



**SECTION 02546
CURED-IN-PLACE PIPE**

PART 1. GENERAL

1.01 SCOPE

- A. Rehabilitation of existing gravity sanitary sewer lines by the Cured-in-Place Pipe (CIPP) process.

1.02 DESIGN CRITERIA

- A. Design liner thickness in accordance with ASTM F1216, F1743, or F2019 (as appropriate for the proposed liner product) using the following criteria:
 - 1. Pipe Diameters: Per Project Drawings
 - 2. Ovality: 3 percent, or as shown on plans
 - 3. Pipe Condition: Fully deteriorated
 - 4. External Water: Ground Surface
 - 5. Short-Term Tensile Strength (ASTM D638):
 - 6. Unreinforced: 3,000 psi
 - 7. Reinforced: 9,000 psi
 - 8. Tensile Strength Reduction Factor: 50 percent
 - 9. Long-Term Tensile Strength:
 - a. Unreinforced: 1,500 psi
 - b. Reinforced: 4,500 psi
 - 10. Flexural Strength (ASTM D790):
 - a. Unreinforced: 4,500 psi
 - b. Reinforced: 6,500 psi
 - 11. Short-Term Flexural Modulus (ASTM D790):
 - a. Unreinforced: 250,000 psi, or as shown on plans
 - b. Reinforced: 700,000 psi, or as shown on plans
 - 12. Flexural Modulus and Flexural Strength Reduction Factor:
 - a. Unreinforced: 50 percent
 - b. Reinforced: 35 percent, contingent upon approval of Owner and Engineer after review of submittal with long-term test data, otherwise 50 percent shall be used.
 - 13. Long Term Flexural Strength:
 - a. Unreinforced: 2,250 psi
 - b. Reinforced: 3,250 psi
 - 14. Long-Term Flexural Modulus:
 - a. Unreinforced: 125,000 psi, or as shown on plans
 - b. Reinforced: 455,000 psi, or as shown on plans
 - 15. k Enhancement Factor: 7
 - 16. Soil Modulus: 1,000 psi, or as shown on plans
 - 17. Soil Density: 120 pcf, or as shown on plans

18. Highway Live Load: AASHTO HS20-44
19. Safety Factor: 2 minimum
20. Minimum Thickness: 6 millimeters for steam and water cured liners
21. Poisson's Ratio: 0.3
22. Liner shall be watertight

1.03 SUBMITTALS

A. Action Submittals:

1. Manufacturer's technical literature on proposed lining system.
 - a. Resin:
 - 1) Specifications.
 - 2) Characteristics.
 - 3) Properties.
 - 4) Itemize exceptions and deviations to Specification.
 - b. Annular space sealant
 - c. Service connection fittings
 - d. In-Line Curing Temperature Monitoring System

B. Informational Submittals:

1. Design calculations:
 - a. Liner thickness design calculations signed and sealed by Professional Engineer in the State of TN.
 - b. Manufacture certification of material to values utilized in calculations.
 - c. If reinforced liners are proposed, submit long-term ASTM D790 and ASTM D2990 test data supporting reduction factor used in design.
2. Manufacturer's installation instructions and procedures. Furnish information, essentially in the same format as below, or give details of the procedure and the steps to be followed for the installation of the CIPP, even if the process is named in the Specification.
 - a. Wet Out.
 - b. Insertion.
 - c. Curing.
 - d. Cool Down.
 - e. Finished Pipe.
3. "Wet out" and curing schedule.
4. Process control sheets for temperature/time during curing, including outputs from in-line curing temperature monitoring system.
5. Installer's and accredited testing laboratory statement of qualifications.
6. Manufacturer's Certificate of Compliance certifying compliance with the applicable specifications and standards.
7. Warranty and/or Special Guarantee.
8. Manufacturer's instructions for material shipping, storage, and handling requirements.

9. Certified copies of test reports of factory tests required by the applicable standards and this Section.
10. Dye testing results
11. DVD or external hard drive of both pre- and post CCTV inspections.

1.04 QUALITY ASSURANCE

- A. Installer shall have a minimum of 5 years' experience and have installed a minimum of 500,000 linear feet with the selected liner product and method of curing.
- B. Superintendent shall have minimum of 3 years of onsite experience with the selected liner product and method of curing.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products as recommended by the manufacture to prevent damages. Materials shall be made safe from theft, vandalism, and damage.
- B. All products and materials specified herein shall be inspected at the request of OWNER or RESIDENT PROJECT REPRESENTATIVE. All materials that fail to conform to these Specifications shall be rejected. After delivery to the Site, any materials that have been damaged in transit or are otherwise unsuitable for use in the Work shall be rejected and removed from the Site by the CONTRACTOR at no cost to the OWNER
- C. Ship resin directly to wet-out facility from manufacturer.
- D. Maintain resin-impregnated tubes in refrigerated truck trailers at a temperature below 45 degrees F to prevent premature curing. Prior to beginning inversion, no portion of the resin-impregnated liner shall be subjected to sunlight or ultraviolet radiation. Resin-impregnated tubes with signs of premature curing shall not be installed and shall be removed from the Project Site.

1.06 SPECIAL GUARANTEE

- A. Provide manufacturer's extended guarantee or warranty, with OWNER named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the OWNER, removal and replacement of Work specified in this Specification section found defective, due to material or workmanship failure, during a period of 5 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions. A warranty inspection can be completed by the OWNER up to 5 years after final acceptance.

PART 2. PRODUCTS

2.01 MATERIALS

A. Resin:

1. Unless otherwise specified, CONTRACTOR shall furnish a general purpose, unsaturated, polyester, epoxy, isophthalic neopentyl glycol, or thermosetting vinyl ester resin, catalyst system, initiators, or hardeners that provide specified cured physical strengths and properties, and compatible with reconstruction inversion process.
2. Resistant to municipal wastewater environment; immersion in septic sewage at temperatures up to 75 degrees F.
3. Curing:
 - a. Designed to cure properly within selected curing method.
 - b. Initiation Temperature: 180 degrees F, maximum for water cure.
4. Resins shall be chemical resistant and tested and manufactured in accordance with ASTM F1216 and ASTM D543.
5. For lines smaller than 24 inches PET resins, resin fillers, resin additives, and resin enhancement agents are prohibited. Only neat resins are acceptable.
6. For lines 24 inches and larger, any resin additives are contingent upon OWNER and ENGINEER approval. All enhanced resins shall be submitted as a part of the action submittal process.
7. For reinforced liners, only neat resins are acceptable.
8. Old resins and reworked resins are prohibited, regardless of whether or not they are mixed with new resin.
9. Produce a cured tube resistant to shrinkage that will not corrode or oxidize and is resistant to abrasion from solids, grit, and sand in wastewater.
10. Bond between tube layers shall be strong and uniform. Layers, after cure, shall be saturated with resin.
11. Styrenated resins are prohibited for pipes that will discharge directly to the environment (e.g. storm drains).
12. Manufacturers and Products:
 - a. Reichhold;
 - b. Interplastic Corporation;
 - c. Ashland Specialty Chemical Company;
 - d. AOC

B. Catalysts:

1. Primary catalyst shall not exceed 1 percent of the resin by volume.
2. Secondary catalyst shall not exceed 1/2 percent of the resin by volume.
3. Catalysts shall be:
 - a. Primary Catalyst: Akzo Products, or as required to meet the performance requirements of the liner.

- b. Secondary Catalyst: Akzo Products or Puritan Products; or as required to meet the performance requirements of the liner.
- C. Tube:
- 1. Consist of layers of flexible nonwoven and absorbent polyester felt manufactured under quality controlled conditions set by manufacturer and applicable requirements set forth in ASTM F1216 and ASTM F1743 that, when cured, will be chemically resistant to reagents as defined in ASTM D543.
 - 2. Lining shall be correct diameter; after installation, there shall be no wrinkles or form permanent fins. Tube shall be capable of stretching to fit irregular pipe sections and fabricated and sized for each section to ensure snug and firm fit inside existing sewer; produce required thickness after resin is cured.
 - 3. Wastewater-contact inside layer of tube shall be coated with an impermeable material compatible with resin and felt and shall not be a dark or non-reflective nature that inhibits proper closed circuit television inspection.
 - 4. For lines 24 inches and larger if reinforcement is utilized it shall consist of Impregnated flexible fiberglass. Each lot of fiberglass liner shall be inspected for defects and tested in accordance with applicable ASTM F2019.
 - 5. Manufacturers:
 - a. Applied Felt.
 - b. Insituform Technologies.
 - c. Liner Products.
 - d. National Liner
 - e. Layne Inliner
 - f. Mississippi Textile

2.02 ACCESSORIES

- A. Hydrophilic Rubber Joint Seal:
 - 1. Greenstreak, Inc
 - 2. Hydrotite, LMK, Insignia
 - 3. Adeka, KM-String
- B. PVC Saddle Tees: Solvent welded type for 8-inch CIPP sewer main connection. Tee shall fit the existing pipe and have an integral 6-inch branch connection with gasket. The saddle shall include two stainless steel straps. Saddle tees shall meet the requirements of ASTM D3034 and ASTM F477.
- C. Connections to CIPP mains greater than 8-inches in diameter shall be with a minimum 6-inch "Inserta-Tee" manufactured by Inserta Fittings Company and specifically designed for the thickness of the installed CIPP liner.

- D. Couplings shall be installed in accordance with Specification 02532, Sanitary Sewers (Gravity).
- E. Curing Temperature Monitoring System:
 - 1. ZIA Systems
 - 2. Pipeline Renewal Technologies, VeriCure.

PART 3. EXECUTION

3.01 WORKER SAFETY

- A. Contractor shall implement all current recommendations, guidelines, and regulations of the National Institute for Occupational Safety and Health (NIOSH), and the Occupational Health and Safety Administration (OSHA) for the safety of workers and the public affected by the CIPP installation.
- B. Records of any complaints or incidents shall be provided to the OWNER.

3.02 PRE-INSTALLATION PREPARATIONS

- A. Complete the following activities, unless approved otherwise by OWNER:
 - 1. Pre-Insertion Cleaning: Rewash, re-clean and ready existing sewer pipe immediately before the pre-insertion television inspection.
 - 2. Pre-Insertion CCTV Inspection: Inspect sewer pipe before insertion of resin impregnated tube to ensure pipe is clean and existing pipe conditions are acceptable for lining. Provide a DVD of the CCTV inspection.
 - 3. Dye Testing: Where sewer line segments may contain abandoned services, CONTRACTOR shall be responsible for performing dye testing to determine if the services are live and require re-instatement.
 - 4. Bypassing Wastewater: Reference Section 02542, Sewer Flow Control.
 - 5. Line Obstructions: If pre-insertion video CCTV inspection reveals an obstruction in the existing pipe (such as heavy solids, dropped joints, protruding service taps or collapsed pipe which may prevent completion of the inversion process), that is not identified on the Project Drawings and cannot be removed by sewer cleaning equipment, then a point repair using a shielded coupling may be made with the approval of OWNER. Shielded couplings shall be used in accordance with Specification 02532, Sanitary Sewers (Gravity).
 - 6. Remove active infiltration prior to installation of the liner.

3.03 INSTALLATION PROCEDURES

- A. Wet Out:
 - 1. Verify lengths in field before cutting liner to length

2. Wet out shall be vacuum impregnated with resin under controlled conditions.
3. Use roller system to uniformly distribute resin throughout tube.
4. Resin shall fill all voids in tube material with no air spaces or pockets.
5. Handle resin impregnated tube to retard or prevent settling until it is read for insertion.
6. Use of alternative methods of resin impregnation shall be approved by the OWNER prior to implementation.

B. Insertion:

1. Install CIPP in accordance with ASTM F1216 (direct inversion) or ASTM F1743 (pull installations) or F2019 (reinforced liners) as appropriate for the liner product used.
2. Dewater existing host pipe prior to installation
3. Insert wet-out tube through an existing manhole or approved access point by means of an inversion method and application of sufficient hydrostatic head to extend tube to next designated termination point.
4. A pull in method using a bladder to expand the tube may be employed if approved by OWNER.
5. After insertion, maintain sufficient pressure to hold tube tight against the host pipe.

C. Curing:

1. Complete a curing process control sheet for every lining completed.
2. Control sheets shall provide required temperatures and time for the different steps of curing process; initial cure, post cure, and cooling as outlined in ASTM F1216.
 - a. Initial cure may be considered completed when exposed portions of flexible tube pipe take a hard set and temperature is adequate, as recommended by manufacturer.
3. After installation, apply steam, hot water, or ultraviolet (UV) light as recommended by liner manufacturer.
 - a. Steam:
 - 1) Provide safety system specifically structured for use of steam.
 - 2) Thermoset Resin: Designed to cure properly when using steam.
 - 3) CIPP Tube Thermoplastic Coating:
 - a) Formulated from material designed specifically to withstand high temperature curing process utilizing steam.
 - b) Polypropylene/polyethylene blend or equal.
 - 4) Equipment:
 - a) Heat source shall be capable of delivering steam throughout section and uniformly raising steam

- temperature above temperature required to affect cure of resin.
- b) Install temperature gauges in the following areas:
 - (1) Incoming steam supply.
 - (2) Outgoing steam supply.
 - (3) Between impregnated tube and pipe invert at lining termination point (lowest elevation point).
 - 5) Steam Temperature: 230 degrees F, minimum.
 - 6) Minimum Interface Temperature between Liner and Tube: 120 degrees F.
 - 7) Pressure Required to Keep Tube Inflated: Per manufacturer's instructions.
 - 8) Time: Per manufacturer's instructions.
 - 9) Cool Down:
 - a) Send air through steam cured CIPP liner until liner cools down to 120 degrees F interface temperature.
 - b) Once 120 degrees F has been reached, water may be introduced to finish cooling line down to 90 degrees F.
 - c) During release of water, prevent vacuum that could damage newly installed CIPP.
 - b. Hot Water:
 - 1) Equipment:
 - a) Heat source shall be capable of delivering hot water throughout section and uniformly raising water temperature above temperature required to affect cure of resin.
 - b) For diameters, smaller than 24 inches in diameter Install temperature gauges in the following areas:
 - (1) Incoming water supply.
 - (2) Outgoing water supply.
 - (3) Between impregnated tube and pipe invert at lining termination point.
 - c) For diameters 24 inches and larger utilize a curing temperature monitoring system.
 - (1) To monitor the temperature inside the tube wall and to verify proper curing temperature sensors shall be placed between the host pipe and the liner and in the bottom of the host pipe (invert) throughout the reach to record the heating and cooling that takes place on the outside of the liner during processing.
 - (2) The sensors shall be spaced apart at intervals no greater than 10 feet.
 - (3) Additionally, sensors shall be strategically placed at points where a significant heat sink is likely to be

- anticipated (such as areas where the host pipe is exposed, made of differing materials, or submerged such as under a river crossing.
- (4) Prior to installing the liner in the host pipe, the temperature monitoring system's functionality shall be confirmed by measuring the ambient temperature with the temperature sensors.
 - (5) No more than two sensors per manhole-to-manhole segment can be found faulty during this test. If three or more sensors are discovered faulty, a new sensor array shall be pulled into the host pipe replacing the previously installed array; and the new array shall be again tested for its proper functioning at the CONTRACTOR's expense.
 - (6) Curing of the resin system shall be as per the directions of the CIPP manufacturer. The temperatures achieved and the duration of holding of the liner at those temperatures shall be per the CIPP manufacturer's established procedures.
 - (7) If any sensors or sensors along the reach indicates that there is a localized issue with respect to achieving proper curing per the written installation procedure, the CONTRACTOR shall address the issue immediately using previously established protocols for such an event.
 - (8) The sensor array's database required in the above paragraph shall have an output report that identifies each sensor by its station in the reach and shows the maximum temperature achieved during the processing of the CIPP and the time sustained at or above the manufacturer's required curing temperature at each sensor.
- 2) Minimum Interface Temperature between Liner and Tube: 120 degrees F.
 - 3) Time: 3 hours, minimum unless manufacturer recommends otherwise and approved by the OWNER.
 - 4) Cool Down:
 - a) Introduce cool water into CIPP to replace water being drained from small hole made in downstream end.
 - b) Cool liner to temperature below 90 degrees F before relieving hydrostatic head.
 - c) During release of water, prevent vacuum that could damage newly installed CIPP.

- c. UV: If this method of curing is selected, material shall be a polyester needle felt or fiberglass based CIPP liner impregnated with an isophthalic neopentyl glycol resin.
 - 1) Curing parameters, such as curing speed, inner air pressure, and wattage, per the manufacturer.
 - 2) Optimal curing speed or travel speed of energized UV light sources is determined for each length of liner based on liner diameter, liner thickness, and exothermic reaction temperature.
 - 3) Invert liner into pipe with standard pressure drum or pull into pipe using a slip sheet.
 - 4) After completion of inversion process introduce light chain in liner and close ends with couplings.
 - 5) Remove and discard inner film material after curing to provide optimal quality of final product.
 - 6) Control panel operating UV curing unit light chain may be pulled on a trailer attached to UV unit.
 - 7) Flushing of UV cured CIPP liner to reduce styrene residual is not required.

D. The finished CIPP shall:

- 1. Be continuous over entire length from manhole to manhole and be free from visual defects such as foreign inclusions, dry spots, keel, boat hull, pinholes, wrinkles, and other deformities.
- 2. For lines 24 inches or larger the CIPP shall have no radially positioned (perpendicular to flow) wrinkles, fins or other discontinuities in the lower third of the pipe which exceed more than 3% of the host pipe inside diameter. Have no radial wrinkles, fins or other discontinuities in the upper 2/3rds of the pipe having a height of 5% or more of the host pipe inside diameter, unless approved.
- 3. When passing through or terminating in a manhole shall be carefully cut out in a shape and manner approved by OWNER.
- 4. Annular space between existing pipe and the CIPP shall be sealed with a hydrophilic rubber joint seal per manufacturer's instructions.
- 5. Meet leakage requirements of pressure test as specified in Section 02532, Sanitary Sewers.

3.04 SEALING AND BENCHES IN MANHOLE

- A. CIPP shall make a tight-fitting seal with existing pipe(s) in manhole. For CIPP that is installed continuous through manhole, the top half of the pipe shall be neatly cut off and not broken or sheared off at least 2 inches away from wall. The channel in the manhole shall be a smooth continuation of the pipe(s) and shall be merged with other pipes or channels, if any.

- B. At each pipe opening into manhole, hydrophilic rubber joint seal shall be bonded with adhesive to the host sewer pipe or to the opening in the manhole barrel to hold it in place during inversion and creating a water-tight seal after curing.
- C. Seal CIPP and existing pipe in manhole as stated above before proceeding on to next manhole section. Manholes shall be individually inspected for liner cut-offs, benches, and sealing of liner annular space.

3.05 MANHOLE DROP CONNECTIONS

- A. Drop connections on existing sewer mains shall be abandoned prior to the installation of CIPP by plugging the manhole to pipe connection with a bulkhead and filling the drop assembly with flowable fill.
- B. Use of internal manhole drop connections shall be indicated on the Project Drawings or directed and approved by the OWNER.

3.06 SERVICE LATERALS

- A. Shutdown
 - 1. Notify OWNER at least 1 week prior to the shutdown when it is necessary to shutdown a private service line while Work is in progress and before the service lines are reconnected. Notify building occupants with a KUB approved door hanger not less than 36 hours prior to shutdown.
 - 2. When a service lateral will be disconnected the flow shall be controlled in accordance with Specification 02542, Sewer Flow Control.
 - 3. No service is to remain shut down without sewer flow control or a leak free temporary connection. Otherwise, CONTRACTOR shall then provide temporary living quarters (i.e., hotel) for the resident at no additional cost to OWNER or the resident. Temporary living quarters shall be approved by OWNER and coordinated through OWNER's Customer Support Representative. Commercial sewer services shall be maintained when businesses are open.
- B. Temporary Service Reinstatements:
 - 1. The exact location and number of service connections shall be determined from a pre-CCTV inspection and field located by marking existing service connections. CONTRACTOR shall determine and identify all active services. CONTRACTOR shall perform temporary service cut outs at active service connections immediately after liner has cured. Initial internal service cut outs shall be made to the lesser of a 6-inch diameter opening or 90 percent of the original diameter of the connection. Do not damage liner pipe and allow to normalize to ambient temperature before 6-inch diameter hole is drilled out.

2. If the service cannot be replaced through excavation then internally reinstate the service to 100 percent of original opening, and provide a smooth opening with no ragged edges. The OWNER must approve all permanent lateral cut outs.
3. Services shall not be reconnected from abandoned or vacant lots, unless directed otherwise by OWNER. Restore and correct missed or faulty reconnections as well as damage caused to property OWNERS for not reconnecting the services soon enough or for not giving notice to the OWNERS.

C. Permanent Service Connection by Excavation:

1. Excavate existing active service connections. Disconnect at joints and existing sewer (now the carrier pipe for the liner) and remove to expose the liner to the extent necessary. Coat cut out hole in liner with approved resin/epoxy that will cure at the ambient temperature.
2. Install PVC saddle tee for the new sewer service lateral over the cut out. Saddle shall be a one-piece saddle attached to the liner with epoxy so that a complete seal is accomplished when the strap-on saddle is tightened with two stainless steel bands; one on each side. The stub-out attached to the saddle shall protrude into liner a distance equal to the wall thickness of liner.
3. All permanent lateral re-instatements shall be completed within 30 days of the initial temporary cut out.
4. Services which are reconnected to rehabilitated liner shall be shown on “as-built drawings” with the distance from the nearest downstream manhole, depth at clean out, and the cleanout distant from mainline.
5. Replace sewer service laterals per Section 02532, Sanitary Sewers (Gravity).

3.07 TESTING FOR ACCEPTANCE

- A. Sampling and Measuring: Two minimum 12-inch long samples shall be cut from the cured liner installation; sample shall be collected and prepared in accordance with restrained sample method described in ASTM F1216 or ASTM F2019. Samples removed for testing shall be individually labeled and logged to record the following:
1. OWNER’s project number and title.
 2. Sample number.
 3. Segment number of line as noted on supplements.
 4. Date and time of sample.
 5. Name of CONTRACTOR.
 6. Location and by whom tested.
 7. Street name and address.
 8. Test results.

- B. Field Thickness testing shall be in accordance with ASTM D2122. The average thickness, calculated from four measurements on each specimen, shall be equal to or greater than the required design thickness. Plate samples may be used in lieu of restrained samples for pipes greater than 18 inches in diameter and in accordance with ASTM F1216.
- C. Send samples to an independent accredited laboratory and test for modulus of elasticity and flexural strength in accordance with ASTM D790, as directed by OWNER. Failure of any test can be grounds for rejection of the CIPP liner. At the direction of OWNER, the second sample shall be tested. Testing results shall be provided to the OWNER within 7 days of receipt.
- D. Destructive Testing: In cases where test results of samples from the 12-inch long pipe section are lower than required values, at the direction of OWNER, CONTRACTOR shall cut samples from liner along length of pipe. The size and shape of the samples shall be determined by OWNER. The CONTRACTOR shall repair the CIPP liner and host pipe at no additional cost to OWNER. Failure of the thickness test shall be grounds for rejection for the CIPP liner.
- E. Resin Sampling: “Wet-out” facility resin mixing equipment shall have a valve downstream of the mixing functions and immediately upstream of the application of the mixed resin to the tube where OWNER can draw resin samples. CONTRACTOR’s batch mix facilities, if any, shall provide for sampling of the mixed batch. Submitted “wet-out” schedule cannot be modified without 24-hour notice to OWNER. Resin samples shall be drawn at times determined by OWNER. The OWNER drawing the samples will arrive unannounced and shall be afforded immediate access to the equipment.
- F. CCTV shall be as specified in Section 02541, Sewer Television Inspection. Televising shall be done after service connections have been made, unless required earlier by OWNER. Provide CCTV DVD’s or external hard drive within two weeks after permanent lateral reinstatements have been completed.
- G. For lines 24-inches and less in diameter shall be air tested as specified in Section 02532, Sanitary Sewers after liner has been installed and service lateral connections have been completed.
- H. For lines greater than 24-inches shall be tested as specified in Sections 02532, Sanitary Sewers.
- I. No visible leak around liner at manhole connections will be allowed.

- J. Correct failed liner or liner deemed unacceptable by OWNER as a result of the post-video inspection or test reports for structural values and thickness.
1. Remedy shall be defined as shown in the following table and shall be based upon lowest test in each test category. Where pipe replacement is required, payment shall be made in full for the cured-in-place pipe. No payment will be made to construct a new sewer segment.

| PIPE CORRECTION | | | |
|------------------------|-------------------------------------|------------------------------|--------------------------|
| TEST | REQ'D VALUE | TEST RESULT | REMEDY |
| Flexural Strength | Design value per approved submittal | 95 to 99% of Req'd value | 10% Unit Price Reduction |
| | Design value per approved submittal | 90 to 94% of Req'd value | 30% Unit Price Reduction |
| | Design value per approved submittal | Less than 90% of Req'd value | Pipe Replacement |
| Flexural Modulus | Design value per approved submittal | 95 to 99% of Req'd value | 10% Unit Price Reduction |
| | Design value per approved submittal | 90 to 94% of Req'd value | 30% Unit Price Reduction |
| | Design value per approved submittal | Less than 90% of Req'd value | Pipe Replacement |
| Thickness | Design Value per approved submittal | 95 to 99% of Req'd value | 10% Unit Price Reduction |
| | Design Value per approved submittal | 90 to 94% of Req'd value | 30% Unit Price Reduction |
| | Design Value per approved submittal | Less than 90% of Req'd value | Pipe Replacement |

END OF SECTION