cleaned. Such precautions shall include the adjustment of cleaning pressure to accommodate field conditions such as sumps and sags, for operations using hydro cleaning equipment. The Contract Administrator shall have the discretion to request adjustment of operating pressures under such conditions and, in the case of sanitary sewers; this pressure shall at no time exceed 13,790 kPa.

Appropriate screen type devices shall also be provided to prevent accumulated debris from entering the downstream sewer pipe.

The removal of calcite, roots, exposed gaskets and protruding connections as well as residual debris associated with the removal operations shall be completed in conjunction with the cleaning operation.

Maintenance hole structures shall have their surfaces appropriately cleaned to be free of dirt, grease or loose material in conjunction with the sewer section cleaning activities and debris accumulated through this activity shall not be allowed to enter the sewer line.

TS 470.07.02.02 Grout Preparation

Follow the manufacturer's specifications for the mixing and safe handling procedures.

Adjust gel time as necessary to compensate for changes in temperature in grout component tanks or hoses. The addition of dilution water to extend gel times is not acceptable unless resulting base grout tank only material exceeds 20% by weight for solution grouts.

During the grouting process, the Contractor shall ensure that the grouting technician monitors the grout component tanks to make sure that proper ratios are being pumped. If unequal levels are noted in the tanks, repeat the pump test as described above and correct any defective equipment.

Gel times shall be calculated using the following formula for solution-based grout unless Contractor experience and field conditions dictate otherwise. Any alterations of the gel time formula shall be approved by the Contract Administrator.

$$Gel\ Time = \left(\frac{Volume\ of\ Pipe\ / \ Packer\ Void\ Space\ (gal)}{Pumping\ Rate\ (gpm)} \right) \left(\frac{60\ sec}{1\ min} \right) + 20\ sec(+/-\ 5\ sec)$$

The Contract Administrator can request at any time, evidence of quality control of grout mix ratios and gel times for on-site grout preparation at no extra cost to the City.

Packer/pipe void shall be defined as the volume between the inflated packer and the inside pipe wall when the packer is inflated according to the manufacturer's specifications.

For example: an 200 mm pipe with a packer void space of 0.3 gallons and a 3 gpm pumping rate would provide.

$$Gel\ Time = \left(\frac{.3(gal)}{3(gpm)} \right) \left(\frac{60\ sec}{1\ min} \right) + (20\ sec) = 26\ sec(+/-\ 5\ sec)$$

TS 470.07.03 Control Tests

To ensure the accuracy, integrity, and performance capabilities of the testing equipment, a demonstration test shall be performed in a sound, undamaged section of pipe. This test will establish the equipment performance capability and ensure that there is no leakage of air or water from the system or other equipment defects that could affect the testing results. If the testing equipment cannot be sealed successfully in the sound section of underground pipe, the Contractor shall repair or otherwise modify its equipment and re-perform the test until the results are satisfactory to the Contract Administrator. This test may be required to be repeated at any time during the testing work if the Contract Administrator so requests.

- 1) After entering each sewer section with the test equipment, but prior to the commencement of joint/defect testing, position the packer on a section of sound sewer pipe between pipe joint/defect and perform a test as specified in the Contract Documents. The equipment shall hold a 48 kPa to 69 kPa test pressure for a period of 15 seconds with a pressure drop of less than 6.89 kPa. In the event of a failed test, repair any defective equipment and re-test to verify proper operation of all equipment at no extra cost to the City. Should it be found that the surface or porosity conditions of the barrel of the sewer pipe cannot meet the test requirements, then the performance testing shall be waived or modified as determined by the Contract Administrator.
- 2) If air testing cannot be performed successfully, repair or otherwise modify air test equipment and repeat the tests. This test may be required at any other time during the performance of testing work if the Contract Administrator suspects the testing equipment is not functioning properly.
- 3) Pump Tests – At the beginning of the Work, prior to application of grout, perform a pump test to determine if proper ratios are being pumped from the grout component tanks at the proper rates and to measure pump rates. Use separate containers to capture the discharges from each of the grout component hoses, to simulate the actual volumes of each component through the interconnect hoses, hose reel and length of grout hose and confirm accuracy of grout pump totalizer. Take corrective action if ratios or rates are not within manufacturer’s recommended standards.
- 4) Grout Tests – Perform and record a grout gel test in the presence of the Contract Administrator by recording the grout tank solution temperature, catalyst tank solution temperature, ambient air temperature in truck, and gel time of the sample whenever the following conditions occur:
 - a) At the beginning of each day; the material in the hoses shall be recycled to the tanks and a sample shall be taken.
 - b) When new batches of grout are mixed.
 - c) Whenever the temperature in the tanks or ambient temperature have changed by more than $\pm 6^{\circ}\text{C}$ from the previous gel test.

TS 470.07.04 Flow Control

During the sewer repair, the flow in the sewer and from all connections shall be maintained. The Contractor shall make all the necessary notifications and arrangements with the owners of each building affected.

The Contractor shall provide all necessary materials for the completion of the flow control activity. The flow control method used shall be based on the site conditions present at the time of completion. All equipment necessary for the completion of the flow control operation shall be provided by the Contractor on a continuous, uninterrupted basis for the duration of the control period.

When sewer line flows are above the maximum limits, generally not more than 1/4 of the pipe diameter to effectively conduct the inspection and sealing operation, flow control procedures shall be performed according to the requirement listed below:

- 1) Flow control through the use of line plugs, pumps or siphons shall be provided in conditions where the depth of flow is above acceptable levels for proper completion of construction, inspection, cleaning or other sewer related activities.
- 2) A sewer line plug designed to permit control of a portion of the flow shall be inserted in the line upstream of the section being inspected. Depth of flow shall be reduced to acceptable levels throughout the inspection and immediately restored upon completion. The Contractor shall monitor flow levels upstream of flow control devices in order to ensure no adverse effect to sewer's function, for example flooding of services.
- 3) The Contractor shall be solely responsible for the removal of all equipment during sewer line flow control operations. In the event that equipment is lodged within the sewer pipeline, the Contractor is responsible for all costs incurred, including damages caused by; open-cut removal methods, and public or private flooding or surcharging. The Contractor shall provide complete restoration to the satisfaction of the Contract Administrator.
- 4) The Contractor shall ensure that all applicable provincial and municipal requirements for safety are satisfied throughout the course of the Work. This requirement shall include, but is not limited to, the equipment and procedures for traffic control, emergency first aid, gas detection, confined spaces entry and emergency rescue planning.
- 5) High flows may occur in the sewer system during rainfall events and spring snow melt periods. During these periods flow control may be difficult or unachievable. The Contractor at all times shall take all necessary precautions to protect all public and private property from flood or damage caused by the Contractor's activities. The Contractor shall allow in its schedule for delays due to these occurrences. No additional payment or extensions of Contract Time shall be allowed resulting from delays due to high flows during spring snow melt and rainfall events.

TS 470.07.05 Defects Not Requiring Testing and Grouting

Testing and grouting shall not be required on sewer sections exhibiting the following conditions or characteristics:

- 1) Sections of the pipe with structural defects between joints/defects, as agreed between the Contract Administrator and the Contractor.
- 2) Any sections of pipe or joints/defects that are in such poor structural condition that in the judgment of the Contract Administrator with Contractor input, significant structural damage of the pipe would occur as a result of the pressure test.

Any structurally undamaged joint/defect that structurally fails or breaks during testing and grouting that are documented to have been done under normal pressure conditions shall be the City's responsibility and cost to repair.

Grout all circumferential cracks and fractures or other defects as specified in the Contract Documents. Do not test or grout any other pipe defects unless so specified or directed by Contract Administrator to do so. Any structurally failed pipe or joint/defect that is grouted at the Contract Administrator's direction, that further fails/breaks during testing and grouting that are documented on CCTV to have been done under normal pressure conditions shall be the City's responsibility and cost to repair. Promptly repair any other sewer damage resulting from the Contractor's operations at no additional cost to the Contract.

The Contractor shall notify the Contract Administrator immediately of any structural concerns with respect to the sewer pipe that are observed during cleaning operations, post cleaning CCTV inspection or during rehabilitation activities in order for the City to take the appropriate remedial measures.

TS 470.07.06 Testing Procedure for Mainlines Sewers

Once cleaned, all sewer joints/defects or other points, as identified by the Contract Administrator, shall be pressure tested to identify those which are potentially defective in allowing infiltration or exfiltration to the sewer system and that may be successfully sealed by the internal pipe sealing process specified in the Contract Documents.

Test pressures shall be verified by the Contract Administrator and be no more than 21 kPa higher than the possible ground water pressure outside the pipe, that is to say the depth of sewer converted to hydrostatic head, plus 21 kPa.

Joint/defect testing pressure shall be equal to 3.5 kPa per vertical 300 mm of pipe depth plus 13.8 kPa; however, test pressure shall not exceed 68.9 kPa without the approval of the Contract Administrator.

Individually test each sewer pipe identified joint/defect at the above-specified pressure and retest after sealing in accordance with the following air test procedure:

- 1) The packer shall be positioned within the pipe in such a manner as to straddle the joint/defect to be tested.
- 2) The packer ends shall be expanded so as to isolate the joint/defect from the remainder of the pipe and create a void area between the packer and the pipe joint/defect. The ends of the testing device shall be expanded against the pipe in accordance with specified inflation pressures to contain the air within the void without leakage past the expanded ends.
- 3) Air or water shall then be introduced into the void area until a stabilized pressure equal to or greater than the required test pressure is observed with the void pressure monitoring equipment. If the required test pressure cannot be developed and stabilized due to defect leakage, the defect shall be deemed to have failed the test and shall be sealed as specified in the Contract Documents.
- 4) If all attempts to isolate the joint/defect fail, pump grout in an attempt to seal the leak around the packer end elements. Should the Contract Administrator determine that the

sewer was inadequately cleaned or that the packer is not performing properly, the Contractor shall not be paid the applicable unit price for testing and sealing to seal the joint/defect as indicated. After the void pressure is observed to be equal to or greater than the required test pressure, the air flow shall be stopped. If the void pressure decays by more than 13.8 kPa within 15 seconds, the joint/defect will have failed the test and shall be sealed.

Upon completing the testing of each identified individual joint/defect, the packer shall be deflated with the void pressure meter continuing to display void pressure. Should the void pressure meter fail to drop to 0.0 ± 3.45 kPa, clean the test equipment of residual grout material or make the necessary equipment repairs to provide for an accurate void pressure reading.

The Contractor shall submit CCTV inspection video on USB flash drive or USB hard drive of the testing process. The CCTV may be in conjunction with the sealing process. No extra payment shall be made for preparing and submitting the Testing and Sealing Inspection CCTV video.

TS 470.07.07 Grouting

Grout all joint connections and identified defects that failed the pressure test by the packer injection grouting method. This shall be accomplished by pumping grout through a system of pumps and hoses into and through the joints/defects of the sewer from the packer within the sewer pipe.

Remove excess grout from pipes. Excess grout shall be defined as a thickness of grout that given its location, size and geometry, could cause a blockage. Flush or push forward to the next downstream maintenance hole, remove from the sewer system, and properly dispose of excess grout.

TS 470.07.08 Sealing by Packer Injection Grouting for Mainline Sewers

The method of repair shall not damage, break, move or cause line settlement, assuming the line is structurally sound. Uncovering of the sewer line, removal of areas of paving or other materials at the existing grade level above the sewer line will not be allowed.

The method of repair shall be such that the original cross-sectional area and shape of the sewer pipe shall not be permanently reduced or changed. Sealing materials that set to a hard, rigid product that might intrude into the sewer line will not be acceptable.

Sealing of infiltration points shall be by inflatable packer and internal chemical application. This shall be accomplished by forcing sealing materials into and through open sewer line joints, identified defects and cracks in the following manner:

- 1) Position the mainline packer over the joint or defect to be sealed by means of a CCTV camera in the line.
- 2) Pneumatically expand the packer sleeves such that they seal against the inside periphery of the pipe to form a void area at the joint/defect now completely isolated from the remainder of the pipe line. Into this isolated area, through hose lines leading from above ground, sufficient chemical sealants shall be pumped with instant reading metered flow controlled proportioning pumps.

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- 3) The pumping and materials being injected with positive displacement electric pumps can be instantly regulated in accordance with the type of infiltration point being sealed. Pressures, proportions and quantities of the injection shall be determined according to the size and locations of the infiltration points, percentage of voids being filled, type of soil encountered, and the rate of flow of the solution in relation to the back pressures.
 - 4) Pump grout materials, in stages if needed, into this isolated area to refusal until and the void or surrounding soil has been filled or solidified with the goal of applying 0.25 to 0.5 gallons of grout per inch-diameter per pipe joint/defect. Refusal is when the packer void pressure during grout pumping instantaneously rises or spikes by 27.6 kPa to 34.4 kPa or more above the normal void pressure experienced during grout pumping operation. Refusal may also be revealed when pumping void pressure exceeds the holding pressure of the packer end elements as evidenced by blow-by past the packer sealing end elements. Refusal shall mean, when the joint/defect will no longer accept any more grout because it has flowed throughout the void and into the surrounding soil; gelled or filled the available void space; and formed a cohesive seal stopping further grout flow. The joint/defect will have then been sealed upon refusal. Record the amount of grout pumped on the sealing log. If sealing is not achieved, refer to item 6 – maximum quantity of grout per joint/defect.
 - 5) Deflate the packer upon completion of the injection. The packer shall then be re-inflated, and the joint/defect retested at a pressure equal to the initial test pressure. If the joint/defect fails this air test, repeat the grouting procedure at no additional cost to the Contract, except for the additional grout used. Repeat this sequence of air testing, grouting and subsequent air testing until either the joint/defect is sealed, or it is determined that the grout consumption is too high (see item 6). The final determination to stop subsequent attempts to seal a joint/defect will be made jointly between the site Inspector and the Contractor. Should the void pressure meter not read zero \pm 3.45 kPa, clean the equipment of residual grout or make the necessary equipment repairs or adjustments to produce accurate void pressure readings.
 - 6) If mainline joint/defect require more than 0.5 gallon of grout per 25 mm-diameter per joint/defect, modify grouting procedure to perform stage grouting by pumping additional grout in up to 4 gallon increments, waiting 1 gel set cycle time or 1 full minute, whichever is greater between stages. Maximum number of stages shall not exceed two stages of 8 gallons to 10 gallons each unless approved by the Contract Administrator.
 - 7) Residual sealing materials that extend into the pipe shall be removed. Any residual materials which accumulate in the line shall be flushed to the nearest maintenance hole and removed to the complete satisfaction of the Contract Administrator.
 - 8) Upon completion of the sealing of each individual infiltration point, the packer shall be deflated until the void pressure meter reads zero pressure, and then re-inflated and the infiltration point retested as specified in the Contract Documents. If necessary, the Contractor shall clean the equipment and pipe of the residual grout, or make necessary equipment repairs or adjustment to produce accurate void pressure readings. Infiltration points that fail to meet the specified test criteria shall be resealed and retested until test criteria can be met in order to receive payment for successfully sealing.
 - 9) The Contractor shall submit television inspection video USB flash drive or USB hard drive of the sealing process, that is to say the Testing and Sealing Inspection. The

CCTV may be in conjunction with the sealing process. No extra payment will be made for preparing and submitting the Testing and Sealing Inspection CCTV video.

- 10) Upon completion of the sealing activity, the Contractor shall clean the line to ensure that all excess chemical from the sealing operation is removed.

TS 470.07.09 Sealing Verification

Joint/defect grouting shall be recorded in conjunction with the testing. Record the void pressure drop continuously on video and in writing immediately before sealing, and immediately after grouting. After the packer is deflated and moved, record on video the visual inspection of the joint/defect.

Use standardized test and seal data sheets and Pipeline Assessment Condition Program (PACP) data codes.

TS 470.07.10 Grout of Maintenance Hole and Sewer Interface

The Contractor shall inspect the interface or joint/defect between the maintenance hole chamber and the sewer for all sources of infiltration and seal accordingly. This is applicable to the upstream and downstream maintenance holes associated with the sewer section being rehabilitated.

TS 470.07.11 Records

During testing and sealing, records shall be kept which identify the distance of the joint/defect from the start maintenance hole using the City's maintenance hole numbering system, test pressure used, if the joint/defect failed to hold the test pressure and the quantity of sealant used. In the case of sealing, the verification test result shall also be recorded.

At the end of each Working Day, the Contractor shall submit to the Contract Administrator, a daily work order in a form acceptable to the Contract Administrator, which shall be signed by the Contractor's supervisor on site. The work order shall form the basis of determining units of work accomplished for payment purposes, and shall include as a minimum the date, hours worked, the length and diameters of piping tested including specific maintenance hole numbers, streets, the total number of joints/defects tested only and the total quantity of joints/defects tested and sealed, and any difficulties arising on location which were the source of delay to the work or which prevented full and complete testing and, where necessary, grouting of the piping.

Daily inspection logs shall be maintained by the Contractor. These daily logs shall show clearly the exact location of each deficiency which was tested or sealed or both, and the quantity of sealant used at each identified joint/defect. All conditions shall have a reference location including the distance away from the reference maintenance hole using the City's maintenance hole numbering system. This daily log shall be signed each day by the Contract Administrator and the Contractor's supervisor.

The Contractor shall submit a final report for each of the areas identified which provide the information for each maintenance hole run, as specified in the Contract Documents.

TS 470.07.12 Disposal of Materials

Collect and properly dispose of cleaning materials used in the cleaning of the grouting equipment.

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 shall be responsible for the complete removal and disposal off-site, of all foreign materials flushed, scraped, or cut out of the sewer line. Flushing and abandoning of debris in sewer lines is not permitted.

Before disposing of solids, the Contractor shall decant all liquids into the City designated sanitary sewer main. There shall not be any dumping or decanting into any storm sewers. Decanting of solids into any sewer main is not permitted. The Contractor shall decant liquid only into sanitary or combined sewers greater than 250 mm in diameter clear of debris and with low flow. Filtering devices shall be used during the decanting process to prevent any debris from entering the sewer system. Prior to decanting, the Contractor shall verify the type of flow in the sewer. Should a blockage occur in the sanitary or combined sewer due to decanting, the cost of all sewer backups and cleaning shall be at no extra cost the City.

Prior to commencement of the Contract, the Contractor shall notify the Contract Administrator of the disposal site(s). The Contractor shall provide the Contract Administrator with the following documentation attached to all relevant invoices:

- a) Contract name and No.
- b) Vehicle ID – License Plate Number
- c) Date of disposal
- d) Time of disposal
- e) Net weight of load
- f) Provide log books and scale printouts to the Contract Administrator.

All debris must be decanted prior to disposal. Off-site debris dewatering facilities must meet provincial environmental regulations and requirements. Provide copies of required licenses, permits and relevant documentation required for dewatering facility to the Contract Administrator before starting the Work.

TS 470.07.13 Post-Rehabilitation Inspections

After grouting is complete, all pipe sections shall be inspected by means of a CCTV Inspection system (V2). The inspection shall be conducted as per the NASSCO Pipeline Assessment and Certification Program. One set of USB flash drive or USB hard drive and reports shall be submitted for each sewer section tested and repaired.

The Contractor shall guarantee the sealing of the pipe joint/defect by the grout after rehabilitation to the extent that the Contractor will repair and/or re-grout any previously grouted defects including, but not limited to, root penetration, signs of infiltration, and cracks in the pipe or grouting material, which may appear in the structure because of faulty design, workmanship, or material furnished by the Contractor.

TS 470.08 QUALITY ASSURANCE – Not Used

TS 470.09 MEASUREMENT FOR PAYMENT

TS 470.09.01 Actual Measurement

TS 470.09.01.01 *Joint or Defect*

For measurement purposes, a count shall be made of the number of joints or defects sealed.

TS 470.10 BASIS OF PAYMENT

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

Appendix 470-A, September 2019
For Use While Designing and Administrating City Contracts

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

Notes to Designer:

The designer should insert the following text into the tender template in Section 2, Clause 8.1 Mandatory Bid Submission Requirements

Information to be Submitted with Bid

The Contractor shall submit its Ministry of the Environment, Conservation and Parks (MECP) license to haul and dispose materials from sewer lines.