SPECIFICATION GUIDELINE FOR PIPELINE

PACKER INJECTION CAPITAL GROUTING

Master Specification
Section 33 01 30.61
Version 1.0
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Special thanks to NASSCO's Infiltration Control Grouting Committee (ICGC) members for the development of this document:

Jim Shelton, P.E. - Arcadis
Marc Anctil - Logiball
Pete Fleetwood - Bio-nomic Service, a Carylon Company
John Manijak - Michels Corporation
Don Rigby - Avanti/Logiball/Prime Resins
Ron Manestar - Aries
Daniel Magill - Avanti
John Nelson - Visu-Sewer
Emily Sadowsky - Arcadis
Britt Babcock, P.E. - Avanti
Ray Bahr - American Chemical Grout
Mark French - Cues
Tony Winiewicz - Cues
Danny Dimura - Shenandoah Construction
Spencer Tuell - Gulf Coast Underground

Disclaimer:

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BACKGROUND AND USE

NASSCO offers two master specification for Pressure Testing and Packer Injection Grouting, commonly referred to as Sewer Grouting or Test and Seal. These two specifications, while similar, accomplish two different purposes and have very different implementation requirements and performance expectations. These two specifications are:

- ***Section 33 01 30.61 – Pipeline Packer Injection Capital Grouting***
- ***Section 33 01 30.61t – Pipeline Packer Injection Pre-Rehabilitation Grouting***

Pressure testing and packer injection grouting, more colloquially referred to as *sewer grouting* or *test and seal* require significant expertise to implement, and these specifications are intended to be used by specifying engineers, implemented by grout technicians, and overseen by inspectors with the appropriate expertise. These specifications were prepared by industry professionals from the Infiltration Control Grouting Committee of NASSCO (ICGC) and were peer reviewed by industry professionals with experience in testing and sealing programs. This specification is not meant for access structure or large pipe diameter conduit grouting that requires drilling and/or ports for the application of the grout product. This specification is not applicable to grouting of annulus in between carrier and casing pipes associated with trenchless buried installations.

Packer injection grouting is used to reduce the infiltration within the pipeline, seal annular space between close fit liners and host pipes at lateral connections, seal pipe joints that have failed the joint test criteria, stabilize defects, provide external pipe support by stabilizing soils outside the pipe and prevent further loss of pipe bedding into the pipe. Packer injection grouting shall be accomplished by pressure injection of chemical grout through existing pipe defects into the soils encompassing the exterior of pipe. Chemical grouts are designed to be injected into the soil surrounding the pipe to stabilize the soil or into the annular space between liners and host pipes to prevent leakage.

This specification ***Section 33 01 30.61 – Pipeline Packer Injection Capital Grouting*** is appropriately termed “Capital Grouting” or “Long-term Grouting” in that it provides pipe stabilization by creating a pipe cradle-like stability in the bedding and a volumetrically significant, long-term, water seal outside the pipe in the pipe bedding to eliminate or nearly eliminate all groundwater and rainfall induced infiltration entering a defect or leaking joint; this type of grouting, installed per the industry standard of care and these specifications, has an anticipated service life of 25 years or more.

The procedures identified in this specification are markedly different than those traditionally used for “Short-term Grouting” or “Pre-Rehabilitation Grouting”. Those historic practices focused on placing a minimum amount of grout in the pipe gasket space and immediately outside the pipe defect resulting in immediate active leak stoppage but not achieving pipe stabilization, which generally resulted in shorter service life compared

to this standard. The specification for those short-lasting procedures is in *Section 33 01 30.61t – Pipeline Packer Injection Pre-Rehabilitation Grouting*.

This technical specification has been prepared as a master specification using the Construction Specification Institute's Master Format organization and numbering system. It also contains multiple Notes to Specifier (NTS) to contact the specification authority (in this case, ICGC) when clarification or elaboration is needed. These NTS are contained in the Comments boxes on the right side of the page. In cases where there are well defined alternative approaches to specifying and/or implementing the work, these are embedded in the specification with **"OR"** clearly marking the required selection of one or the other. The availability and applicability of tools, techniques, and materials should be confirmed for each project.

Where more than one recommendation or philosophy is presented, user of this specification may assume one of two conditions. One, there are multiple methods, explanations, etc. to achieving the stated purpose. Or two, there are multiple varying opinions – each reasonably supported by experience and study – but no single conclusive case facts to promote or deny either opinion.

The recommended measurement and payment descriptions are intended to be used in concert with these specifications. These coordinated model bid items measurement and payment language and sample payment schedule are additionally provided to ensure grouting contractors are incentivized to focus on the most important aspects of this work: namely, pumping grout to the proper places in the proper shapes, concentrations, and volumes. This specification should be used in conjunction with the Grout Test and Seal section of the Pipeline Assessment Certification Program (PACP), latest version, for inspection and construction.

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SECTION 33 01 30.61
PIPELINE PACKER INJECTION CAPITAL GROUTING

PART 1 - GENERAL[1]

1.1 DESCRIPTION

A. Packer injection grouting shall be used to reduce groundwater and rainfall induced infiltration flow into the pipeline, seal annular space between liners and host pipes at lateral tap connections, seal pipe joints and tap connections that have failed the test criteria, seal certain defects, prevent further loss of pipe bedding into the pipe, impede the migration of groundwater in the pipe trench, and stabilize the pipe and pipe bedding.

B. Packer injection grouting shall be accomplished by pressure injection of chemical grout into the soils outside the pipe. Grouts shall be designed to be injected into the soil surrounding the pipe, which stabilizes the pipe bedding and forms an impermeable seal, and into the annular space between close fit liners and host pipes. Adequate volumes of grout must be injected to form an effective seal. This application will be through joints and penetrations from within the pipe (packer method) and through certain defects in the pipe wall in tandem with a closed-circuit television inspection system.

C. The various pipeline component items subject to these test and seal methods include:

1. Main Line Joint (MLJ) - joints in mainline segment connected to a manhole at each end. MLJ is defined by the “J” or Joint field in the Pipeline Assessment Certification Program (PACP) Details Section inspection form.

2. Lateral Tap Connection (LTC) – Tap connection of lateral to mainline sewer, including a defined length of lateral from the tap and any annular space that might be present between a liner and the host pipe in situations where the main line has been lined. LTC is defined within the Tap group of PACP. Appropriate descriptors and modifiers need to be applied per PACP definitions to further define the asset. The Manhole Assessment Certification Program (MACP) and Lateral Assessment Certification Program (LACP) define Tap differently than PACP. Consult a certified PACP/MACP/LACP user for information on providing the appropriate observation code for these applications.

3. Cured in Place Pipe Liner Annular Space Tap (AST) – Annular space opening at tap cut between liner and host pipe in situations where the main line has been lined. AST is defined within the Tap group of PACP. Appropriate descriptors need to be applied per PACP definitions to further define the asset. MACP and LACP define Tap differently than PACP. Consult a certified PACP/MACP/LACP user for information on providing the appropriate observation code for these applications.

4. Laterals Connected to Manholes (LCM) – Lateral pipe directly connected to and reached from manhole. LCM is defined within MACP. Consult a certified PACP/MACP/LACP user for information on providing the appropriate observation code for these applications.
5. Outside Drop Connections (ODC)[2] – Drop pipes connected to mainline sewer and manhole including a defined length of drop pipe from the main. ODC is defined within PACP as Access Point observations. Appropriate descriptors and modifiers need to be applied per PACP definitions to further define the asset. MACP defines this observation differently. Consult a certified PACP/MACP user for information on providing the appropriate observation code for these applications.
6. Lateral Accessed from Cleanout (LACO)[3] – Lateral pipe reached through a cleanout. LACO is defined within LACP as an Access Point observation. Appropriate descriptors and modifiers need to be applied per LACP definitions to further define the asset. Consult a certified PACP/MACP user for information on providing the appropriate observation code for these applications.
7. Longitudinal Fracture Defects (LFD) – Longitudinal or multiple fractures and crack within a pipe.[4] LFD is defined within PACP/ LACP as a Structural observation. Appropriate descriptors and modifiers need to be applied to the observation to further define the asset. Consult a certified PACP/LACP user for information on providing the appropriate observation code for these applications.

D. Grout Volume Goal: The calculated volume of grout to be pumped outside the pipe defect to stabilize the pipe bedding and provide a long-lasting seal against groundwater and pipe bedding fine infiltration.

E. Provide all labor, materials, tools, equipment, and incidentals as shown, specified, and required for testing sewer pipe joints, taps, lateral pipe joints, and other features by hydraulically applying a positive pressure to the joints and monitoring the pressure in the void. The test medium shall be air.

F. Provide all labor, materials, tools, equipment, and incidentals as shown, specified, and required to grout mainline pipe joints, select defects in pipe body, joints in laterals connected to manholes, lateral tap connections, manhole outside drop connections, and lateral joints accessed through cleanouts using solution grouts using various packer injection grouting methods and tools.

G. Site Environmental Conditions

1. The site is characterized by a water table that is seasonally above the joints but does experience extended periods when the pipe bedding becomes unsaturated.[5]

2. All pipes are active sewers and have continuous moisture levels to promote consistent hydration of hydrophilic chemical grouts.[6]
3. There are no freeze/thaw concerns at the depth of the sewers involved in this Work.[7]
4. Pipes are generally bedded in native subsoil materials, consisting variably of either sandy clays or well graded silty sands OR ASHTO) ## OR Sand.[8]
5. There are pipes that are subject to periods of soil dryness.[9]

1.2 REQUIREMENTS:

A. This Work requires work in active sewers. Follow all federal, state, and local requirements for safety in confined spaces.

B. Conduct worker safety training prior to and within one year of start of work that includes reviewing the hazards associated with hoses, pumps, tanks, couplers, compressors, bottles, motors, and all other related application apparatus. Additional safety considerations including safely handling, mixing, and transporting of chemical grouts should be provided by the grout manufacturer or supplier or both, 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.

1.3 RELATED SECTIONS[10]

A. Section 33 01 30.16, Television Inspection of Sewers.

B. Section 33 01 30.41, Cleaning of Sewers.

C. Section 33 01 30.43, Removal of Protruding Service Connections.

D. Section 33 01 72, Cured in Place Pipe Lining.

E. Section 33 01 72u, Cured in Place Pipe Lining – UV.

F. Section 33 01 72.v, Spiral Wound PVC Panel Pipe Lining.

1.4 QUALIFICATIONS[11]

A. All MLJ work shall be supervised by a technician. A technician is required for each crew. Technician qualifications shall include:

1. Previously performed pressure testing and injection grout sealing of a minimum of 3,000 MLJs and 250 LTC/ASTs.[12]
2. Successfully completed safety training recommended by grout material and grout equipment suppliers.

3. Successfully completed a 16 hour minimum pipeline packer capital grouting field training conducted by a multi-vendor consortium of packer, rig, and grout material vendors.

B. LACO work shall be supervised by a foreman having the following experience in addition to those listed in paragraph A above. A qualified foreman is required for each LACO crew. Foreman qualifications are:

1. Previously performed pressure testing and chemical grout sealing of a minimum of 25 LACOs.
2. Successfully completed safety training recommended by grout material and grout equipment suppliers.
3. Successfully completed a 16 hour minimum pipeline packer capital grouting field training conducted by a multi-vendor consortium of packer, rig, and grout material vendors.

C. LFD work shall be supervised by a foreman having the following qualifications in addition to those listed in paragraph A above. A foreman is required for each LFD crew. Foreman qualifications are:

1. Previously performed pressure testing and chemical grout sealing of a minimum of 15 LFDs.[14]
2. Successfully completed safety training recommended by grout material and grout equipment suppliers.
3. Successfully completed a 16 hour minimum pipeline packer capital grouting field training conducted by a multi-vendor consortium of packer, rig, and grout material vendors.

D. LCM work shall be supervised by a foreman having the following qualifications in addition to those listed in paragraph A above. A foreman is required for each LCM crew. Foreman qualifications are:

1. Previously performed pressure testing and chemical grout sealing of a minimum of 30 LCMs.[15]
2. Successfully completed safety training recommended by grout material and grout equipment suppliers.
3. Successfully completed a 16 hour minimum pipeline packer capital grouting field training conducted by a multi-vendor consortium of packer, rig, and grout material vendors.

E. ODC work shall be supervised by a foreman having the following qualifications in addition to those listed in paragraph A above. A foreman is required for each ODC crew. Foreman qualifications are:

1. Previously performed pressure testing and chemical grout sealing of a minimum of 10 ODCs.[16]
2. Successfully completed safety training recommended by grout material and grout equipment suppliers.
3. Successfully completed a 16-hour minimum pipeline packer capital grouting field training conducted by a multi-vendor consortium of packer, rig, and grout material vendors.

1.5 WARRANTY

A. Testing and grouting work shall be warrantied for materials and workmanship guaranteed by the CONTRACTOR to be free of visible leakage per PACP Infiltration definitions for a period of 2 years[17] from the date of Final Completion unless otherwise stipulated in writing by the OWNER prior to the date of Conditional Acceptance.[18] During this period, actionable defects documented by OWNER from video or photographic documentation or from warranty testing per Paragraphs 3.19 - 3.22, pipe segments on that inspection reach that were originally tested will be retested and, if necessary, resealed by CONTRACTOR at no additional cost to OWNER. In addition to the Warranty Inspections specified under Paragraph 3.18, the OWNER may conduct independent inspections, at its own expense, of the grouting Work at any time prior to the completion of the guarantee period.

1.6 SUBMITTALS

A. Documentation of required qualifications of personnel.

B. Documentation of grouting safety training of all field staff.

C. Equipment operating procedures and systems.

D. Grout information:

1. Third party testing grout component chemical composition, including primary chemical percentages.
2. Grout mixture ratio (including additives).
3. Procedure for adjusting grout gel time during initial preparation.
4. Procedures for adjusting grout gel time as temperature changes.
5. Curves of grout gel time versus temperature.
6. Instructions for addition of components.
7. Safety Data Sheets.

E. Equipment operating procedures and systems to be used, including manufacturer's literature on grout pumps (including pump curve demonstrating compliance with required pumping rates), operating pressures, packers, skins, packer mounted gauges, pressure readings on screen, and lateral blockage clearing equipment.

F. Packer to pipe void volume between the packers and host pipe and maximum packer end element inflation pressure when new.

G. Spare parts list.

H. Documentation of Joint Testing Observations in accordance with Section 33 01 30.16, Television Inspection of Sewers or in accordance with Grout and Seal codes and reporting per PACP Manual, latest version is a Television Inspection of Sewers specification is not included in the project manual.

I. List and corresponding digital images, in accordance with Paragraph 3.3, of lateral taps containing roots or other obstructive conditions.

J. Upon completion of grouting each segment, submit to ENGINEER a report showing the following data for each item tested, grouted, or attempted to be grouted.

1. Location of the pipeline segment/lateral address in which the testing was done.
2. Stationing.
3. Location of any items not tested and the reason for not testing.
4. Time, date, and temperature.
5. Grout mixture formulation, including additives.
6. End seal pipe-packer contact pressure and seal pressure.
7. Test pressure achieved and the duration of test maintained for each item passing the air test.
8. End-of-hoses pump rates.
9. In situ packer pumping rate
10. Gel time(s) from cup testing.
11. Quantity of grout used to seal each item.
12. Step grouting practice, including pump on and off cycle times and volumes, if applicable.
13. Post-grout pressure test results.
14. Regrouting and retesting giving above data as required.

15. Video recording cross-reference index.

K. Documentation of Post-Construction Inspection in accordance with Section 33 01 30.16, Television Inspection of Sewers or in accordance with Grout and Seal codes and reporting per PACP Manual, latest version is a Television Inspection of Sewers specification is not included in the project manual.

L. Documentation of Warranty Inspection in accordance with Section 33 01 30.16, Television Inspection of Sewers or in accordance with Grout and Seal codes and reporting per PACP Manual, latest version is a Television Inspection of Sewers specification is not included in the project manual.

1.8 REFERENCE STANDARDS[19]

A. NASSCO, Inc. prepared *Pipeline Assessment and Certification Program (PACP)* Reference Manual, latest version.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. The basic equipment shall consist of a remotely operated television camera capable of pan and tilt, testing and grouting devices (referred to hereafter as packers), grout preparation tanks (Tank A –Base Chemical and Additives and Tank B – Oxidizer Only) and 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 and a means for continuously measuring the actual static pressure of the test medium and grout within the void area only. Packers shall be expanded by air pressure.

B. All packers shall be fitted with a void pressure sensor (either a transducer or gauge) mounted on the packer. If using a void gauge as the pressure sensor, the maximum top range shall be 15 psi and readable using the television camera. There can be no check valve between the void space and the pressure sensor. Packer void pressure shall be shown either on-screen or captured on-video. The air test gauge in the control panel in the studio may not be used for air testing or post-grouting pressure confirmation because the length of hose and the presence of check valves renders this technique unreliable and inaccurate at pressures below 12 psi.

C. Grout control panel shall have gauges for monitoring packer element pressure. Packer element pressure gauges shall have a range of 0-60 psi.

D. MLJ packers shall have void volume less than 0.3 gallons for 8-inch packers, 0.4 gallons for 10-inch packers and 0.5 gallons for 12-inch packers.

E. LTC and AST packers shall have mainline void space volume less than 0.75 gallons and sock void space less than 0.2 gallons per foot for 4" diameter socks and 0.25 gallons per foot for 6" diameter socks.

F. LTC and AST packers shall consist of inflatable mainline end elements and a lateral grouting sock and plug that creates a void area extending beyond the tap or drop connection. Whenever possible, use a lateral sock sized to match the diameter of the lateral being grouted. Effective sealing length shall be __ feet[20]., unless required by transition or pipe configuration less than this, otherwise indicated on the plans, or as directed by ENGINEER. Where the lateral or drop is capped, utilize alternate lateral grouting plug or equipment sized appropriately for the capped lateral. If the lateral transitions from 6" to 4" in diameter within the view of the mainline camera and less than 2 feet from the tap, use a 4" lateral grouting plug. Maintain a variety of lengths of lateral grouting plugs and adjust length of lateral grout plug as required.

G. LCM, LACO, ODC, and LFD packers shall consist of a flexible push-pull-type packer. LCM, LACO, and LFD packers shall be sized for the diameter and pipe joint spacing found in the field, have void spaces commensurate with their duty, and be acceptable to the ENGINEER. The packer shall be able to test the items specified and be able to negotiate fittings associated with the pipe construction. If the lateral contains a transition, CONTRACTOR may change out diameters of push packer or grout using a smaller diameter packer but no relief for excess residual grout will be provided nor payment for the extra wasted grout.

H. Packers operating in concrete, iron, or steel pipe shall obtain airtight seals against surfaces characterized as PACP SAV and as PACP SAP with protrusion less than 3/32" [21]using proper packer diameter as determined against actual pipe diameter so long the pipe maintains a near circular geometry using either special skins or by grouting the packer in place. Pipes with mushroom shapes due to chemical attack or invert loss due to erosion are generally not sealable with remote packers.

I. Grouting equipment shall consist of the packer, hoses, and pumping systems capable of supplying an uninterrupted flow of sealing materials to completely fill the voids. Pump systems shall be sized to deliver a minimum of 3 gpm during end-of-hose pumping tests and achieve at least a 3 gpm uninterrupted pumping rate over a 5-minute period.[22]

J. A tiger tail, boot, or downhole roller, manhole frame roller, and truck step grid plate or pavement tail or slide are required to protect hoses from chafing.

K. Equipment for cleaning lateral blockages shall be present on-site while any grouting work is being conducted.

L. Provide at least one back up bladder or packer on-site for each packer scheduled for work on any given day.[23]

M. Provide the following spare parts on site, or demonstrate the ability to get these to the site within ## hours:[24,25]

1. Compressor[26]
2. Replacement belts for compressor
3. Generator and shore power cable
4. Camera [26]
5. Crawler and camera repair kit [27]
6. Tag winch [28]
7. Tag winch motor and tag winch transformer
8. Ball valves
9. Hose ends
10. Pump/pump parts
11. Video cable ends
12. Chemical hose check valves and stainless steel quick disconnects
13. Crawler motor
14. LTC packer motor
15. Winch motor
16. Nozzle
17. Root cutter
18. Jetter hose ends and swedge kit
19. Void pressure transducer or Packer mounted pressure gauge (2), depending on packer setup
20. Spare lateral grouting sock
21. Patch repair kit for lateral grouting sock
22. Packer sensor membrane for sensor system
23. 3-function rubber check-valves for packer (3)

2.2 GROUTS - GENERAL

A. All grout materials must have the following characteristics:

1. Able to react /perform in the presence of water (groundwater) with minimal dilution while being injected.
2. Maintain a constant viscosity during the pumping process prior to gelling.
3. Prevent the passage of water (infiltration) into the pipe.
4. Not be subject to shrinkage from water loss in conditions where relative humidity in soil is present.
5. Be moderately flexible, yet rigid enough to stand under its own weight.
6. Be chemically stable and resistant to acids, alkalis, and organics found in sewage.
7. Be easily removable from inside the sewer line after gelling.
8. Cause no upset of treatment or pumping system downstream of the grouting location.

B. Handle, mix, and store grout components in accordance with the manufacturer's recommendations.

C. Provide appropriate protective measures to ensure that the grout components and the chemicals produced in mixing are under the control of the CONTRACTOR always and are not available to unauthorized personnel.

D. All grout materials used shall meet the following minimum application requirements:

1. All component materials shall be transportable by common carriers.
2. Packing of component materials shall be compatible with field storage requirements.
3. Grout components shall be packed in such a fashion as to provide for maximum worker safety when handling the materials and minimize spillage when preparing for use.
4. Gel initiation shall take place at the point of injection/repair.
5. Cleanup shall be done in accordance with the manufacturer recommendations.

2.3 GROUTS

A. Acrylamide base grout shall have the following characteristics:

1. 9#% acrylamide and #% Methylene-bis acrylamide (MBA).[29]
2. A minimum of ##% acrylamide base material by weight in the total grout mix. A higher concentration of acrylamide base material may be used to increase strength or offset dilution during injection.[30]

3. A viscosity of approximately 2 centipoises, which can be increased with additives.
4. A controllable reaction time from 10 seconds to 5 minutes.

B. Acrylic base grout shall have the following characteristics: [31]

1. A minimum of ##% acrylic base material by weight in the total grout mix. A higher concentration of acrylic base material may be used to increase strength or offset dilution during injection.[32]
2. A viscosity of approximately 2 centipoises, which can be increased with additives.
3. A controllable reaction time from 10 seconds to 60 minutes.

C. Acrylate base grout shall have the following characteristics:

1. A minimum of ##% acrylate base material by weight in the total grout mix. A higher concentration of acrylate base material may be used to increase strength or offset dilution during injection.[32]
2. A viscosity of approximately 1-3 centipoise, which can be increased with additives.
3. A controllable reaction time from 10 seconds to 1 hour.

2.4 ADDITIVES

A. Latex

1. Add latex additive (or equal) to increase compressive and tensile strength of grouts to protect against shrinkage, enhance flexibility, and strengthen the grout. Latex shall not contain any organic solvents. The quantity of latex added shall be ##% and shall take the place of the same volume of water normally added in a non-latex grout batch on the A Tank (grout tank).[33] The quantity of latex shall be doubled for grouting non-circular defects. The quantity of latex shall be ##% when grouting the annular space of CIPP liners.[34] Follow manufacturer's recommendations for product handling and mixing. Latex additive shall have the following characteristics.

Solids Content	49% minimum	ASTM D-1010
Viscosity	100-130 cps @ 77°F max	ASTM D-1638
Solvent	Water	

B. Freeze Inhibitor

1. Ethylene glycol may be added to the A and/or B tanks to reduce the freezing temperature[35] of the liquid grout during winter operations when the truck

interior and hoses cannot be kept above freezing temperatures. Ethylene glycol shall replace the same volume of water normally added to the tanks. Follow manufacturer's recommendations for product handling and mixing to prevent freezing.

C. Dye

1. When not using latex, add a fluorescent blue dye to the A side grout tank and a fluorescent yellow dye to the B side tank so that pump balance issues can be discerned and so a visual residual layer of green-colored grout remains to provide confirmation that mixed grout was pumped.

D. Gel Time Extender

1. Add gel time extending agent in accordance with the manufacturer's recommendations to extend gel time as necessary. Completely dissolve chemical crystals in water before introducing to the grout tank.

E. Diatomaceous Earth/Cellulose

1. Add diatomaceous earth (DE) or cellulose as a bulking agent to the where specified and when annular space grouting to the A Tank (grout tank). Completely and continuously disperse bulking agent in the tank. The quantity of bulking agent added shall be ##% and shall take the place of the same volume of water normally added grout batch on the A Tank (grout tank). Follow manufacturer's recommendations for product handling and mixing.[36]

PART 3 - EXECUTION

3.1 CONTROL TESTS

A. Packer Tests - Demonstrate the acceptable performance of packers in the presence of the ENGINEER by conducting demonstration tests.

1. Conduct this test weekly. For pipe less than or equal to 18 inches in diameter, provide a straight pipe of appropriate diameters and ovality and sufficient length to test MLJ, LTC, LACO, LFD, and LCM packers of appropriate. The test cylinder shall be equipped with a void release valve to exercise a controlled release of pressurized air to test the packer under both sound and leaking conditions. The test cylinder shall also be equipped with both a local pressure gauge (0-30 psi) and a connection to the packer test control center/studio; these shall both indicate the pressure in the packer void space.

a. With release valve sealed, inflate packer until it contacts the pipe; record this packer-pipe contact pressure. Inflated packer to 15 psi greater than the packer-pipe contact pressure. Generate a void pressure of 10 psi. The

equipment shall hold at this test pressure for a period of 60 seconds with a pressure drop of less than 1 psi.

b. If above test is passed, crack the release to simulate a very small leak. After ~20 seconds, seal the release and confirm that a pressure drop has occurred and that the local gauge is within ±1.0 psi of the reading in the control center/studio.

2. Conduct this test every segment for MLJ and LTC packers, and every 5th lateral for LCM and LACO packers. After entering each pipeline segment with the MLJ and LTC packer, but prior to the commencement of testing, position the packer on a section of sound sewer pipe between pipe joints, and perform a test. The equipment shall hold a 10-psi test pressure for a period of 30 seconds with a pressure drop of less than 1 psi. In the event of a failed test, repair any defective equipment and re-test to verify proper operation of all equipment at no additional compensation. Should it be found that the barrel of the sewer pipe will not allow valid in situ barrel test requirements due to corrosion or other barrel defects, then the performance testing shall be waived or modified as determined by the ENGINEER. LFD packers do not need to do this test.

3. If air testing equipment cannot be performed successfully, repair or otherwise modify air test equipment and repeat the tests until the results are satisfactory to the ENGINEER. The in-situ barrel test may be required at any other time during the performance of testing work if the ENGINEER suspects the testing equipment is not functioning properly.

B. Pump Tests

1. At the start of the job and once monthly or every 1000 gallons of grout pumped, whichever is more frequent, pump grout in uninterrupted flow for full 5 minutes to demonstrate the pumping system can operated continuously at a minimum 3 gpm rate and deliver a minimum of 9 gallons within 3 minutes.

2. At the beginning of each day prior to application of grout, perform a pump test to determine if equal ratios are being pumped from the grout component tanks at the proper rates and to measure pump rates. Pump 1 gallon of grout from each tank into two separate volumetric measuring containers. Take corrective action if unequal quantities are being pumped. Repeat the pump test until equal quantities are pumped from the grout tanks. Record the amount of time required to pump the two gallons and, when using air pumps, count the pump strokes to confirm the number of pump strokes required to achieve the delivery rate.

C. In situ Pumping Capacity Tests – Once inside the pipe and pumping grout through the packer into the first defect of the segment, record the in-situ pumping rate

delivered, and modify the grout gel time as appropriate. Check in situ pumping rate each time the packer is reconnected to the hoses.

D. Grout Gel Time Tests - Perform a grout gel test in the presence of the ENGINEER to determine the grout mixture gel time. If packer is not in the pipe, recycle into the respective tanks or properly dispose any grout remaining in the hoses. Run mixers for a minimum of 1 minute, then allow entrained air to release from the grout tanks a minimum of 5 minutes before collecting grout samples in disposable cups. Ensure equal portions of Tank A and Tank B are collected prior to mixing. If foam is present on surface of tank, collect sample from below the foam. Determine gel time by taking cup samples from each tank:

1. Prior to grouting each day.
2. Prior to grouting when a different gel time is required.
3. When new batches of grout are mixed.
4. When the temperature of the solutions in either of the tanks have changed by more than 5°F from the previous gel test.

E. Grout Concentration Tests – When grout is not mixed under the observation of the ENGINEER, perform a grout concentration test using a CONTRACTOR-provided hydrometer or refractometer, temperature gauge, and a grout concentration: temperature chart on demand of the ENGINEER to determine the grout concentration.

3.2 PIPE PREPARATION

A. Clean sewer and remove roots in mainline sewer except minor hair roots prior to testing in accordance with Section 33 01 30.41, Cleaning of Sewers.[37]

B. In accordance with Section 33 01 30.43, Removal of Protruding Service Connections, cut back or otherwise remove any portions of laterals that protrude more than 5/8-inch into the mainline to avoid interference with the testing and sealing equipment.

C. Install all excavated point repairs specified for the pipe segment prior to conducting any grouting work.

D. Clean laterals in accordance with Paragraph 3.4 and in accordance with Section 33 01 30.41, Cleaning of Sewers.

E. In accordance with the Details, plug LCMs that are shown on the Drawings as inactive.

F. Clean all LTCs, ODCs, LCMs, ASTs and LACOs in the project area that are not marked as inactive on the Drawings.

G. Following cleaning, televise all MLJs, LTCs, ODCs, LCMs, LFDs, and LACOs that are not marked as inactive on the Drawings in accordance with Section 33 01 30.16, Television Inspection of Sewers. Unless otherwise specified or indicated, LTC inspections will be limited to pan and tilt inspection from mainline camera.

H. Submit Pre-Construction Inspection for any LTC, LCM, AST, LFD, ODC, or LACO that is found to be inactive or in a condition that cannot be tested and grouted.

3.3 GENERAL PRE-TEST AND GROUT REQUIREMENTS

A. For any segment, LTC, ODCs, LCM, LFD, or LACO that CONTRACTOR, OWNER, or ENGINEER believes has issues compromising the ability to cost-effectively grout or achieve the project's longevity effectiveness goals, ENGINEER will review the Pre-Construction Inspection and direct CONTRACTOR as to which MLJs, LTCs, ODCs, LCMs, LFDs, and LACOs are to be (a) tested and grouted without further cleaning, (b) plugged, (c) otherwise repaired, (d) additionally cleaned, or (e) to receive no further rehabilitation.

B. Confirm the inside diameter of the mainline and lateral pipes to be tested and apply the appropriate packer.

C. Confirm with ENGINEER the length of sock to be used for LTCs and ASTs.

D. Confirm with ENGINEER where LFDs are to be conducted and what length LFD to utilize.

E. Confirm with ENGINEER what packer end element pressure to utilize for MLJ work where defects originate at joints.

F. Confirm with ENGINEER what root removal must be achieved prior to grouting.

G. Confirm the inside diameter of the mainline and lateral pipes to be tested and apply the appropriate packer.

H. During testing and sealing, provide sewer flow control to provide unimpeded view of the packer.

I. Perform testing and grouting only in the presence of or with the knowledge and concurrence of the ENGINEER. Modify grouting procedures only at the concurrence of ENGINEER.

J. Record the testing procedure and grouting in accordance with Section 33 01 30.16, Television Inspection of Sewers. The recording shall show the location of the item and the test pressure in subtitles. Grouting and testing shall be incorporated on the same recording. Specifically note all defects and taps and ensure footage counter is accurate throughout testing and grouting to allow proper warranty testing linear referencing.[38]

3.4 ROOTS AND OBSTRUCTIONS IN LATERALS[39]

A. Remove roots and debris that prohibit testing/grouting from LCMs, and LACOs for the length of lateral to be tested/grouted.

B. During mainline sewer and/or lateral inspection, document all LTCs containing roots and obstructive conditions that are visible from the mainline pan and tilt camera and present (a) roots greater than fine roots or (b) roots or defects of a nature to prevent testing and sealing of LTC. ENGINEER will review the LTCs containing roots and obstructions and direct CONTRACTOR as to which LTCs are to be (a) cleaned and grouted, either from the main or from the cleanout, (b) grouted without cleaning – in which case such lateral tap would be excluded from warranty testing, or (c) removed from the scope of work – in which case no payment for such lateral will be made. Successful cleaning of LTCs (i.e. such that the LTC can be effectively grouted and no more than fine hair roots remain) will be paid per the applicable item on the Schedule of Prices. No payment will be made for unsuccessful attempts to clean LTCs.

1. All decisions regarding allowable roots in LTCs shall be made in the field during the work by the ENGINEER and shall be final. It is the CONTRACTOR'S responsibility to either remove roots and debris or obtain ENGINEER approval in writing to leave them in place.[40]

OR

2. For each such LTC, submit a screen shot image clearly showing the extent of roots or obstructive condition to ENGINEER. Submit images in electronic format, labeled and organized in a manner to easily retrieve the image for the LTC in question. The list of LTCs with roots shall include upstream and downstream manhole numbers, station, property address served, plan sheet number where tap is located and photograph of outside cleanout, if present.[41]

3.5 GROUT PREPARATION

A. Follow the manufacturer's recommendations for the mixing and safety procedures to protect personnel from any adverse effects of the grouting compounds. Add and mix base components and additives at rates that will eliminate the formation of lumps within grout tanks solutions. Use accurate scale(s) or volumetric containers to measure the various non-water grout solution components as concentrations specified. Thoroughly mix all components in the appropriate tanks. Provide accurate thermometers to verify temperature of grouting components in tanks. Where practical, add majority of needed water to both grout tanks and mix the base acrylamide into Tank A the evening before to allow the endothermic reaction to complete and ambient temperature to be

achieved and mix the latex to allow the surfactant to dissipate and minimize foaming before using grout.

B. Add gel time extending agent or cool the grout component tanks and/or hoses as necessary to compensate for changes in temperature in grout component tanks or hoses resulting from changes in ambient conditions. The addition of dilution water to extend gel times is only acceptable using the B (non-grout) tank so that the resulting grout still achieves minimum base material concentrations.

C. During the grouting process, monitor 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, grout concentration test, and grout gel time test as described above.

3.6 GROUT VOLUME GOALS AND GEL TIME[42]

A. Grout Volume Goal: Use the attached Grout Volume and Gel Time Calculator, which considers pipe material, bedding depth, bedding material, and joint spacing, to determine grout volume per defect goals.[43]

1. Vitrified clay pipe (VCP), clay tile pipe (CT), asbestos cement pipe (AC) and unreinforced concrete pipe (CP) are more prone to break/fracture and therefore require bedding grouting as well as defect grouting to provide long-term seal stability. These pipes should use the VCP/CP Grout Volume and Gel Time.

2. Polyvinyl chloride pipe (PVC), ductile iron pipe (DIP), reinforced concrete pipe (RCP), and other flexible pipes are less prone to break/fracture and therefore require less stabilization as well as defect grouting to provide long-term seal stability. These pipes should use the PVC/RCP/DIP Grout Volume and Gel Time.

3. Bedding depth: Assume 3” unless otherwise shown or specified on plans or in specifications or field knowledge provides specific information.[44]

4. Bedding material: Assume sand unless otherwise shown or specified on plans or in specifications or field knowledge provides specific information.[44]

B. Gel Time: Gel times shall be within 10 seconds of the following unless field conditions dictate otherwise and with approval of ENGINEER.

1. MLJ, LCM, and LACO for VCP, CT, AC, and CP: Calculate gel time using the below formula and attached Calculator.[45]

$$Gel\ Time = \left(\frac{\{Annular\ Space + CouplingSpace\ (gal)\} + \{Grout\ Volume\ Goal * .75\}}{Pumping\ Rate(gpm)}\right)\left(\frac{60sec}{1min}\right)$$

2. MLJ, LCM, and LACO for PVC, RCP, and DIP: Calculate gel time using the below formula and attached Calculator.[46]

$$Gel\ Time = \left(\frac{\{Annular\ Space + CouplingSpace\ (gal)\} + \{Grout\ Volume\ Goal * .5\}}{Pumping\ Rate(gpm)}\right)\left(\frac{60sec}{1min}\right)$$

3. LTC for AC, CT, CP, and VCP: Calculate gel time using the below formula and attached Calculator.
    i. For CT and CP laterals, assume joint failure rate is 90% and joint spacing is 3'.
    ii. For VCP and AC laterals, assume joint failure rate is 60% and joint spacing is 4'.

$$\text{Gel Time} = \left(\frac{\{\text{SockAnnular Space} + \text{Mainline void space(gal)}\} + \{\{[\text{roundup}(1 + (\text{Sock Length /joint spacing}))] \text{ x \#\% joint failure rate}\} \text{ x Grout goal per joint}] * .75\ (\text{gal})\}\}}{\text{Pumping Rate(gpm)}}\right)\left(\frac{60\text{sec}}{1\text{min}}\right)$$

4. LTC for PVC, DIP, and RCP: Calculate gel time using the below formula and attached Calculator.
    iii. For PVC and DIP laterals, assume joint failure rate is 25% and joint spacing is 5'.

$$\text{Gel Time} = \left(\frac{\{\text{SockAnnular Space} + \text{Mainline void space(gal)}\} + \{\{[\text{roundup}(1 + (\text{Sock Length /joint spacing}))] \text{ x \#\% joint failure rate}\} \text{ x Grout goal per joint}]\ (\text{gal})\}\}}{\text{Pumping Rate(gpm)}}\right)\left(\frac{60\text{sec}}{1\text{min}}\right)$$

5. LFD for VCP, CT, AC, and CP: Calculate gel time using the below formula:

$$Gel\ Time = \left(\frac{\{Annular\ Space\ (gal)\} + \{Grout\ Volume\ Goal * .33)\}}{Pumping\ Rate(gpm)}\right)\left(\frac{60sec}{1min}\right)$$

6. LFD for PVC, DIP, and RCP: Calculate gel time using the below formula:

$$Gel\ Time = \left(\frac{\{Annular\ Space\ (gal)\} + \{Grout\ Volume\ Goal * .5\}}{Pumping\ Rate(gpm)}\right)\left(\frac{60sec}{1min}\right)$$

7. Annular Space Grouting: Calculate gel time using the below formula:[47]

$$Gel\ Time = \left(\frac{\{Annular\ Space\} * \{Perimeter\ of\ pipe\} + \{Sealing\ Distance\ from\ tap\ x\ 2\} * 7.48 + Void\ Space\ (gals)}{Pumping\ Rate(gpm)}\right)\left(\frac{60sec}{1min}\right)$$

OR, if only addressing pipes with diameters ≤ 18":

C. Grout Volume Goal for pipe diameters less than 18"[48]

1. VCP, AC, CT, and CP: ## gallons per inch diameter for VCP and CP [49]
2. PVC, DIP, and RCP: ## gallons per inch diameter for VCP and CP[50]

D. Gel Time: Gel times shall be within 10 seconds of the following unless field conditions dictate otherwise and with approval of ENGINEER.

1. MLJ, LCM, and LACO: Calculate gel time using the below formula and attached Gel Time Table.[51]

$$Gel\ Time = \left(\frac{\{Annular\ Space + CouplingSpace\ (gal)\} + \{PipeDiameter(inch)x\#groutgoal(gpin - dia\}}{Pumping\ Rate(gpm)}\right)\left(\frac{60sec}{1min}\ \text{x } 1.2\right)$$

2. LTC: Calculate gel time using the below formula and attached Gel Time Table. Assume lateral joint failure rate is:

   i. For CT and CP laterals, assume joint failure rate is 90% and joint spacing is 3'.[52]

ii. For VCP and AC laterals, assume joint failure rate is 60% and joint spacing is 4'.[52]

iii. For PVC and DIP laterals, assume joint failure rate is 25% and joint spacing is 5'.[52]

$$\text{Gel Time} = \left(\frac{\{\text{SockAnnular Space (gal)}\} + \{\{[1 + (\text{Sock Length (ft)}/\text{joint spacing})] \text{ x \#\% joint failure rate}\} \text{ x [Pipe Diameter (inch) x \# grout goal (gpin-dia)]} + \text{Mainline void space (gal)}\}}{\text{Pumping Rate(gpm)}}\right)\left(\frac{60\text{sec}}{1\text{min}}\right)$$

3. LFD: Calculate gel time using the below formula:[53]

$$Gel\ Time = \left(\frac{\{Annular\ Space\ (gal)\} + \{PipeDiameter(inch)x0.25(gpin - dia - ft)x(PipeLength + 2\}}{Pumping\ Rate(gpm)}\right)\left(\frac{60sec}{1min}\right)$$

E. Where groundwater is entering the pipe from multiple locations near the point of grouting or where grout consistently enters back into the pipe from adjacent joints, lower gel time and/or modify grouting procedures to allow faster grout set times and minimize grout wash-in through adjacent defects. Consult with ENGINEER before proceeding with any site-specific measures.

3.7 TESTING AND GROUTING DEFECTS

A. Testing and grouting will not be required on pipe exhibiting the following conditions or characteristics. Provide ENGINEER with digital image and intention not to grout any such defect.

1. Longitudinal, spiral, or multiple fractures, as classified by PACP, unless specifically shown or specified or directed by ENGINEER to be grouted via LFD grouting.[54]
2. Broken or partially collapsed pipe, as classified by PACP.
3. Sections of the pipe without defects between joints.
4. Any section of pipe that is scheduled for replacement or other work involving excavation or new connections.
5. Any sections of pipe or joints that are in such poor structural condition that in the judgment of ENGINEER or CONTRACTOR, significant structural damage of the pipe would occur as a result of the pressure test.
6. Defects in cured in place liners.[55]

B. Attempt to test and, if needed and possible, grout any joint separated less than 1-inch or any angular or offset joint.

C. Do not test, but do grout, all circumferential cracks and fractures, visibly leaking joints, and joints with visible defects.

D. Grout all LFDs or other defects as specified or as directed by ENGINEER.

E. Do not test or grout any other pipe defects unless so specified or shown or directed by ENGINEER to do so.

F. Any visually structurally undamaged joint that structurally cracks, fractures, breaks, or collapses during testing and grouting that are documented on video to have been done under normal pressure conditions shall be the OWNER's responsibility and cost to repair. Promptly repair any other sewer damage resulting from the CONTRACTOR's operations at no additional compensation.

G. Any visually structurally defective joint that collapses during low pressure MLJ grouting that are documented on video to have been done under proper low pressure grouting conditions shall be the OWNER's responsibility and cost to repair. Promptly repair any other sewer damage resulting from the CONTRACTOR's operations at no additional compensation.

H. Test and seal manhole outside drop connection joints using a push packer appropriately sized for diameter and length of outside drop pipe. Test and seal as much of the outside drop connection from the main to the manhole as practical using ODC packer.

I. Position packers over joints or defects by means of a closed-circuit television camera in the line.

J. For each joint/lateral/defect tested/grouted, record exact location and volume of grout placed in PACP Remarks field.

K. For each segment, record ambient temperature, grout tank temperature, gel set test time, and packer inflation pressure in PACP header in appropriate fields.[56]

L. Specifically identify each tap and break location on the grout report to aid in properly locating joints during warranty testing.

3.8 JOINT TESTING PROCEDURES

A. Joint testing target pressure before grouting shall be equal to ½ psi per vertical foot of pipe depth plus 3 psi; however, target test pressure shall not exceed 12 psi nor be lower than 6 psi unless directed by the ENGINEER. Control test equipment to ensure the specified test pressure is not exceeded by more than 2 psi.

1. If void pressure gauge is not working or not visible/readable and less than 1/3rd the remaining items to test remain, CONTRACTOR may complete

segment using panel gauge but test pressures shall be increased by 5 psi and test time by 5 seconds (to overcome the check valves and regulators in the plumbing). No additional work may be conducted beyond this until the void pressure gauge is working properly.

B. Test joints on LCMs from the manhole to a location[57] ## feet up the lateral or to the cleanout, whichever comes first. If there is a transition in the LCM, test the transition unless its offset prevents packer insertion and seal. Direct visual observation shall be used to position the packer.

C. Test joints on LACOs from the cleanout to the main, to previously grouted joints done during LTC grouting, or until the lateral diameter increases beyond the sealing capabilities of the LACO packer, whichever comes first. Direct visual observation shall be used to position the packer.

D. Do not test joints with visible longitudinal, spiral, or multiple fractures or cracks or where the packer cannot be seated because of tap connection. Note reason for not testing on the log.

E. Individually test each MLJ, LACO, ODC, and LCM joints at the above-specified pressure (and retest after sealing) in accordance with the following procedure:

1. The packer shall be positioned within the pipe in such a manner as to straddle the joint to be tested. If uncertain, pump small amount of grout to confirm the void space is properly located (spitting) before inflating the packer.

2. The packer ends shall be expanded to isolate the joint from the remainder of the pipe and create a void area between the packer and the pipe joint. The ends of the testing device shall be expanded against the pipe with sufficient inflation pressure to contain the air within the void without leakage past the expanded ends. Record end seal pipe-packer contact pressure and seal pressure used.

   a. Packer end seal pressures for visually sound VCP shall not be greater than 15 psi more than the required packer-pipe contact pressure.

   b. Packer end seal pressures for VCP with joint defects shall use low pressure MLJ techniques such that the end element pressures shall not be greater than 8 psi more than the required packer-pipe contact pressure.

   c. For rough surface pipe such as corroded concrete pipe[58], use grout to seal the leaks around the packer end if airtight seal cannot be achieved. Gel time may be reduced to half the normally specified time under these circumstances with the approval of ENGINEER. The CONTRACTOR shall be paid the unit price for grout to seal the packer unless ENGINEER determines that the sewer was inadequately cleaned or the packer is not

performing properly but will not be paid the unit price for joint grouting for this activity.

3. Air shall then be slowly introduced into the void area until a pressure equal to the required test pressure is observed on the pressure monitoring equipment. Control inflation rate of the packer to minimize over-pressurization of the void space by adjusting the quick inflate timer to stop rapid inflation before the packer contacts the pipe.
4. After the void pressure is observed to be equal to the required test pressure, the air flow shall be stopped. If the void pressure as measured at the packer decays by more than 1.0 psi below the required test pressure within 15 seconds, the joint will be deemed to have failed the test and shall be sealed.
    a. If the void is over pressurized and the void pressure decays, the 15 second period shall begin once the test pressure is achieved. If the void is unavoidably but significantly over pressurized from water or residual grout (e.g., 2x the target test pressure) and the void pressure decays, use a 10 second period to determine if the joint(s) pass or fail.
    b. If testing after grouting and the void pressure is unavoidably but significantly over-pressurized from water or residual grout (e.g., 2x the target test pressure) and the void pressure decays, add an additional 2 psi of pressure and use a 10 second period to determine if the joint(s) pass or fail.
5. Upon completing the successful testing of each individual joint, the packer shall be deflated with the void pressure meter continuing to display void pressure. Should the void pressure meter fail to drop to ±1 psi, clean the test equipment of residual grout material or make the necessary equipment adjustments to provide for an accurate void pressure reading.

3.9 LTC TESTING PROCEDURE

A. LTC void pressure shall be equal to ½ psi per vertical foot of pipe depth plus 3 psi; however, test pressure shall not exceed 10 psi nor be lower than 6 psi unless directed by the ENGINEER. Control test equipment to ensure the specified test pressure is not exceeded by more than 2 psi.[59]

1. If void pressure gauge is not working or not visible/readable and less than 1/3rd the remaining items to test remain, CONTRACTOR may complete segment using panel gauge but test pressures shall be increased by 5 psi and test time by 5 seconds (to overcome the check valves and regulators in the plumbing). No additional work may be conducted beyond this until the void pressure gauge is working properly.

B. Air testing LTCs shall be accomplished by isolating the area to be tested with the packer and by applying positive pressure into the isolated void area. A pan and tilt camera shall be used to position the lateral packer. The bladder shall be inverted from the mainline assembly into the lateral pipe and inflated. The mainline elements shall then be inflated to isolate the lateral connection and the portion of the lateral to be tested. A sensing unit shall be located within the void area and will accurately and continuously transmit void pressure readout to the control panel or pressure gauge viewable with CCTV camera.

C. The test procedure will consist of applying air pressure into each isolated void area. A sensing unit shall be located within the void area and will accurately transmit continuous pressure readout to the control panel. Air shall then be slowly introduced into the void area until a pressure equal to the required test pressure is observed on the pressure monitoring equipment.

D. 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 1.0 psi within 20 seconds, the LTC will have failed the test and shall be sealed. If the void is over pressurized and the void pressure decays, the 20 second period shall begin once the test pressure is achieved.

E. After completing the air test for each individual LTC specified herein, deflate the packer, with the void pressure meter continuing to display void pressure. If the void pressure does not drop to ±1 psi, clean the test equipment of residual grout material or make the necessary equipment adjustments to provide for an accurate void pressure reading.

F. For laterals capped less than two feet from the main, CONTRACTOR may use a mainline packer to test the lateral tap.

G. Length of lateral to be tested shall be as shown or indicated.

3.10 LFD AND ANNULAR SPACE TAP TESTING PROCEDURES

A. Do not test LFDs and annular tap spaces.

3.11 GROUTING - GENERAL

A. The pumps, meter, and packer shall be integrated so that grout component proportions, quantities, and pressures can be monitored and regulated in accordance with the type and size of the leak, percentage of voids being filled, type of soil surrounding the pipe, and the rate of flow of the grout in relation to the back pressures.

B. Grout all MLJ, LTC, LCM and LACO joints that failed the pressure test, that are visibly leaking at a rate classified as ID (dripper) or greater by PACP, or that have

fracture, crack, or chipped joint defects originating at the joint and terminating within 8 inches of the joint by the packer injection method. Grout all LFDs or other pipe defects specified or directed without testing. Generally, this shall be accomplished by forcing grout through a system of pumps and hoses into and through the joints of the sewer from the packer within the sewer pipe. Jetting or driving pipes from the surface shall not be allowed.

C. Record in the Additional Comments fields[60] of the PACP header the assumed bedding depth, assumed bedding material, calculated grout volume goal, in situ pump rate, gel time entered calculated by the Grout Volume and Gel Time Calculator, actual initial gel time, and adjusted gel time and time of correction.

D. When grouting VCP joints with defects originating at the joint, use a low-end element technique (LEET) whereby the end elements are inflated to only 8 psi above pipe-packer contact pressure. Specifically note in the grouting record each joint that has a defect originating from it.

E. If less than three times the void space or less than 1 gallon of grout above the packer void space is pumped outside the pipe (i.e., not blown by the end elements), whichever is less, the joint will be marked as passing; grout used in this circumstance will not be paid for.[61] However, note in the grouting record the volume of grout in excess of void space and blow-by utilized.

F. If a packer with a higher void space than specified is used, the additional grout used to fill this larger void space shall not be paid for.

G. After each time pumping grout at one of the above items, if the void space pressure drops faster than the allowable rate at the defined target test pressures, then continue pumping grout in accordance with these procedures. If the void space pressure does not drop, deflate the packer, purge air test line/valve, then reinflate and retest at target test pressure.

   1. When using grout to seat the packer, retest as above except do not deflate the packer first.

H. If the item fails this air test, repeat the grouting procedure at no additional cost to OWNER. Repeat this sequence of air testing, grouting, and subsequent air testing until either the item is sealed, or it is determined that the grout consumption is too high. The final determination to stop subsequent attempts to seal an item will be made jointly between OWNER and CONTRACTOR.

I. Generally, pump to refusal or in accordance with step grouting procedures. Refusal shall mean the mixed grout has flowed through the void space, through any joint failure or defect, into any annular space or surrounding soil; gelled or filled the available void space, annular space, and soil pore space; formed a cohesive seal stopping further grout flow; and an air test as described above is successfully passed.

J. If grout is observed to enter the pipe upstream or downstream of the packer through defects, taps, liner cut, or joints, either cut pumping rate in half or adjust gel time to half the proscribed rate. Continue to adjust until grout pass-by is no longer an issue. Readjust grout time and pump rate back to proscribed rate if determined warranted by ENGINEER.

K. If blow-by occurs before achieving minimum grout volume goal, lower the pumping rate to allow a slower introduction of grout into the void space by decreasing air pressure/feed to air pumps, turning down the pump rate of electric pumps, or manually using a 5-10 second break between each pump stroke. Adjust gel time accordingly if this happens on more than half the items being grouted.

L. In the grouting record, record in the comments field for each item:

1. Volume of grout in excess of void space and/or blow by pumped into pipe bedding at each joint
2. Step grout increments
3. Whether max grout volume was reached
4. Final test pressure after completion of grouting
5. If joint has J code defect
6. If packer was grouted in place
7. All taps, breaks, and fractures for the purposes of aligning grouting records during warranty testing.

M. Grouting packer in place

1. Gel time may be reduced from the normally specified time in halves until a testable seal is achieved if pipe wall conditions do not allow a valid packer to successfully seal with the approval of ENGINEER. The gel time will be established in trials in the presence of ENGINEER using the adjacent pipe wall where no crack, fracture, or breaks are present.
2. CONTRACTOR shall be paid the unit price for grout to seal the packer unless ENGINEER determines that the sewer was inadequately cleaned, or the packer is not performing properly but will not be paid the unit price for joint grouting for this activity.

N. If the item fails to seal, continue the grouting procedure. Repeat this sequence of grouting and testing until either the item is sealed, or it is determined that the grout consumption is too high. The final determination to stop subsequent attempts to seal an item will be made by ENGINEER after consultation with CONTRACTOR.

O. For pipes whose crowns are less than 4 feet below grade[62], provide an observer to monitor for grout short circuiting or piping to the surface.

P. Remove all grout from pipe that obscures the pipe wall, joint, or defect when conducting post-grouting inspections. Excess grout does not need to be removed from inactive laterals.[63]

OR

Q. Remove excess grout from pipe by jetting pipe. Excess grout does not need to be removed from inactive laterals. Excess grout for MLJs, LCMs, and LACOs shall be defined as: a thickness of grout greater than 1" thick at any point; an amount of grout that given its location, size and geometry in the judgment of the ENGINEER could cause a blockage; or an amount such that more than 10% of the total pipe wall is obscured by grout. Excess grout for LFDs and LTCs shall be defined as: a thickness of grout greater than 1" thick at any point (except when 4" LTC packers are used for 6" to 4" transitions near the tap, in which case the excess grout standard does not apply); an amount of grout that given its location, size and geometry in the judgment of the ENGINEER could cause a blockage. It is the CONTRACTOR'S responsibility to either remove the grout or obtain OWNER approval in writing to leave grout in place.

R. All decisions regarding excess grout shall be made by the ENGINEER based on the Post-Construction Inspection and shall be final.[64]

OR

S. All decisions regarding excess grout shall be made in the field during the work by the ENGINEER and shall be final. It is the CONTRACTOR'S responsibility to either remove the grout or obtain ENGINEER's approval in writing to leave grout in place. If CONTRACTOR is uncertain if the amount of residual grout remaining inside the pipe is acceptable, CONTRACTOR shall contact and afford ENGINEER opportunity to view the pipe using CONTRACTOR's cameras to render a decision.

3.12 JOINT GROUTING

A. Stop pumping grout after pumping grout volume goal, wait 1 gel set cycle time (or longer at CONTRACTOR's discretion), retest, and if the joint does not pass the air test, then continue grouting by pumping additional grout in 1.5 gallon increments for pipe diameters 4-6 inches, in 2 gallon increments for 8-12, in 2.5 gallon increments for pipe diameters 14-21 inches, and in 3 gallon increments for pipe diameters greater than 21 inches, or until refusal. If necessary to prevent packer blowby, pump in smaller increments. After each step, wait 1 gel set cycle time (or longer at CONTRACTOR's discretion) before retesting, and, if needed, continuing with additional grout steps until successful test, until maximum grout volume is reached, or until directed to stop by ENGINEER.

B. Curtail grouting when grout rate exceeds twice the Grout Volume Goal.

C. Where using low end element technique (LEET) for joints with defects, increase the maximum grout per joint by 33%. Notify ENGINEER verbally and via email of intended changes before making this change.[65]

D. If more than 16% of the joints (1 in 6) are not passing at Max Grout when using in step grouting procedure, cut your gel time in half. Notify ENGINEER verbally and via email of intended changes before making this change.

E. If more than 25% of the joints (1 in 4) need Max Grout volumes using step grouting procedures to achieve seal, cut your gel time in half. Notify ENGINEER verbally and via email of intended changes before making this change.

F. Invoke and repeat this process until a gel time of 15 seconds is reached. Do not use gel times less than 15 seconds for MLJs, LCMs, or LACOs.

G. For any given joint that does not seal at Max Grout, move packer forward to the next joint, complete test and seal work on that second joint, then return to the joint that did not pass, retest it, and if necessary, pump additional grout using step grouting procedures for up to an additional 4 gallons of grout. This second test shall be considered a verification test.

   1. If after reaching the Max Grout plus four gallons additional grout, the joint continues to fail the air test, note “Max Grout Fail” within the comments for that joint observation.

H. If after decreasing gel time it is found that grout volume goals are consistently not being met, gel time will be judged to be too short and gel times will be incrementally increased until grout volume goals are consistently achieved. Seek and follow instructions from ENGINEER on when to return to original gel times.

I. After the final post-grout pressure testing of each joint, move the packer forward, wiping away the excess grout that extends into the pipe, reduces the pipe diameter, or restricts flow. Leave the sealed joints reasonably flush with the existing pipe surface.

J. For LCM or LACO grouting, confirm through camera inspection lateral flow after completing all sealing of each lateral. If a grout blockage is evident, clear the lateral.

3.13 LTC AND ODC GROUTING

A. Grout LTCs or ODCs that do not pass the air test, shows evidence of leakage, or where CONTRACTOR has been directed to grout a tap that contains visible roots.

B. Stop pumping grout after pumping grout volume goal, wait a 1 gel cycle, retest, and if the LTC does not pass the air test continue grouting by pumping additional grout in 2-gallon increments, waiting 1 gel set cycle time between steps, retesting,

and, if needed, continuing with additional 2-gallon grout steps until successful test or until directed to stop by OWNER. Record the amount of grout pumped on the sealing log.

C. Curtail grouting when grout volume reaches thrice the grout volume goal.

D. If after reaching the Max Grout, the LTC fails the air test, note "Max Grout Fail" within the comments for that LTC observation.

E. If greater than 20% of LTCs won't seal when utilizing step grouting and achieving the above maximum grout volume per LTC above, cut gel time in half and maintain pump rate. Invoke this process until a gel time of 20 seconds is reached. Do not use gel times less than 20 seconds for LTCs without approval of ENGINEER.

F. If after decreasing gel time it is found that grout volume goals are consistently not being met, gel time will be judged to be too short and gel times will be incrementally increased until grout volume goals are consistently achieved. Seek and follow instructions from ENGINEER on when to return to original gel times.

G. Air tests after grouting LTCs containing roots is not required.

H. Blockages in the lateral that are not the result of grouting operations shall not be the responsibility of the CONTRACTOR.

I. Confirm lateral flow after sealing of each lateral tap. This can be accomplished by one of the below methods:

1. Visually inspecting the entire length of the grouted lateral.
2. With the lateral packer in position, retract the inversion tube and inject air pressure into the lateral. Should a pressure build in the lateral and not drop to approximately zero immediately after the pressurized air is turned off, it will be assumed that the building sewer connection is substantially blocked with grout and the CONTRACTOR shall immediately clear the lateral at no additional cost to OWNER.
3. With the camera viewing the connection point, attempt to obtain a water flush by the occupant. If no water is viewed during this procedure, it will be assumed that the building sewer connection is substantially blocked with grout and the CONTRACTOR shall immediately clear the lateral at no additional cost to OWNER.

3.14 LONGITUDINAL FRACTURE DEFECT GROUTING[66]

A. Pump until refusal or until the grout pumped exceeds 125% of grout volume goal, at which time modify grouting procedure to step grouting by pumping additional grout in 2-gallon increments until refusal, air test pass, maximum grout volume is

achieved, or directed to stop or continue by ENGINEER. Record the amount of grout pumped on the sealing log.

B. Generally, stop grouting when grout rate exceeds 200% of grout volume goal, unless approved by ENGINEER.

3.15 ANNULAR SPACE TAP (AST) GROUTING[67]

A. Grout all annular spaces using LTC packer with ##' sock.[68]

B. Pump to refusal.

3.16 VERIFICATION TESTING

A. Conduct verification testing as directed by ENGINEER for quality control purposes. ENGINEER will select the MLJs, LTCs, LCMs, or LACOs for pull back testing.[69]

C. Test on a given line segment or lateral:

1. 5% of the grouted MLJs (minimum of two),
2. 2% of MLJs that passed testing without grouting (minimum of one)
3. 5% of LCM joints (minimum of two)
4. 5% of LACO joints (minimum of two)
5. 10% of the grouted LTCs on a given segment (minimum of one, excluding taps with roots not removed).

D. Within a sewer line segment or lateral, if any tested items fail the pullback test, retest an additional 10% of said items in that sewer line segment or lateral at no additional cost to OWNER. If any of these tested items fail the pullback test, retest all the remaining said items in that sewer line segment or lateral at no additional cost to OWNER.

3.17 POST-CONSTRUCTION INSPECTION

A. Conduct Post-Construction Inspection of all pipes, taps, and laterals tested and/or grouted in accordance with Section 33 01 30.16, Television Inspection of Sewers. Any items found to leak that are not specifically excluded for the purposes of Warranty Testing shall be sealed prior to conducting Post-Construction Inspections. Remove from the pipe wall and bottom any excess grout. Collect and remove from the sewer all excess grout removed from the pipe wall.[70]

3.18 WARRANTY TESTING GENERAL[71]

A. Actual period for testing shall be determined by the ENGINEER and will be generally conducted during high groundwater conditions to ensure performance

under potential leakage conditions are assessed. CONTRACTOR will be provided with 60 days' notice of the warranty testing. Conduct all warranty tests in the presence of the ENGINEER.

B. Any items impacted by acts of God (e.g., earthquake, sinkholes, floods), adverse impacts from other utilities (e.g., crossbones, water main failures) are excluded from warranty testing and assurances.

C. ENGINEER will select items for warranty testing that represent the mix of field conditions and grouting results. ENGINEER will consider impediments to warranty testing including bypass pumping, traffic control, access, and private property issues.

D. Warranty test pressure shall be 4 psi.

3.19 MLJ WARRANTY TESTING

A. Conduct warranty testing on 15% [72] of MLJs regardless of whether they passed or failed the pre- or post-grouting air test or a minimum of two sewer line segments, whichever is greater, 18 to 24 months after Substantial Completion. ENGINEER will select the pipe segments to be warranty tested, with the selection of pipe segments representative of the inventory of diameters and materials originally tested.

B. If more than 10% [73] of the warranty tested MLJs fail, test an additional 15%[74] of the pipe segments or two additional sewer line segments, whichever is greater, will be warranty tested at no additional compensation. If more than 10% [75] of the second group of warranty tested MLJs fail, test the MLJs in 50% of the remaining untested pipe segments at no additional compensation. If more than 10% [75] of the warranty tested MLJs fail, test all MLJs in the remaining untested pipe segments at no additional compensation.

C. Grout and retest all MLJs failing warranty testing regardless of whether they passed or failed the pre- or post-grouting air test at no additional compensation. Grout gel time for warranty testing grouting shall be 30 seconds.

D. For each pipe warranty tested, perform a Warranty Inspection.

E. MLJs that received maximum grout volume, regardless of whether achieved a successful post-grouting air test originally or which had joint originating defects, will be tested and, if needed, regrouted, but are exempted from the warranty testing percentages.

3.20 LCM, ODC, AND LACO WARRANTY TESTING

A. Conduct warranty testing on 15% of the LCM, ODC, and LACO joints regardless of whether they passed or failed the pre- or post-grouting air test 18 to 24 months

after Substantial Completion. ENGINEER will select the LCMs, ODCs, and LACOs to be warranty tested, with the selection of laterals representative of the inventory of diameters and materials originally tested.

B. If more than 10% of the warranty tested LCM and LACOs joints fail, test an additional 15% of the LCMs, ODCs, and LACOs at no additional compensation. If more than 10% of the second group of warranty tested LCM, ODCs, and LACOs joints fail, test 100% of the remaining, untested, LCMs, ODCs, and LACOs at no additional compensation.

C. Grout and retest all LCM, ODC, and LACO joints failing warranty testing regardless of whether they passed or failed the pre- or post-grouting air test at no additional compensation. Grout gel time for warranty testing grouting shall be 20 seconds.

D. Perform a Warranty Inspection of all LCM, ODCs and LACO joints that are warranty tested.

E. LCM, ODC, and LACO joints that received maximum grout volume, regardless of whether achieved a successful post-grouting air test originally or which had joint originating defects, will be tested and, if needed, regrouted, but are exempted from the warranty testing percentages.

3.21 LTC WARRANTY TESTING

A. Conduct warranty testing on 15% of the LTCs (excluding grouted taps that contained roots) regardless of whether they passed or failed the pre- or post-grouting air test 18 to 24 months after Substantial Completion. ENGINEER will select the LTCs to be warranty tested, with the selection of pipe segments representative of the inventory of diameters and materials originally tested.

B. If more than 10% of the warranty tested LTCs fail, test an additional 15% of the LTCs at no additional compensation. If more than 10% of the second group of warranty tested LTCs fail, test 100% of the remaining, untested, LTCs at no additional compensation.

C. Grout and retest all LTCs failing warranty testing regardless of whether they passed or failed the pre- or post-grouting air test at no additional compensation. Grout gel time for warranty testing grouting shall be 45 seconds.

D. Perform a Warranty Inspection of all LTCs that are warranty tested.

E. LTCs that received maximum grout volume, regardless of whether achieved a successful post-grouting air test originally or which had joint originating defects, will be tested and, if needed, regrouted, but are exempted from the warranty testing percentages.

3.22 LFD WARRANTY TESTING

A. Conduct warranty testing on 15% of the LFDs (excluding grouted taps that contained roots) 18 to 24 months after Substantial Completion. ENGINEER will select the LFDs to be warranty tested, with the selection of pipe segments representative of the inventory of diameters and materials originally tested. Warranty testing will consist of visual examination for leakage.

B. If more than 10% of the warranty tested LFDs fail, test an additional 15% of the LFDs at no additional compensation. If more than 10% of the second group of warranty tested LFDs fail, test 100% of the remaining, untested, LFDs at no additional compensation.

C. Grout and retest all LFDs failing warranty testing at no additional compensation. Grout gel time for warranty testing grouting shall be 60 seconds.

D. Perform a Warranty Inspection of all LFDs that are warranty tested.

E. LFDs that received the maximum grout volume or which did not achieve a successful post-grouting air test originally will be tested and, if needed, regrouted, but are exempted from the warranty testing percentages.

3.23 AST WARRANTY TESTING

A. Conduct warranty testing on 15% of the ASTs (excluding grouted taps that contained roots) 18 to 24 months after Substantial Completion. ENGINEER will select the ASTs to be warranty tested, with the selection of pipe segments representative of the inventory of diameters and materials originally tested.

B. If more than 10% of the warranty tested ASTs fail, test an additional 15% of the ASTs at no additional compensation. If more than 10% of the second group of warranty tested ASTs fail, test 100% of the remaining, untested, ASTs at no additional compensation.

C. Grout and retest all ASTs failing warranty testing at no additional compensation. Grout gel time for warranty testing grouting shall be 30 seconds.

D. Perform a Warranty Inspection of all ASTs that are warranty tested.

PART 4 - MEASUREMENT AND PAYMENT

4.1 DESCRIPTION

A. The items listed below beginning with Article 4.4, refer to and are the same pay items listed in the Schedule of Prices. They constitute all of the pay items for the completion of the Work. No direct or separate payment will be made for

providing miscellaneous temporary or accessory services, including all other items not specifically named in specific bid item descriptions but which are needed for the prosecution of the Work and to meet all other requirements of the Agreement. Compensation for all such services, things and materials shall be included in the prices stipulated for the pay items listed herein.

B. Each lump sum and unit bid price will be deemed to include an amount considered by Contractor to be adequate to cover Contractor's overhead and profit for each separately identified item.

C. The Contractor shall receive and accept the compensation provided in the Schedule of Prices and the Contract as full payment for furnishing all materials, labor, tools, and equipment for performing all operations necessary to complete the Work under the Contract, and also in full payment for all loss or damages arising from the nature of the Work, or from any discrepancy between the actual quantities of Work and quantities herein estimated by the OWNER.

D. The prices stated in the Schedule of Prices include all costs and expenses for taxes, labor, equipment, materials, commissions, transportation charges and expenses, patent fees and royalties, labor for handling materials during inspection, together with any and all other costs and expenses for performing and completing the Work as shown on the Drawings and specified herein. The basis of payment for an item shown in the Schedule of Prices shall be in accordance with the description of that item in this Section.

E. The Contractor's attention is called to the fact that the unit prices for the various items of Work are intended to establish a total price for completing the Work in its entirety. Should the Contractor feel that the cost for any item of Work has not been defined by a Schedule of Prices payment item, he shall include the cost for that Work in some other applicable Bid Item, so that his Proposal for the project reflects his total price for completing the Work in its entirety.

F. Unless specifically included in a Bid Item, the cost of dewatering, safety, regulatory compliance, normal bypass pumping, maintenance of traffic, restoration, environmental protection including construction entrances, inspections, testing, and other work not specified but required to complete the Work as specified will not be separately paid for but shall be considered as incidental to other Bid Items and included in the prices bid for them.

G. As noted in the individual Specifications, payment for certain Items may be reducd in lieu of required remedial efforts if defects in the Work are observed or if the Work fails to pass the required performance criteria.

H. Abbreviations and acrynoms are defined in the pertinent specifications.

4.2 ESTIMATE OF QUANTITIES

A. Estimated quantities for unit price pay items, as listed in the Schedule of Prices, are approximate only and are included solely for the purpose of establishing pay basis. OWNER does not expressly or by implication agree that the nature of the materials encountered below the surface of the ground or the actual quantities of material encountered or required will correspond therewith and reserves the right to increase or decrease any quantity or to eliminate any quantity or Bid Item as OWNER may deem necessary. CONTRACTOR or OWNER will not be entitled to any adjustment in a unit bid price as a result of any change in an estimated quantity and agrees to accept the aforesaid unit bid prices as complete and total compensation for any additions or deductions caused by a variation in quantities as a result of more accurate measurement or by changes or alterations in the Work ordered by OWNER.

4.3 ALTERATIONS

A. OWNER reserves the right to change the Work under the Contract, whenever any conditions or obstructions are met that render such changes desirable or necessary. All such alterations shall be paid for under the total lump sum bid or at a unit price bid for these items of Work, except as follows.

1. In case such alterations made the Work less expensive to the Contractor, a proper deduction shall be made from the Contract prices and the Contractor shall have no claim on this account for damages or for anticipated profits on the Work.
2. In case such alterations make the Work more expensive, a proper addition shall be made to the Contract prices.

4.4 BID ITEMS

A. Bid Items 1 - 4: Preparatory Sewer Cleaning and Pre-Test CCTV Inspection.[76]

1. Measurement: The quantity for these Items will be the linear feet of sewer pipes cleaned and inspected from center of manhole to center of manhole measured by wheel or tape on the ground surface horizontally along the centerline of the pipe cleaned for each respective diameter of pipe.
2. Payment: This payment shall only be made once for any given pipe segment, regardless of the number of preparatory cleanings required to complete the various inspections and rehabilitation work, unless a physical obstruction or lack of two manholes prevents the complete inspection, in which case partial payment will be made once for the partial inspection and

full payment will be made once the obstruction is removed or the manhole is located. The unit price for this Item will be full compensation for providing all labor, materials, disposal, equipment, tools, and incidentals for all aspects of preparatory sewer cleaning and inspection.

B. Bid Items 5, 7, 9, 11, 13, 15,17,19, and 21: Testing of MLJs

1. Measurement: The quantity for this Item will be the number of MLJs tested by each respective diameter. If packers covering multiple joints are used, payment will be based on the number of joints tested multiplied by 75%.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of testing MLJs. Visual observation of actively running water from leaking joints and circumferential defect, whether tested or not, shall be paid under these Bid Items. Payment for testing MLJs following chemical sealing is included under Packer Injection Grouting Items 6, 8, 10 12, 14, 16, 18, 20, and 22.

C. Bid Items 6, 8, 10 12, 14, 16, 18, 20, and 22: Grouting of MLJs.

1. Measurement: The quantity for this Item will be the number of MLJs or circumferential defects chemically sealed by each respective diameter. If packers covering multiple joints are used, payment will be based on the number of joints grouted multiplied by 75%.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials (except grout), equipment, tools, and incidentals for all aspects of chemically sealing MLJs. No price differentiation is made for grouting technique used. The minimum price for this line item is[77] $## per joint. Payment for grout is under Item 38.

D. Bid Item 23: Pre-Construction Cleaning, Root Removal, Pre-testing CCTV Inspection, Post-grouting Cleaning, and Post-grouting CCTV of LCMs

1. Measurement: The quantity for this Item will be the number of LCMs that are cleaned and televised.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of cleaning, root removal, and CCTV of LCMs. Payment will only be made once for each lateral, regardless of the number of preparatory and post-grouting cleanings required to complete the rehabilitation and inspect the LCM.

E. Bid Item 24: Testing LCM joints

1. Measurement & Payment: The quantity for this Item will be the number of LCM joints tested. If packers covering multiple joints are used, payment will be based on the number of joints grouted multiplied by 75%.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of testing LCM joints. Visual observation of actively running water from leaking joints and circumferential defect, whether tested or not, shall be paid under these Bid Items. Payment for testing LCM joints following chemical sealing is included under Grouting LCM Joints Item 25.

F. Bid Item 25: Grouting LCM joints

1. Measurement & Payment: The quantity for this Item will be the number of LCM joints grouted. If packers covering multiple joints are used, payment will be based on the number of joints grouted multiplied by 75%.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials (except grout), equipment, tools, and incidentals for all aspects of testing and grouting of LCMs. No price differentiation is made for grouting technique used. The minimum price for this line item is[78] $## per joint. Payment for grout is under Item 38.

G. Bid Item 26, and 28: Testing of LTCs

1. Measurement: The quantity for this Item will be the number of LTCs tested by each respective sock length and pipe diameter.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of testing of LTCs.

H. Bid Item 27, 29: Chemical Sealing LTCs

1. Measurement: The quantity for this Item will be the number of LTCs grouted by each respective sock length.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials (except grout), equipment, tools, post-construction CCTV and incidentals for all aspects of grouting of LTCs. No price differentiation is made for grouting technique used. The minimum price for this line item is[79] $### per LTC. Payment for grout is under Item 38.

I. Bid Item 30: LTC Cleaning/Root Removal

1. Measurement: The quantity for this Item will be the number of LTCs that have no cleanouts, are authorized for root removal by OWNER, and whose roots are successfully removed by Contractor.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of removing roots from LTCs without cleanouts. No payment shall be made for unsuccessful cleaning/root removal attempts.

J. Bid Item 31: Locating, Opening, Cleaning, Pre-Construction CCTV Inspection, Post-Grouting Cleaning, Post-Construction CCTV Inspection, and Restoring 4" and 6" LACOs without obstructions

1. Measurement: The quantity for this Item will be the number of LACOs with sweeps or clear opening tees (i.e., without obstruction) that are located, uncovered to depth of 18", opened, cleaned including root removal if required prior to grouting, CCTV inspected prior to grouting, cleaned after grouting, CCTV inspected after grouting, and restored to existing conditions, including capping and reburial, as appropriate.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of locating, opening, cleaning, including root removal if required, prior to grouting, pre-grouting CCTV inspection, cleaning after grouting, post grouting CCTV inspection, and restoring the cleanout and surrounding disturbance for LACOs without obstruction. Payment will only be made once for each lateral, regardless of the number of preparatory and post-grouting cleanings and inspections required to complete the Work.

K. Bid Item 32: Test Joints on 4" and 6" LACOs without obstructions

1. Measurement: The quantity for this Item will be the number of joints actually tested on LACOs without obstructions.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of testing LACO without obstruction joints.

L. Bid Item 33: Locating, Opening, Cleaning, Pre-Construction CCTV Inspection, Post-Grouting Cleaning, Post-Construction CCTV Inspection, and Restoring 4" and 6" LACOs with obstructions

1. Measurement: The quantity for this Item will be the number of LACOs with non-sweep turns or non-clear opening tees (i.e., with obstruction) which require the use of pull-in techniques from the manhole to insert the packer and camera that are located, opened, cleaned, including root removal if required, prior to grouting, CCTV inspected prior to grouting, cleaned after grouting, CCTV inspected after grouting, and restored.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of locating, opening, cleaning, including root removal if required, prior to grouting, pre-grouting CCTV inspection, cleaning after grouting, post grouting CCTV inspection, and restoring the cleanout and surrounding disturbance for LACOs with obstruction. Payment will only be made once

for each lateral, regardless of the number of preparatory cleanings and inspections required to complete the Work.

M. Bid Item 34: Test Joints on 4" and 6" LACOs with obstructions

1. Measurement: The quantity for this Item will be the number of joints actually tested on LACOs with obstructions.
2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of testing LACO with obstruction joints.

N. Bid Item 35: Grout Joints on 4" and 6" LACO

1. Measurement: The quantity for this Item will be the number of LACOs grouted. No price differentiation is made for grouting technique used.
2. Payment: The unit price for this Item will be full compensation for providing all labor, materials (except grout), equipment, tools, and incidentals for all aspects of grouting LACO joints. The minimum price for this line item is[80] $## per LTC. Payment for grout is under Item 38.

O. Bid Item 36: LFD Grout Segment Setup

1. Measurement: The quantity for this Item will be the number of 8"-12" diameter manhole to manhole segments where an LFD packer is used.
2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals to insert the LFD packer into an 8"-12" diameter pipe segment, regardless of the pipe diameter, joint spacing, or number of LFDs to be grouted on a given segment. If a more than one manhole to manhole segment is addressed using a single packer insertion, payment will be made for each segment. Payment will only be made once for LFD setup regardless of the actual number of times the packer is inserted and removed within a given segment.

P. Bid Item 37: LFD Grouting

1. Measurement: The quantity for this Item will be the number of 8"-12" diameter LFDs grouted by each respective joint length.
2. Payment: The unit price for this Item will be full compensation for providing all labor, materials (except grout), equipment, tools, post-construction CCTV and incidentals for all aspects of LFD grouting using long sock packers. Payment for grout is under Item 38. Payment will only be made once for grouting of fractures within pipe joint to pipe joint span regardless of the number of fractures grouted within the span.

Q. Bid Item 38: Grout

1. Measurement: The quantity for this Item will be the number of gallons of grout used for sealing MLJs, ODCs, LTCs, LCMs, LFDs, and LACOS (including void space grout -- except for multi-joint MJL packers and LTC packers where an undersized sock is used in a lateral (e.g., 4" sock in a 6" lateral), in which case the void space volume will be subtracted from the volume of grout measured for payment), and manholes injection grouting.
2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals not included in Items 6, 8, 10, 12, 14, 16, 18, 20, 22, 25, 27, 29, 35, 37, 67, and 68 required for all aspects of grouting. The price for this line item has been set by the OWNER at [81] $## per gallon.

R. Bid Item 39: Removal of Protruding Laterals

1. Measurement: The quantity for this Item will be the number of protruding laterals removed.
2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of removing protruding laterals.

S. Bid Item 40: Plugging of Inactive Laterals Connected to Manhole:

1. Measurement: The quantity for this Item will be the actual number of laterals directly connected to manholes plugged.
2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of plugging inactive laterals directly connected to manhole.

T. Bid Item 41: 4" or 6" Bypass Pumping

1. Measurement: The quantity for this Item shall be the number of 12-hour days that a particular sewer main is bypass pumped using a 4" or 6" pump and productive inspection, cleaning, or rehabilitation work, as determined by OWNER, is achieved.
2. Payment: The unit price for this item will be full compensation for providing all labor, materials, equipment, tools and incidentals required to complete all aspects of bypass pumping including up to 800 ft. of lay flat discharge hose and 80' of suction piping. No additional compensation will be provided for installation or removal of the pumping system. No additional compensation will be provided for plugging or bypass pumping for flows less than 250 gallons per minute.

U. Bid Item 42. VerificationTest of MLJs

1. Measurement: The quantity for this Item will be the number MLJs where Verification tests are ordered by OWNER.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials (except grout), equipment, tools, and incidentals for all aspects of Verification testing of an MLJ. The minimum price for this line item is[82] $## per joint.

V. Bid Item 43. VerificationTest of LTCs

1. Measurement: The quantity for this Item will be the number LTCs where Verification tests are ordered by OWNER.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials (except grout), equipment, tools, and incidentals for all aspects of Verification testing of an LTC. The minimum price for this line item is[83] $### per LTC.

W. Bid Item 44. VerificationTest of LCM joints

1. Measurement: The quantity for this Item will be the number of individual joints on an LCM where Verification tests are ordered by OWNER.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials (except grout), equipment, tools, and incidentals for all aspects of Verification testing of individual joints on LCMs. The minimum price for this line item is[84] $## per joint.

X. Bid Item 45. VerificationTest of LACO joints

1. Measurement: The quantity for this Item will be the number of individual LACO joints where Verification tests are ordered by OWNER.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials (except grout), equipment, tools, and incidentals for all aspects of Verification testing of individual joints on LACOs. The minimum price for this line item is[85] $## per joint.

Y. Bid Item 46: Post Construction Mainline Cleaning and CCTV Inspection

1. Measurement: The quantity for this Item shall be the length of sewer main in linear feet cleaned and inspected during Post-Construction Mainline Cleaning and CCTV Inspection. For each pipe segment inspected, the quantity will be the same as what was measured under Items 1-4.

2. Payment: The unit price for this item will be full compensation for providing all labor, materials, equipment, tools, and incidentals required to complete all aspects of cleanings and inspections. This payment shall only be made once for any given pipe segment. No additional compensation will be

provided for repairs and post-repair inspections completed during the Post-Construction Inspection.

Z. Bid Item 47: Lateral Inspection and Sonding through Cleanout or Manhole

1. Measurement: The quantity for this Item will be the number of 4-inch through 6-inch nominal diameter laterals inspected and sonded from either manholes or cleanouts. Inspections less than 40’ long will not qualify for payment unless OWNER determines pipe obstacles prevented reasonable achievement of length goal in order to qualify for payment. The entire lateral must be televised from the main line to the house when inspecting and sonding from manholes and from the cleanout to the main when inspecting and sonding from cleanout unless obstructions in the lateral prevent this in order to qualify for payment.
2. Payment: The unit price for this item will be full compensation for providing all labor, materials, equipment, tools, and incidentals required to complete all aspects of these inspections and sondings.

AA. Bid Item 48: Lateral Inspection and Sonding via Side Launch CCTV from the Sewer Main

1. Measurement: The quantity for this Item will be the number of 4-inch through 6-inch nominal diameter laterals connected directly to the mainline sewer that are inspected and sonded from the mainline to the house using side launch camera and sonde. Inspections/sondes less than 30’ long will not qualify for payment unless OWNER determines pipe obstacles prevented reasonable achievement of length goal in order to qualify for payment. The entire lateral must be televised and sonded up to 80’ from the main line unless unless OWNER determines pipe obstacles prevented reasonable achievement of length goal in order to qualify for payment.
2. Payment: The unit price for this item will be full compensation for providing all labor, materials, equipment, tools, and incidentals required to complete all aspects of these inspections.

BB. Bid Items W1 -W4: Preparatory Sewer Cleaning, Pre-Test CCTV Inspection, and Post-Warranty Testing CCTV Inspection.

1. Measurement: The quantity for these Items will be the linear feet of sewer pipes cleaned, pre-test inspected, and post-test inspected from center of manhole to center of manhole measured by wheel or tape on the ground surface horizontally along the centerline of the pipe cleaned for each respective diameter of pipe.

2. Payment: This payment shall only be made once for any given pipe segment, regardless of the number of preparatory cleanings required to complete the warranty work. The unit price for this Item will be full compensation for providing all labor, materials, disposal, equipment, tools, and incidentals for all aspects of preparatory sewer cleaning and inspection.

CC. Bid Items W5-W13: Warranty Inspection - MLJs.

1. Measurement: The quantity for this Item will be the number of MLJs where warranty tests are conducted by each respective diameter.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of MLJ warranty testing as specified. No additional compensation will be provided for repairs, grout, and post-repair inspections completed during the warranty period. The minimum price for this line item shall be 1.5 times the price bid to test under the respective testing Bid Items 5,7,9,11,13,15,17,19, and 21.[86]

DD. Bid Item W14: Warranty Inspection – LTCs.

1. Measurement: The quantity for this Item will be the number of LTCs where warranty tests are conducted.

3. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of LTC warranty testing as specified. No additional compensation will be provided for repairs, grout, and post-repair inspections completed during the warranty period. The minimum price for this line item shall be 1.5 times the price bid to test under the respective testing Bid Items 26 and 28.[87]

EE. Bid Item W15: Warranty Inspection – LACO without obstruction.

1. Measurement: The quantity for this Item will be the number LACOs without obstruction where warranty tests are conducted.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of testing all previously tested joints on LACOs without obstruction warranty testing as specified. No additional compensation will be provided for repairs, grout, and post-repair inspections completed during the warranty period. The minimum price for this line item shall be 1.5 times the price bid to test under Bid Item 32.[88]

FF. Bid Item W16: Warranty Inspection – LACO with obstruction.

1. Measurement: The quantity for this Item will be the number LACOs with obstruction where warranty tests are conducted.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of testing all previously tested joints on LACOs with obstruction warranty testing as specified. No additional compensation will be provided for repairs, grout, and post-repair inspections completed during the warranty period. The minimum price for this line item shall be 1.5 times the price bid to test under Bid Item 34.[89]

GG. Bid Item W17: Warranty Inspection – LCM.

1. Measurement: The quantity for this Item will be the number LCMs where warranty tests are conducted.

2. Payment: The unit price for this Item will be full compensation for providing all labor, materials, equipment, tools, and incidentals for all aspects of testing all previously tested joints on LCMs warranty testing as specified. No additional compensation will be provided for repairs, grout, and post-repair inspections completed during the warranty period. The minimum price for this line item shall be 1.5 times the price bid to test under Bid Item 24.[90]

HH. Bid Item A1: Contingency Allowance

1. Measurement & Payment: A mandatory contingency allowance has been established in the Schedule of Prices. All Bidders shall include this allowance in their Bid. CONTRACTOR shall present a cost and additional time proposal for any additional related work requested by OWNER or for increasing unit price quantities. The proposal must be approved by the OWNER prior to release of any general contingency monies.

II. Bid Item A2: Open Cut Excavated Point Repair Contingency Allowance

1. Measurement & Payment: CONTRACTOR shall present a cost and additional time proposal for any additional related work requested by OWNER for open cut pipeline replacement work. The proposal must be approved by the OWNER prior to release of any allowance monies. If the actual cost for such work is less or greater than that indicated on the Schedule of Prices, the allowance amount for this item will be adjusted accordingly, based on the actual costs. The final amount for the allowance shall be adjusted based on the actual approved expenditures.

JJ. Bid Item A3: Sewer Solids Disposal Allowance

1. Measurement & Payment: CONTRACTOR shall present a cost and additional time proposal for storage, transportation, and disposal of sewer solids removed from sewers and landfilled at Richland Waste Management Landfill. The proposal must be approved by the OWNER prior to release of

any allowance monies. If the actual cost for such work is less or greater than that indicated on the Schedule of Prices, the allowance amount for this item will be adjusted accordingly, based on the actual costs. The final amount for the allowance shall be adjusted based on the actual approved expenditures.

KK. Bid Item M1: Mobilization

1. Measurement& Payment: The lump sum for this Item will be full compensation for providing initial services and facilities required to mobilize for and commence with the Work under this Project. Payment for mobilization will be made in two equal payments over the first two pay applications OR as a percentage equal to the amount of pay request, without retainage, divided by[91] $_____. Payment for this item will be made only once.

+ + END OF SECTION + +

End Notes / Notes to Specifier:

1. For the purposes of this guidance specification, ENGINEER denotes the person responsible ensuring for the proper execution of the design and the administration of the technical aspects of the construction.

2. ODC grouting is a developing approach. It requires special equipment and process knowledge to reliably execute.

3. LACO grouting is a specialized approach. It requires special equipment and process knowledge to reliably execute.

4. LFD grouting is a specialized approach. It requires special equipment and process knowledge to reliably execute.

5. Revise as appropriate to site conditions.

6. Adjust based on depth and site.

7. Adjust based on knowledge.

8. In 2018, Avanti conducted soil humidity testing that proved that even in desert climates that humidity levels at sewer depth are such that grout desiccation won't happen.

9. Additives like latex and glycol that displace water content in the grout have traditionally been used to combat grout drying.

10. While there are currently no NASSCO master spec format guidance specifications for these, NASSCO specification do exist to support this work. The requirements for these activities should be included in any project specification for grouting, especially CCTV and cleaning. Add other sections as needed to complete the work.
This example uses Master Format numbering specifications as examples only. References to this made throughout this specification are indictive of places where these cross-referenced requirements should be included in an actual project manual.

11. When programs are completed and available, add:

b. Successfully completed either NASSCO's Grout Technician Certification Program or NASSCO's Engineer & Inspector Grouting Certification Program.

c. Completed the required continuing education requirements to maintain in good standing his NASSCO's Grout Technician Certification or Engineer & Inspector Grouting Certification.

These certification programs are currently under development by NASSCO.
Many contractors will not send their technicians to this training until they have been on the job for at least a year.

12. These are each the equivalent of 2 months of full-time grouting experience. These are minimum standards. Experience has shown it takes between 1-3 years of grouting experience before a grout technician if both productive and experienced. For projects where technicians do not have these amounts of experience, a greater level of highly trained/certified inspection oversight is highly recommended.

13. This is the equivalent of 1-2 weeks of work experience.

14. This is the equivalent of 1-2 weeks of work experience.

15. This is the equivalent of 1-2 weeks of work experience.

16. This is the equivalent of 1-2 weeks of work experience.

17. Adjust per Owner direction. Two years has become the industry standard of proof that testing and grouting remain sound.

18. Adjust terminology to match general and supplemental conditions terms.

19. ASTMs are not reference here as they are not referenced anywhere in the spec. This is standard spec writing protocol.

20. Establish length based on project objectives, site conditions, and tap configuration. Standard lengths are 4'-8'. Pricing increases significantly with risk to 12'. After 12', you are doing ultralong LTC (up to 30'), which dramatically increases cleaning and grouting risks, and therefore costs. If cleanout exist, it is generally more cost effective to do a 4'-6' LTC and then LACO from cleanout back to the main.

21. Check with manufacturer's latest packer capabilities.

22. These requirements are directed primarily toward production (and hence, inspection oversight costs) and represent best practices by installer. Pump systems are directly related to productivity. The lower the pump rate, the longer the gel time, the slower the production rate.

From a quality perspective, a pumping system that can't deliver required air also presents a false pump refusal indication.

23. These requirements are directed toward production (and hence, inspection oversight costs) and represent best practices by installer.

24. Requirements for spare parts are directed toward production (and hence, inspection oversight costs) and are best practices but do not need to be included unless Owner wishes to ensure inspection costs/time are not unnecessarily wasted.

25. This should be set by OWNER based on need to complete work on a particular schedule.

26. Require complete spare when more than one grouting crew is anticipated.

27. Should include: Screws, Bolts, O-Rings, Replacement Wheels, Replacement Lights, Replacement Tracks (if using), Camera Tag Cables, Extra Camera Connector Cables, Soldering Iron and Solder, Shrink Tube, Hot air gun, Electrical Tape, Clevis, Cable Bullet, Cable Repair Kit.

28. Require complete spare when more than one grouting crew is anticipated.

29. MBA serves as the chemical cross link in the grout formulation and all current available testing of strength, adhesion, flexibility, and dehydration resistance, effectiveness, and in situ performance is based on the 95:5 ratio.
There are alternative versions of the historical 95% Acrylamide 5% Methylene-bis acrylamide (MBA) formulation available in the market.
No testing has been done on the performance, durability, or longevity of acrylamide grout formulas with concentrations different than 95:5. Limited studies of acrylamide grout biodegradation in-situ at any MBA concentration have been conducted. Independent studies are currently under way. Higher or lower concentrations of MBA may perform differently, Engineers should evaluate risk of project goals associated with either lower or higher concentrations of MBA.

30. 12% grout is generally considered the industry standard. It provides an optimum balance of cost, strength, and pumpability. Acrylamide grouts can be effective over a broad range of concentrations. Acrylamide concentrations as low as 10%, without additives can be effective over the long term in structurally stable pipe bedding situations where there is constant groundwater. In situations where ground humidity is not constantly present, such as very shallow pipes, acrylamide grout in some pipe bedding matrices may shrink and break seal. Higher concentrations of acrylamide, as

well as the addition of water replacing additives like DE, glycol, and latex, slow the shrinkage rate and increase the rebound rate once remoistened.
In the absence of specific site conditions, 12% of 95:5 acrylamide concentration is recommended to provide effective concentration in situ in most situations. Concentrations up to 20% may be necessary when groundwater dilution due to high pipe bedding water velocities are anticipated.

31. Acrylics and Acrylates have a limited history in USA packer injection grouting. Limited or no testing for procedures to enhance effectiveness or longevity have been completed, and the procedures outlined for acrylamide may not be entirely equivalent for these alternative grout materials.

32. Consult manufacturers for specific concentrations for a given application.

33. The more latex added to the grout, the more flexible and resistant to drying the grout becomes. High concentrations slow pumping rates and increase equipment clogging issues. Concentrations between 1% and 6% can be handled by most grout equipment, though the higher the latex concentration, the more maintenance issues in pumps and hose arise. 3% has been shown to the maximum field concentration that can be used without dramatically impacting production or equipment. Very hot weather (>90F) exacerbates latex clogging issues in pumps and hoses and warrants field directive to temporarily reduce latex concentrations if work cannot be delayed.
Typical concentrations are 1-2% for regular grouting. Latex concentrations are increased when grouting large fractures to provide a more cohesive grout matrix and for large diameter grouting when the need to grout the packer in place is likely.
There are currently no standards for grouting annular space CIPPL lateral tap cuts. Current recommendation for latex in this situation is 3% unless cellulose or diatomaceous earth is also used, in which case latex can be reduced to 1.5%.
There is no empirical basis for these concentrations; they are based on anecdotal experience. Avanti is currently conducting testing to determine the grout shrinkage reduction properties of latex.

34. There is no empirical basis for these concentrations; they are based on anecdotal experience. Avanti is currently conducting testing to determine the grout shrinkage reduction properties of latex.

35. Minimum effect on temperature is down to 23 F.

36. There is no empirical basis for these concentrations; they are based on anecdotal experience. We need research into how much to add in different applications and then we need to add in Part 3 Execution sections for where and when and how to use these.

37. Include an appropriate version of these requirements in the scope of work/bid/specification package.

38. It is important that the inspector highlight this requirement every segment so that warranty testing reports can easily aligned with initial testing reports.

39. Pay basis for removal of roots should be addressed as a distribution of risk item.

40. Use this paragraph when full time inspections by trained and experienced Inspector is not provided. Revise per anticipated inspector coverage.

41. Use this paragraph when there is not full-time inspection by trained and experienced inspector or when contractor is expected to submit pre-rehabilitation CCTV inspections before rehabilitation method is finalized.

42. Groundwater and pipe bedding conditions dramatically impact the volume goals and hence the gel times. The gel time and volume goal modifications are mostly but can never be entirely provided for in a specification. Consult Engineer when unusual field conditions indicate these specified practices are not achieving goals.

43. Grout Volume Goal Generator available at www.Sewergrouting.com.

44. Adjust per Engineer's assessment of field conditions.

45. As reflected in calculator tool, for pump rates <=3 gpm. Max gel time is 240 seconds. For pump rate of 4 gpm,, max gel time is 180 seconds. For pump rates >= 5 gpm. Max gel time is 150 seconds.

46. For pump rates <=3 gpm. Max gel time is 240 seconds. For pump rate of 4 gpm,, max gel time is 180 seconds. For pump rates >= 5 gpm. Max gel time is 150 seconds.

47. Typical separation from liner and host pipe in 8" CIPPL is 2mm. A distance of 5 feet on either side of the tap is suggested, but this distance has not been optimized via studies.

48. For pipe diameters less than 18", the above grouting goals typically render goals between 0.5 and .75 gallons per inch diameter for VCP and CP and between .25 and .5 gallons per inch diameter for PVC, DIP, and RCP. At these diameters, the formula in Paragraph can be used.

49. Select value between 0.5 and 0.75 gallons per inch diameter.

50. Select value between 0.25 and 0.5 gallons per inch diameter.

51. For pump rates <=3 gpm. Max gel time is 240 seconds. For pump rate of 4 gpm,, max gel time is 180 seconds. For pump rates >= 5 gpm. Max gel time is 150 seconds.

52. Adjust if specific field condition knowledge is available.

53. The 20% adder is to reflect reduced pumping rates due to backpressures when working in the pipe vs. end of hose pump test rates, for increases in temperature as the day warms, and to provide additional time for the ungelled grout to permeate the soil before gelling.

54. LFD grouting requires special equipment and process knowledge to reliably execute.

55. This technique has not been developed or perfected, and there are both performance risks (failure to seal) and liner buckling risks if not well considered. This specification currently does not cover this technique.

56. Specify in Television Inspection spec if you want these in independent options header fields 60-69 or in field 59 alone.

57. Adjust for project objectives and site conditions.

58. Typically, SAP coded pipe can be test and sealed. Typical packers can usually seal with surface projections less than 3/32nd".

59. If void pressure gauge is not working or visible and Contractor elects to use panel gauge, 2-5 psi is typically required to overcome the check valves in the line. Therefore, minimum testing pressure should be increase to 8 psi.

60. Specify in Television Inspection spec if you want these in independent options header fields 60-69 or in field 59 alone.

61. This is a pay basis issues that should be defined in measurement and payment.

62. In instances where latex is not used, use dyes to ensure any surfacing grout is readily visible. E.G., use red or blue dyes in green grass.
h
63. Adjust this section to match requirements for post-grouting video image quality, especially with the 5% requirement, which will compel cleaning.

64. Paragraph S is the preferred option. Pick option based on inspector coverage.

If decision is deferred until Post-Construction CCTV review, recognize that this will compel contractor to return to the site, reclean, and retelevise the pipe at no additional compensation. As such, expect higher than typical prices to reflect this risk/cost.

65. Changes in gel time will affect the remaining batch in truck. Remaining grout in hoses will not have new gel time until changed batch reaches end of hose. Consider the length of hose and volume of grout contained in hose to determine amount of grout to be pumped before changed gel duration reaches packer.

66. LFD packers are currently limited to 15" diameter pipes.

67. Using short sock does not account for grouting Lateral. For LTC methods refer to section 3.12. Section 3.14 refers to grouting of Annual Space in CIPP ONLY.

68. To ensure grout does not preferentially flow into the soil outside the lateral tap connection but instead flows into the annular space, a 1' – 3' sock is recommended.

69. USE THESE RULES OF ENGAGEMENT:

- When an inspector shows up at rig a during grouting:
    - For MLJs: Pull back the packer 4 MLJs and test the 4th and 3rd MLJs regardless of whether they have passed or failed, plus any within 6 joints of your current location that max grouted and either did or did not seal. (The max grout MLJs do not count against your performance—we just want to see how these perform, and you get paid for each one we ask for).
    - If any of the non-max grout MLJs fail, pull back 10 MLJs and test the 10th and the 9th MLJs. (These also get paid for).
        - If either of these fail, pull back to start of line and retest first 25% of the joints (per specifications at no cost to Owner)
        - If any of these fail, pull back to start of line after completing all LTCs on that segment and retest the entire segment (per specifications at no cost to Owner)
- For LTCs: Pull back to closest LTC already tested (not the one you were just on, but the one before that) and test that LTC (this is a pay item)
- If this fails, pull back to start of line and retest all LTC on the entire segment (per specifications at no cost to Owner)

- When no inspector shows up at your rig during grouting and you have finished the entire segment:

    - For MLJs: Pull back at least 6 joints and test 1 MLJ that failed and was grouted and 1 that passed without grouting, plus any within 6 joints of

your current location that max grouted and either did or did not seal. Record location on your grouting records and record retests on video. (These are pay items, but inspector reserves the right to confirm you did these via video review in your rig).

- For LTCs: Pull back to closest LTC already tested (not the one you were just on, but the one before that) and test that LTC. Record location on your grouting records and record retests on video. (These are pay items, but inspector reserves the right to confirm you did these via video review in your rig).

70. Include only if Owner wants a completely unobstructed view of the pipe after rehab.

71. Warranty Testing should not be considered and optional work item; it is a critical part of ensuring the Contractor pays attention to the job conditions and appropriately adjusts implementation per these specifications, even when an inspector is not there to ensure field changes are warranted.

Warranty Testing should be conducted after two seasons of wet-dry cycles to evaluate long-term performance. Longitudinal Studies have shown very little change in sealing effectiveness between 2 years and 10 years after Capital Grouting, so an 18-24 month wait period is most appropriate.

Longer warranty periods help develop utility confidence that the installed work will remain sealed to the level specified and is a key requirement to developing confidence that Capital Grouting is a long-lasting rehabilitation technology.

Make sure client understands that contract will remain at Substantial Completion for extended period while wait period hiatus passes until Warranty Testing.

When work is bonded, confirm longer warranty periods do not restrict surety or do not disproportionately raise bond costs. While 1 year warranty is typical in other rehab technologies, a 2-year warranty is generally easily covered by the term of the Surety Bond. Warranties longer than 3 years are difficult to bond and generally rely upon the integrity of the CONTRACTOR and his desire to maintain his reputation and his ability to continue to do work for OWNER.

72. Adjust to meet project goals.

73. Adjust based on Owner objectives, difficulty of achieving long lasting seals due to dry soils, and length of warranty (i.e., the longer the warranty, the higher this number should be).

74. Adjust additional test increments to match original test batch increments.

75. Match failure rates.

76. Consider if each of these items warrants a break out bid item to cover either off road or significant highway control where there is a mix of access obstacles that markedly changes the cost of the work.

77. Contractors may attempt to penny this line item in favor of loading their pricing into the more knowable quantity of testing. When they do this, it becomes a disincentive to grouting and to grouting properly. A minimum price ensures disincentives to pumping grout are removed by ensuring there is a reasonable revenue attached to this time-consuming work. In reality, grouting costs ~3x as much as testing.
Suggested pricing for this item is $15 per joint for 8" pipes.

78. Contractors may attempt to penny this line item in favor of loading their pricing into the more knowable quantity of testing. When they do this, it becomes a disincentive to grouting and to grouting properly. A minimum price ensures disincentives to pumping grout are removed by ensuring there is a reasonable revenue attached to this time-consuming work. In reality, grouting costs ~3x as much as testing.
Suggested pricing for this item is $10 per joint for 8" pipes.

79. Contractors may attempt to penny this line item in favor of loading their pricing into the more knowable quantity of testing. When they do this, it becomes a disincentive to grouting and to grouting properly. A minimum price ensures disincentives to pumping grout are removed by ensuring there is a reasonable revenue attached to this time-consuming work. In reality, grouting costs ~3x as much as testing.
Suggested pricing for this item is $125 per tap for 8' sock.

80. Contractors may attempt to penny this line item in favor of loading their pricing into the more knowable quantity of testing. When they do this, it becomes a disincentive to grouting and to grouting properly. A minimum price ensures disincentives to pumping grout are removed by ensuring there is a reasonable revenue attached to this time-consuming work. In reality, grouting costs ~3x as much as testing.
Suggested pricing for this item is $102 per joint.

81. Contractors may attempt to penny this line item and underuse grout typical of Maintenance Grouting techniques. A fixed price set 20% above the cost of materials, labor, and waste ensures this item is a money maker for the contractor and incentivizes the use of grout, which is the biggest contributor to long-term sealing and stability of the pipe.
Suggested pricing for this item is $10 per gallon.

82. Contractors may attempt to penny this line item and not use it. A minimum price ensures this important QC step is worthwhile to the contractor to conduct.
Suggested pricing for this item is $20 per joint for 8" pipes.

83. Contractors may attempt to penny this line item and not use it. A minimum price ensures this important QC step is worthwhile to the contractor to conduct. Suggested pricing for this item is $125 per tap.

84. Contractors may attempt to penny this line item and not use it. A minimum price ensures this important QC step is worthwhile to the contractor to conduct. Suggested pricing for this item is $15 per joint.

85. Contractors may attempt to penny this line item and not use it. A minimum price ensures this important QC step is worthwhile to the contractor to conduct. Suggested pricing for this item is $15 per joint.

86. Contractors may be loath to conduct the Warranty Testing. If the work is bonded, this minimum should be 1.5x base bid item price. If work is not bonded, use 2.5x base bid price.

87. Contractors may be loath to conduct the Warranty Testing. If the work is bonded, this minimum should be 1.5x base bid item price. If work is not bonded, use 2.5x base bid price.

88. Contractors may be loath to conduct the Warranty Testing. If the work is bonded, this minimum should be 1.5x base bid item price. If work is not bonded, use 2.5x base bid price.

89. Contractors may be loath to conduct the Warranty Testing. If the work is bonded, this minimum should be 1.5x base bid item price. If work is not bonded, use 2.5x base bid price.

90. Contractors may be loath to conduct the Warranty Testing. If the work is bonded, this minimum should be 1.5x base bid item price. If work is not bonded, use 2.5x base bid price.

91. This figure should vary based on the size of the project and if it is bonded or not. If bonded, then use the 50% paid over the first two progress payment requests. If the work is unbonded and there is a 5-10% retainage, make the dollar amount equal to the first 25% of the work to ensure contractor does the work. If the work is unbonded and there is no retainage, consider eliminating Mobilization altogether and making contractor's mobilization costs part of his unit prices (probably will be reflected in his Clean and CCTV prices).

SECTION 33 01 30.61
PIPELINE PACKER INJECTION CAPITAL GROUTING