Petition for Declaratory Statement
Before the Florida Building Commission
Office of Codes and Standards

December 5, 2024

Addressed to: Mr. Mo Madani
2601 Blair Stone Rd
Tallahassee, Florida 32399
Email: Mo.Madani@myfloridalicense.com

Company: Pipelining Technologies, Inc.
Michael Wilson, President
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DS 2024-044

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Mr. Mo Madani,

The specific statutory provisions, code provisions, rules, or orders I seek an expanded and more detailed interpretation for, are:

Florida Building Code 8th Edition 2023

- *CH.7 Sanitary Drainage 718.1 Cured-in-place:* ***Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216 or ASTM F1743*** (Exhibit A)
- *CH. 30 Sanitary Drainage Section P3012 Rehabilitation of Building Sewers and Building Drains – P3012.1 Cured-in-place:* ***Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216*** (Exhibit B) ***or ASTM F1743.*** (Exhibit C)

Background:

Pipelining Technologies, Inc. (PTI), Petitioner, is a fully insured Licensed Plumbing Contractor, CFC1428578, solely in the business of structurally rehabilitating aged and defective **horizontal** drainage pipes below ground and under building slabs, and **vertical** drainage pipes behind walls, using Cured-In-Place Pipe (CIPP) lining tools, materials, and technology.

PTI is seeking to rehabilitate an 8,280-foot vertical drainage system in a multi-story building, which includes 4", 5", and 6" cast iron stacks with 1,048 lateral branch connections. We plan to use a low cost CIPP (Cured-In-Place Pipe) method called "Gapping," "Start and Stop," or "Hybrid" Pipe Lining.

This approach avoids covering branch fittings with CIPP lining material, eliminating the need for costly remote-controlled cutting devices to reopen these connections. During the initial camera inspection, we measure the distances between branch connections to determine the locations of the "gapped" sections where the original cast iron lateral branch fittings will remain unlined. The lining material is now cut as one continuous piece to match the total length of the pipe, and then specific sections are removed to correspond with the pre-determined branch connection locations. This creates an "assembly" of multiple sections of CIPP lining material attached to a total length inflatable bladder.

The prepared liner is installed as an assembly with "start and stop gaps" at each branch connection. In the "hybrid "process, any bare "gapped" cast iron branch fittings are coated with epoxy after the sectional liner segments are cured and the inflatable bladder is removed.

Currently, there are no ASTM standards, Florida Building Codes, or third-party certifications (e.g., IPC/ICC 303.4) for using epoxy, polyurea, polyurethane brush coatings, spin casting, or spray coating methods for deteriorated drainage pipe rehabilitation.

My request for a Declaratory Statement, with an expanded and more detailed interpretation of FBC CH.7 Sanitary Drainage 718.1 and FBC CH. 30 Sanitary Drainage Section P3012, should address the following three questions:

Question 1:

Can an installation using a CIPP "Gapping", "Start and Stop", or a "Hybrid Lining" process to **"cut out all lateral connection points from the sleeve prior to the installation of the liners"** or a similar CIPP drainage pipe rehabilitation material installation method be utilized in reference with the Florida Building Codes 718.1 and P3012.1 (Exhibit A) requirement of adherence to ASTM F1216 (Exhibit B) and ASTM F1743? (Exhibit C)?

Question 2:

Can a CIPP "Gapping", "Start and Stop", or a "Hybrid Lining" process to **"cut out all lateral connection points from the sleeve prior to the installation of the liners"** or similar drainage pipe rehabilitation material installation methods or processes along with an epoxy, polyurea, or polyurethane "brush coating, spin casting, or spray coating" process be utilized with the Florida Building Codes 718.1 and P3012.1 (Exhibit A) requirement of adherence to ASTM F1216 (Exhibit B) and ASTM F1743 (Exhibit C), and IPC/ICC Code 303.4 (Exhibit E) regarding third party certifications?

Question 3:

Can a CIPP installation of epoxy, polyurea, or polyurethane "brush coating, spin casting, or spray coating" as part of a drainage pipe rehabilitation process be utilized with the Florida Building Codes 718.1 and P3012.1(Exhibit A) requirement of adherence to ASTM F1216 (Exhibit B) and ASTM F1743 (Exhibit C), and IPC/ICC Code 303.4 (Exhibit E) regarding third party certifications?

Thank you for your consideration of this request.

Michael Wilson,
President/Qualifier
Pipelining Technologies, Inc.
CFC #1428578 | (561) 502-0487 | Mike@pipelt.com

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December 5, 2024

VIA FEDEX & E-MAIL
(Mo.Madani@myfloridalicense.com)

Mr. Mo Madani
Office of Codes and Standards
Department of Business and Professional Regulation
2601 Blair stone Rd
Tallahassee, Florida 32399

Re: Pipelining Technologies, Inc. - Petition for Declaratory Statement

Mr. Madani:

Our firm has the pleasure of representing Pipelining Technologies, Inc. ("Pipelining Technologies"), a plumbing contractor here in the State of Florida. Pipelining Technologies has prepared the attached Petition for Declaratory Statement for review by the Florida Building Commission pursuant to § 120.565 of the Florida Statutes, and Florida Administrative Code R. 28-105.002.

We respectfully request that the commission review and consider said petition. While it is believed that the petition is complete, should your office require anything further, you are welcome to contact Pipelining Technologies directly via their president Mr. Michael Wilson. Mr. Wilson can be reached at mike@pipelt.com and (561) 502-0497.

Sincerely,

ADAMS & REESE, LLP

Kyle C. Rea, Esq.

TABLE OF CONTENTS
OF SUPPORTING DOCUMENTS FOR GAPPING
DECLARATORY STATEMENT

2024 Supplement to the 8th Edition (2023) Florida Building Code (Supplement 1)

Effective date – Except as otherwise expressly provided in the supplement, effective date for this supplement is April 16, 2024

8th Edition (2023) Florida Building Code, Building

102.2 Building. The provisions of the *Florida Building Code* shall apply to the construction, erection, alteration, modification, repair, equipment, use and occupancy, location, maintenance, removal and demolition of every public and private building, structure or facility or floating residential structure, or any appurtenances connected or attached to such buildings, structures or facilities. Additions, alterations, repairs and changes of use or occupancy group in all buildings and structures shall comply with the provisions provided in the *Florida Building Code, Existing Building*. The following buildings, structures and facilities are exempt from the *Florida Building Code* as provided by law, and any further exemptions shall be as determined by the legislature and provided by law:

(a)– (k) No change

(l) A drone port as defined in s. 330.41(2).

(Code language for consistency with HB 327 – bill effective date – July 1, 2023)

***Revise section 105.3.1.2 (Item 4)* to read as follows:**

4. Any specialized mechanical, electrical, or plumbing document for any new building or addition which includes a medical gas, oxygen, steam, vacuum, toxic air filtration, halon, or fire detection and alarm system which costs more than $5,000.

Exception:

Simplified permitting processes ~~process for fire alarm system projects~~. —

(1) As used in this section, the term:

(a) "Component" means valves, fire sprinklers, escutcheons, hangers, compressors, or any other item deemed acceptable by the local enforcing agency. For purposes of this paragraph, a valve does not include pressure-regulating, pressure-reducing, or pressure-control valves.

CHAPTER 4 FIXTURES, FAUCETS AND FIXTURE FITTI

2. Where multi-user facilities are designed to serve all genders, the minimum fixture count sh be calculated 100 percent, based on total occupant load. In such multi-user user facilities, eac fixture type shall be in accordance with ~~ICC A117.1~~ *Florida Building Code, Accessibility*, an each urinal that is provided shall be located in a stall.

403.2.2 Restrooms and changing facilities respective to sex.
Covered entities, as defined in §553.865, Florida Statutes, shall provide separate restrooms an changing facilities based on biological sex, or to provide single-user unisex facilities.

718.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainag piping shall be in accordance with ASTM F1216 or ASTM F1743. ~~Sectional cured-in-place rehabilitation of *building sewer* piping and sewer service lateral piping shall be in accordanc with ASTM F2599. Main and lateral cured-in-place rehabilitation of *building sewer* and sew service lateral piping and their connections to the main sewer pipe shall be in accordance wit ASTM F2561. Hydrophilic rings or gaskets in cured-in-place rehabilitation of *building sewe* piping and sewer service laterals shall be in accordance with ASTM F3240 to ensure water tightness and elimination of ground water penetration.~~

2404.8 (301.12) Seismic resistance. Reserved. ~~Where earthquake loads are applicable in accordance with this code, the supports shall be designed and installed for the seismic forces i accordance with this code.~~

P-FBC-FG – Ch24 – Errata

G2427.5.4, Item 3

Delete Section P2912.1.1 as follows:

P3012.1 Cured-in-place. Cured-in-place rehabilitation of building sewers and building drainage piping shall be in accordance with ASTM F1216 or ASTM F1743

P-FBC-P-Ch.7-Glitch #2

INTERNATIONAL

Designation: F1216 − 22

EXHIBIT B
PG. 1 of 9

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube[1,2]

This standard is issued under the fixed designation F1216; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (´) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice describes the procedures for the reconstruction of pipelines and conduits (2 in. to 108 in. diameter) by the installation of a resin-impregnated, flexible tube which is inverted into the existing conduit by use of a hydrostatic head or air pressure. The resin is cured by circulating hot water, introducing controlled steam within the tube, or by photoinitiated reaction. When cured, the finished pipe will be continuous and tight-fitting. This reconstruction process is used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and ventilation systems.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 7.4.2.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents
D638 Test Method for Tensile Properties of Plastics
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D903 Test Method for Peel or Stripping Strength of Adhesive Bonds
D1600 Terminology for Abbreviated Terms Relating to Plastics
D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings
D3839 Guide for Underground Installation of "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe
D5813 Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems
E797/E797M Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method
F412 Terminology Relating to Plastic Piping Systems

2.2 *AWWA Standard:*[4]

M 28 Rehabilitation of Water Mains, Third Ed.

2.3 *NASSCO Standard:*[5]

Sewer Pipe Cleaning Specification Guideline

3. Terminology

3.1 Definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise specified.

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[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

Current edition approved Aug. 15, 2022. Published August 2022. Originally approved in 1989. Last previous edition approved 2021 as F1216 – 21. DOI: 10.1520/F1216-22.

[2] The following report has been published on one of the processes: Driver, F. T., and Olson, M. R., "*Demonstration of Sewer Relining by the Insituform Process, Northbrook, Illinois*," EPA-600/2-83-064, Environmental Protection Agency, 1983. Interested parties can obtain copies from the Environmental Protection Agency or from a local technical library.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

[5] Available from the National Association of Sewer Service Companies, 5285 Westview Drive, Suite 202, Frederick, MD 21703. http://www.nassco.org/

***A Summary of Changes section appears at the end of this standard**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cured-in-place pipe (CIPP)*—a hollow cylinder containing a nonwoven or a woven material, or a combination of nonwoven and woven material surrounded by a cured thermosetting resin. Plastic coatings may be included. This pipe is formed within an existing pipe. Therefore, it takes the shape of and fits tightly to the existing pipe.

3.2.2 *inversion*—the process of turning the resin-impregnated tube inside out by the use of water pressure or air pressure.

3.2.3 *lift*—a portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

3.2.4 *photoinitiated reaction*—the polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated tube inverted through the existing conduit. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Tube*—The tube shall consist of one or more layers of flexible needled felt or an equivalent nonwoven or woven material, or a combination of nonwoven and woven materials, capable of carrying resin, withstanding installation pressures and curing temperatures. The tube and any non-structural plastic coating or flexible membrane included in the tube construction shall be compatible with the resin system used. The material shall be able to stretch to fit irregular pipe sections and negotiate bends. The tube shall be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance shall be made for circumferential stretching during inversion.

5.2 *Resin*—A general purpose, unsaturated, styrene-based, thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the inversion process shall be used. The resin must be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The CIPP system shall be expected to have as a minimum the initial structural properties given in Table 1. These physical strength properties shall be determined in accordance with Section 8.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value psi	Minimum Value (MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6. Design Considerations

6.1 *General Guidelines*—The design thickness of the CIPP is largely a function of the condition of the existing pipe. Design equations and details are given in Appendix X1.

7. Installation

7.1 *Cleaning and Inspection:*

7.1.1 Prior to entering access areas such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations.

7.1.2 *Cleaning of Pipeline*—All internal debris that will interfere with the installation or adversely affect the performance of the CIPP shall be removed from the original pipeline. Gravity pipes are cleaned with hydraulically powered equipment, high-velocity jet cleaners, mechanically powered equipment, or other applicable method(s) (see NASSCO Sewer Pipe Cleaning Specification Guideline). Pressure pipelines are cleaned with cable-attached devices, fluid-propelled devices, or other applicable method(s) (see Chapter 3 "Pipe Cleaning Methods" in AWWA, M 28 Rehabilitation of Water Mains, Third Ed.).

7.1.3 *Inspection of Pipelines*—Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or worker entry. The interior of the pipeline shall be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions shall be noted and corrected prior to installation of CIPP.

7.1.4 *Line Obstructions*—The original pipeline shall be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % to ensure proper installation of the resin-impregnated tube. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, then a point repair excavation shall be made to uncover and remove or repair the obstruction prior to the installation of the CIPP.

7.2 *Resin Impregnation*—The tube shall be vacuum-impregnated with resin (wet-out) under controlled conditions. The volume of resin used shall be sufficient to fill all the void space present in the tube material at nominal thickness and diameter. The volume shall be adjusted by adding excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe.

NOTE 1—In pipelines 8 in. diameter and less, 5 % to 10 % excess resin should be added.

7.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the pump and bypass lines shall be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

7.3.1 Public advisory services will be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the mainline is back in service.

7.4 *Inversion:*

7.4.1 *Using Hydrostatic Head*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point. The tube shall be inserted into the vertical inversion standpipe with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the tube shall be turned inside out and attached to the standpipe so that a leakproof seal is created. The inversion head shall be adjusted to be of sufficient height to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to over-stress the felt fiber.

7.4.1.1 An alternative method of installation is a top inversion. In this case, the tube is attached to a top ring and is inverted to form a standpipe from the tube itself or another method accepted by the engineer.

NOTE 2—The tube manufacturer should provide information on the maximum allowable tensile stress for the tube.

7.4.2 *Using Air Pressure*—The wet-out tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of air pressure sufficient to fully extend it to the next designated manhole or termination point. The tube shall be connected by an attachment at the upper end of the guide chute so that a leakproof seal is created and with the impermeable plastic membranes side out. As the tube enters the guide chute, the tube shall be turned inside out. The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care shall be taken during the inversion so as not to overstress the woven and nonwoven materials. **Warning—**Suitable precautions shall be taken to eliminate hazards to personnel in the proximity of the construction when pressurized air is being use.

7.4.3 *Required Pressures*—Before the inversion begins, the tube manufacturer shall provide the minimum pressure required to hold the tube tight against the existing conduit, and the maximum allowable pressure so as not to damage the tube. Once the inversion has started, the pressure shall be maintained between the minimum and maximum pressures until the inversion has been completed.

NOTE 3—After inversion is completed, pressures can be adjusted to facilitate the safe installation of condensate removal equipment or other mechanisms required to transition to the curing process.

7.5 *Lubricant*—When lubricant is used to reduce friction during inversion, the lubricant shall be poured into the inversion water in the downtube or applied directly to the tube. The lubricant used shall be a nontoxic product that has no detrimental effects on the tube or boiler and pump system, will not support the growth of bacteria, and will not adversely affect the fluid to be transported.

7.6 *Curing:*

7.6.1 *Using Circulating Heated Water*—After inversion is completed, a suitable heat source and water recirculation equipment are required to circulate heated water throughout the pipe. The equipment shall be capable of delivering hot water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. Water temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.1.1 The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing water supply. Another such gauge shall be placed between the impregnated tube and the pipe invert at the termination to determine the temperatures during cure.

7.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to the post-cure temperature recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.2 *Using Steam*—After inversion is completed, suitable steam-generating equipment is required and shall be capable of producing a sufficient amount of thermal energy throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The volume of air being sent through the pipe shall be sufficient to minimize condensation of the steam occurring during the curing. The temperature in the line during the cure period shall be as recommended by the resin manufacturer.

7.6.2.1 The steam-generating equipment shall be fitted with a suitable monitor to gauge the temperature of the outgoing steam. The temperature of the resin being cured shall be monitored by placing gauges between the impregnated tube and the existing pipe at both ends to determine the temperature during cure.

7.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to post-cure temperatures recommended by the resin manufacturer. The post-cure temperature shall be held for a period as recommended by the resin manufacturer, during which time the distribution of thermal energy via control of steam and air flow maintains the stated temperature. The curing of the CIPP must take into account the existing pipe material, the resin system, the current vertical alignment (that is, sags), and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.3 *Using Photoinitiated Reaction*—After the inversion is completed, while the tube is expanded under pressure, a light curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

7.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

7.6.3.2 *Processing*—Before the inversion begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

7.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

7.6.4 *Required Pressures*—The estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process shall be provided by the tube manufacturer and shall be increased to include consideration of the external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures shall be maintained until the cure has been completed. The pressure shall be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP shall be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 7.8 and Section 8.

7.7 *Cool-Down:*

7.7.1 *Using Cool Water After Heated Water Cure*—The new pipe should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Care shall be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed pipe.

7.7.2 *Using Cool Water After Steam Cure*—The new pipe should be cooled to a temperature below 113 °F (45 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Care shall be taken in the release of the air pressure so that a vacuum will not be developed that could damage the newly installed pipe.

7.8 *Workmanship*—The finished pipe shall be continuous over the entire length of an inversion run and be free of dry spots, lifts, and delaminations. If these conditions are present, remove and replace the CIPP in these areas.

7.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the space between the pipes shall be sealed by an approved method using compatible materials, if required by the owner in contract documents.

7.9 *Service Connections*—After the new pipe has been cured in place, the existing active service connections shall be reconnected. This should generally be done without excavation, and in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device.

8. Inspection Practices

8.1 For each inversion length designated by the owner in the Contract documents or purchase order, the preparation of a CIPP sample is required, using one of the following two methods, depending on access and the size of the host pipe.

8.1.1 For pipe sizes of 18 in. or less, the sample shall be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been inverted through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 In medium and large-diameter applications and areas with limited access, the sample shall be fabricated from material taken from the tube and the resin/catalyst system used and cured in a clamped mold placed in the downtube when circulating heated water is used and in the silencer when steam is used. This method can also be used for sizes 18 in. or less, in situations where preparing samples in accordance with 8.1.1 can not be obtained due to physical constrains, if approved by the owner.

8.1.3 The samples for each of these cases shall be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing, if applicable. The following test procedures shall be followed after the sample is cured and removed.

8.1.3.1 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress shall be measured for gravity and pressure pipe applications in accordance with Test Methods D790 and shall meet the requirements of Table 1.

8.1.3.2 *Tensile Properties*—The tensile strength shall be measured for pressure pipe applications in accordance with Test Method D638 and must meet the requirements of Table 1.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes shall be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test shall take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points shall not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end shall not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPA) and the water level inside of the inversion standpipe shall be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than the groundwater level, whichever is greater. The leakage quantity shall be gauged by the water level in a temporary standpipe placed in the upstream plug. The test shall be conducted for a minimum of one hour.

NOTE 4—It is impractical to test pipes above 36-in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the owner in the contract documents or purchase order, pressure pipes shall be subjected to a hydrostatic pressure test. A recommended pressure and leakage test would be at twice the known working pressure or at the working pressure plus 50 psi, whichever is less. Hold this pressure for a period of two to three hours to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of one hour. The allowable leakage during the pressure test shall be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 5—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the owner in the contract documents or purchase order, a delamination test shall be performed on each inversion length specified. The CIPP samples shall be prepared in accordance with 8.1.2, except that a portion of the tube material in the sample shall be dry and isolated from the resin in order to separate tube layers for testing. (Consult the tube manufacturer for further information.) Delamination testing shall be in accordance with Test Method D903, with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip shall be 1 in. (25 mm)/min.

8.4.2 Five test specimens shall be tested for each inversion specified.

8.4.3 The thickness of the test specimen shall be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate shall be a minimum of 10 lb/in. (178.60 g/mm) of width for typical CIPP applications.

NOTE 6—The purchaser may designate the dissimilar layers between which the delamination test will be conducted.

NOTE 7—For additional details on conducting the delamination test, contact the CIPP contractor.

8.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements shall be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements shall be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the pipe to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchase and seller.

8.6.1 *Ultrasonic Testing of Wall Thickness*—An alternative method to 8.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797/E797M. A minimum of eight (8) evenly spaced measurements shall be made around the internal circumference of the installed CIPP within the host pipe at a distance of 12 in. to 18 in. from the end of the pipe. For pipe diameters of fifteen (15) in. or greater, a minimum of sixteen (16) evenly spaced measurements shall be recorded. The ultrasonic method to be used is the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of E797/E797M. A calibration block shall be manufactured from the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendations. The average thickness shall be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.7 *Inspection and Acceptance*—The installation shall be inspected visually if practical, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater shall be observed through the CIPP itself. All service entrances shall be accounted for and be unobstructed.

APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *Terminology*:

X1.1.1 *partially deteriorated pipe*—the original pipe can support the soil and surcharge loads throughout the design life of the rehabilitated pipe. The soil adjacent to the existing pipe must provide adequate side support. The pipe may have longitudinal cracks and up to 10.0 % distortion of the diameter. If the distortion of the diameter is greater than 10.0 %, alternative design methods are required.

X1.1.2 *fully deteriorated pipe*—the original pipe is not structurally sound and cannot support soil and live loads or is expected to reach this condition over the design life of the rehabilitated pipe. This condition is evident when sections of the original pipe are missing, the pipe has lost its original shape, or the pipe has corroded due to the effects of the fluid, atmosphere, soil, or applied loads.

X1.2 *Gravity Pipe*:

X1.2.1 *Partially Deteriorated Gravity Pipe Condition*—The CIPP is designed to support the hydraulic loads due to groundwater, since the soil and surcharge loads can be supported by the original pipe. The groundwater level should be determined by the purchaser and the thickness of the CIPP should be sufficient to withstand this hydrostatic pressure without collapsing. The following equation may be used to determine the thickness required:

$$P = \frac{2KE_L}{(1-\nu^2)} \cdot \frac{1}{(DR-1)^3} \cdot \frac{C}{N} \quad \text{(X1.1)}$$

where:

P = groundwater load, psi (MPa), measured from the invert of the pipe
K = enhancement factor of the soil and existing pipe adjacent to the new pipe (a minimum value of 7.0 is recommended where there is full support of the existing pipe),
E_L = long-term (time corrected) modulus of elasticity for CIPP, psi (MPa) (see Note X1.1),
ν = Poisson's ratio (0.3 average),
DR = dimension ratio of CIPP,
C = ovality reduction factor =

$$\left(\left[1-\frac{\Delta}{100}\right] / \left[1+\frac{\Delta}{100}\right]^2\right)^3$$

Δ = percentage ovality of original pipe equals

$$100 \times \frac{(Mean\ Inside\ Diameter - Minimum\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

or

$$100 \times \frac{(Maximum\ Inside\ Diameter - Mean\ Inside\ Diameter)}{Mean\ Inside\ Diameter}$$

and

N = factor of safety.

NOTE X1.1—The choice of value (from manufacturer's literature) of E_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value for E_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

NOTE X1.2—If there is no groundwater above the pipe invert, the CIPP should typically have a maximum *SDR* of 100, dependent upon design conditions.

X1.2.1.1 If the original pipe is oval, the CIPP design from Eq X1.1 shall have a minimum thickness as calculated by the following formula:

$$1.5\frac{\Delta}{100}\left(1+\frac{\Delta}{100}\right)DR^2 - 0.5\left(1+\frac{\Delta}{100}\right)DR = \frac{\sigma_L}{PN} \quad \text{(X1.2)}$$

where:

σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5).

X1.2.1.2 See Table X1.1 for typical design calculations.

X1.2.2 *Fully Deteriorated Gravity Pipe Condition*—The CIPP is designed to support hydraulic, soil, and live loads. The groundwater level, soil type and depth, and live load should be determined by the purchaser, and the following equation should be used to calculate the CIPP thickness required to withstand these loads without collapsing:

TABLE X1.1 Maximum Groundwater Loads for Partially Deteriorated Gravity Pipe Condition

Diameter, in. (Inside Diameter of Original Pipe)	Nominal CIPP Thickness, mm	CIPP Thickness, *t*, in.	Maximum Allowable Groundwater Load[A] (above invert)	
			ft	m
8	6	0.236	40.0	12.2
10	6	0.236	20.1	6.1
12	6	0.236	11.5	3.5
15	9	0.354	20.1	6.1
18	9	0.354	11.5	3.5
18	12	0.472	27.8	8.5
24	12	0.472	11.5	3.5
24	15	0.591	22.8	6.9
30	15	0.591	11.5	3.5
30	18	0.709	20.1	6.1

[A]Assumes K = 7.0, E = 125 000 psi (862 MPa) (50-year strength), ν = 0.30, C = 0.64 (5 % ovality), and N = 2.0

$$q_t = \frac{1}{N}\left[32\, R_w\, B'\, E'_s \cdot C\,(E_L I/D^3)\right]^{1/2} \quad (X1.3)$$

where:

q_t = total external pressure on pipe, psi (MPa),
= $0.433H_w + wHR_w/144 + W_s$, (English Units),
$0.00981H_w + wHR_w/1000 + W_s$, (Metric Units)
R_w = water buoyancy factor (0.67 min) = $1 - 0.33\,(H_w/H)$,
w = soil density, lb.ft^3 (KN/m^3),
W_s = live load, psi (Mpa),
H_w = height of water above top of pipe, ft (m)
H = height of soil above top of pipe, ft (m),
B' = coefficient of elastic support = $1/(1 + 4e^{-0.065H})$ inch-pound units, $(1/(1 + 4e^{-0.213H})$ SI units
I = moment of inertia of CIPP, in.^{4}/in. (mm^4/mm) = $t^3/12$,
t = thickness of CIPP, in. (mm),
C = ovality reduction factor (see X1.2.1),
N = factor of safety,
E'_s = modulus of soil reaction, psi (MPa) (see Note X1.4),
E_L = long-term modulus of elasticity for CIPP, psi (MPa), and
D = mean inside diameter of original pipe, in. (mm)

X1.2.2.1 The CIPP design from Eq X1.3 should have a minimum thickness as calculated by the following formula:

$$\frac{EI}{D^3} = \frac{E}{12(DR)^3} \geq 0.093\,(inch-pound\ units), \quad (X1.4)$$

or

$$\frac{E}{12(DR)^3} \geq 0.00064\,(SI\ units)$$

where:

E = initial modulus of elasticity, psi (MPa)

NOTE X1.3—For pipelines at depth not subject to construction disturbance, or if the pipeline was originally installed using tunneling method, the soil load may be calculated using a tunnel load analysis. Finite element analysis is an alternative design method for noncircular pipes.

NOTE X1.4—For definition of modulus of soil reaction, see Practice D3839.

X1.2.2.2 The minimum CIPP design thickness for a fully deteriorated condition should also meet the requirements of Eq X1.1 and X1.2.

X1.3 *Pressure Pipe*:

X1.3.1 *Partially Deteriorated Pressure Condition*—A CIPP installed in an existing underground pipe is designed to support external hydrostatic loads due to groundwater as well as withstand the internal pressure in spanning across any holes in the original pipe wall. The results of Eq X1.1 are compared to those from Eq X1.6 or Eq X1.7, as directed by Eq X1.5, and the largest of the thicknesses is selected. In an above-ground design condition, the CIPP is designed to withstand the internal pressure only by using Eq X1.5-X1.7 as applicable.

X1.3.1.1 If the ratio of the hole in the original pipe wall to the pipe diameter does not exceed the quantity shown in Eq X1.5, then the CIPP is assumed to be a circular flat plate fixed at the edge and subjected to transverse pressure only. In this case, Eq X1.6 is used for design. For holes larger than the d/D value in Eq X1.5, the liner cannot be considered in flat plate loading, but rather in ring tension or hoop stress, and Eq X1.7 is used.

$$\frac{d}{D} \leq 1.83\left(\frac{t}{D}\right)^{1/2} \quad (X1.5)$$

where:

d = diameter of hole or opening in original pipe wall, in. (mm),
D = mean inside diameter of original pipe, in. (mm), and
t = thickness of CIPP, in. (mm).

$$P = \frac{5.33}{(DR-1)^2}\left(\frac{D}{d}\right)^2 \frac{\sigma_L}{N} \quad (X1.6)$$

where:

DR = dimension ratio of CIPP,
D = mean inside diameter of original pipe, in. (mm),
d = diameter of hole or opening in original pipe wall, in. (mm),
σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5), and
N = factor of safety.

NOTE X1.5—The choice of value (from manufacturer's literature) of σ_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.3.2 *Fully Deteriorated Pressure Pipe Condition*—A CIPP to be installed in an underground condition is designed to withstand all external loads and the full internal pressure. The design thicknesses are calculated from Eq X1.1, Eq X1.3, Eq X1.4, and Eq X1.7, and the largest thickness is selected. If the pipe is above ground, the CIPP is designed to withstand internal pressure only by using Eq X1.7.

$$P = \frac{2\sigma_{TL}}{(DR-2)\,N} \quad (X1.7)$$

where:

P = internal pressure, psi (MPa),
σ_{TL} = long-term (time corrected) tensile strength for CIPP, psi (MPa) (see Note 12),
DR = dimension ratio of CIPP, and
N = factor of safety.

NOTE X1.6—The choice of value (from manufacturer's literature) of σ_{TL} will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_{TL} will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.4 *Negative Pressure*—Where the pipe is subject to a vacuum, the CIPP should be designed as a gravity pipe with the external hydrostatic pressure increased by an amount equal to the negative pressure.

NOTE X1.7—Table X1.1 presents maximum groundwater loads for partially deteriorated pipes for selected typical nominal pipe sizes. CIPP is custom made to fit the original pipe and can be fabricated to a variety of sizes from 2 in. to 108 in. diameter which would be impractical to list here.

X2. CHEMICAL-RESISTANCE TESTS

X2.1 *Scope*:

X2.1.1 This appendix covers the test procedures for chemical-resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

X2.2 *Procedure for Chemical-Resistance Testing*:

X2.2.1 Chemical resistance tests should be completed in accordance with Practices D543. Exposure should be for a minimum of one month at 73.4 °F (23 °C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with Section 8 of this practice.

X2.2.2 Table X2.1 presents a list of chemical solutions that serve as a recommended minimum requirement for the chemical-resistant properties of CIPP in standard domestic sanitary sewer applications.

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical-resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Tap water (pH 6–9)	100
Nitric acid	5
Phosphoric acid	10
Sulfuric acid	10
Gasoline	100
Vegetable oil	100
Detergent	0.1
Soap	0.1

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–21) that may impact the use of this standard. (Approved August 15, 2022.)

(1) Changed non-mandatory wording to mandatory wording throughout the standard.

Committee F17 has identified the location of selected changes to this standard since the last issue (F1216–16) that may impact the use of this standard. (Approved November 1, 2021.)

(1) Added 3.2.4 and 7.6.3.

(2) Section 7.6.4 was revised.

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

INTERNATIONAL

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EXHIBIT C
PG. 1 of 8

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)[1]

This standard is issued under the fixed designation F1743; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (´) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice describes the procedures for the reconstruction of pipelines and conduits (2 in. to 96 in. (5 cm to 244 cm) diameter) by the pulled-in-place installation of a resin-impregnated, flexible fabric tube into an existing conduit and secondarily inflated through the inversion of a calibration hose by the use of a hydrostatic head or air pressure (see Fig. 1). The resin is cured by circulating hot water, by the introduction of controlled steam into the tube, or by photoinitiated reaction. When cured, the finished cured-in-place pipe will be continuous and tight fitting. This reconstruction process may be used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and ventilation systems.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

NOTE 1—There are no ISO standards covering the primary subject matter of this practice.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1920 Practice for Cleaning of Vitrified Clay Sanitary Sewer Pipelines
D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents
D638 Test Method for Tensile Properties of Plastics
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D903 Test Method for Peel or Stripping Strength of Adhesive Bonds
D1600 Terminology for Abbreviated Terms Relating to Plastics
D1682 Test Method for Breaking Load and Elongation of Textile Fabric (Withdrawn 1992)[3]
D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials
D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings
D4814 Specification for Automotive Spark-Ignition Engine Fuel
D5813 Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems
E797 Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method
F412 Terminology Relating to Plastic Piping Systems
F1216 Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

2.2 *AWWA Standard:*[4]

M28 Manual on Cleaning and Lining Water Mains[4]

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

*A Summary of Changes section appears at the end of this standard

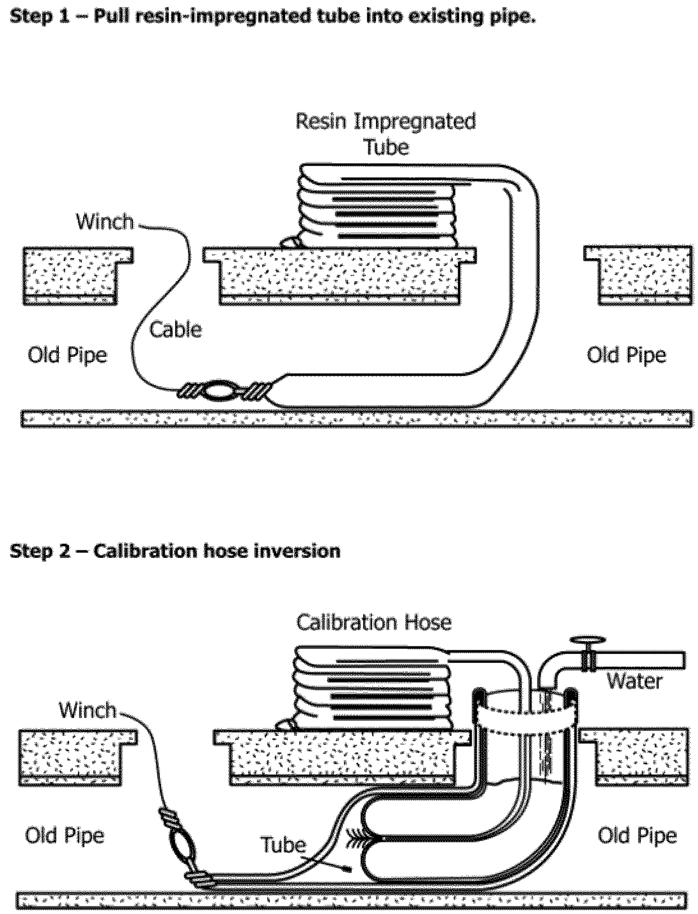


FIG. 1 Cured-in-Place Pipe Installation Methods

2.3 *NASSCO Standard:*[5]

Recommended Specifications for Sewer Collection System Rehabilitation

3. Terminology

3.1 *General*—Definitions are in accordance with Terminology F412. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration hose*—an impermeable bladder which is inverted within the resin-impregnated fabric tube by hydrostatic head or air pressure and may optionally be removed or remain in place as a permanent part of the installed cured-in-place pipe as described in 5.2.2.

3.2.2 *cured-in-place pipe (CIPP)*—a hollow cylinder consisting of a fabric tube with cured (cross-linked) thermosetting resin. Interior or exterior plastic coatings, or both, may be included. The CIPP is formed within an existing pipe and takes the shape of and fits tightly to the pipe.

3.2.3 *delamination*—separation of layers of the CIPP.

3.2.4 *dry spot*—an area of fabric of the finished CIPP which is deficient or devoid of resin.

3.2.5 *fabric tube*—flexible needled felt, or equivalent, woven or nonwoven material(s), or both, formed into a tubular shape which during the installation process is saturated with resin and holds the resin in place during the installation and curing process.

3.2.6 *inversion*—the process of turning the calibration hose inside out by the use of water pressure or air pressure.

3.2.7 *lift*—a portion of the CIPP that is a departure from the existing conduit wall forming a section of reverse curvature in the CIPP.

3.2.8 *photoinitiated reaction*—The polymerization of a resin system initiated by light or other electromagnetic radiation.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated fabric tube pulled-in-place through an existing conduit and secondarily inflated through the inversion of a calibration hose. Modifications may be required for specific job conditions.

5. Recommended Materials and Manufacture

5.1 *General*—The resins, fabric tube, tube coatings, or other materials, such as the permanent calibration hose when combined as a composite structure, shall produce CIPP that meets the requirements of this specification.

5.2 *CIPP Wall Composition*—The wall shall consist of a plastic coated fabric tube filled with a thermosetting (cross-linked) resin, and if used, a filler.

5.2.1 *Fabric Tube*—The fabric tube should consist of one or more layers of flexible needled felt, or equivalent, woven or nonwoven material(s), or both, capable of carrying resin, withstanding installation pressures, and curing temperatures. The material(s) of construction should be able to stretch to fit irregular pipe sections and negotiate bends. Longitudinal and circumferential joints between multiple layers of fabric should be staggered so as not to overlap. The outside layer of the fabric tube should have an impermeable flexible coating(s) whose function is to contain the resin during and after fabric tube impregnation. The outer coating(s) must facilitate monitoring of resin saturation of the material(s) of construction of the fabric tube. The fabric tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance should be made for circumferential and longitudinal stretching of the fabric tube during installation. As required, the fabric tube should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the fabric tube should be compatible with the resin system used.

5.2.2 *Calibration Hose:*

5.2.2.1 *Removable Calibration Hose*—The removable calibration hose should consist of an impermeable plastic, or impermeable plastic coating(s) on flexible woven or nonwoven

[5] Available from the National Association of Sewer Service Companies, NASSCO 11521 Cronridge Drive, Suite J Owings Mills, MD 21117, http://www.nassco.org.

material(s), or both, that do not absorb resin and are capable of being removed from the CIPP.

5.2.2.2 *Permanent Calibration Hose*—The permanent calibration hose should consist of an impermeable plastic coating on a flexible needled felt or equivalent woven or nonwoven material(s), or both, that are capable of absorbing resin and are of a thickness to become fully saturated with resin. The calibration hose should be translucent to facilitate post-installation inspection. The calibration hose should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the resin saturated fabric tube. Once inverted, the calibration hose becomes part of the fabric tube, and once properly cured, should bond permanently with the fabric tube. The properties of the calibration hose should meet minimum tensile strength requirements in the longitudinal and transverse directions as specified in 7.1. All the material(s) of construction for the calibration hose should be compatible with the resin system used.

5.2.3 *Resin*—A chemically resistant isophthalic based polyester, or vinyl ester thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the installation process should be used. The resin should be able to cure in the presence of water and the initiation temperature for cure should be less than 180 °F (82.2 °C). The cured resin/fabric tube system, with or without the calibration hose, shall be expected to have as a minimum the initial structural properties given in Table 1. These physical properties should be determined in accordance with Section 8. The cured resin/fabric tube system, with or without the calibration hose, should meet the minimum chemical resistance requirements as specified in 7.2.

6. Installation Recommendations

6.1 *Cleaning and Pre-Inspection :*

6.1.1 Prior to entering access areas, such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations.

6.1.2 *Cleaning of Pipeline*—All internal debris shall be removed from the original pipeline. Non-pressure gravity pipes shall be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment in accordance with manufacturers guidelines, Practice C1920, for VCP pipe or NASSCO Recommended Specifications for Sewer Collection System Rehabilitation, as applicable. Pressure pipelines should be cleaned with cable attached devices or fluid propelled devices in accordance with AWWA M28.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value psi	Minimum Value (MPa)
Flexural strength	D790	4500	(31)
Flexural modulus	D790	250 000	(1724)
Tensile strength (for pressure pipes only)	D638	3000	(21)

[A]The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

6.1.3 *Inspection of Pipelines*—Inspection of pipelines should be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed-circuit television or man entry. The interior of the pipeline should be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions should be noted so that they can be corrected.

6.1.4 *Line Obstructions*—The original pipeline should be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % that may hinder or prevent the installation of the resin-impregnated fabric tube. If inspection reveals an obstruction that cannot be removed by conventional sewer-cleaning equipment, then a point-repair excavation should be made to uncover and remove or repair the obstruction.

6.2 *Resin Impregnation*—The fabric tube should be totally impregnated with resin (wet-out) and run through a set of rollers separated by a space, calibrated under controlled conditions to ensure proper distribution of resin. The volume of resin used should be sufficient to fully saturate all the voids of the fabric tube material, as well as all resin-absorbing material of the calibration hose at nominal thickness and diameter. The volume should be adjusted by adding 3 % to 15 % excess resin to allow for the change in resin volume due to polymerization, the change in resin volume due to thermal expansion or contraction, and resin migration through the perforations of the fabric tube and out onto the host pipe.

6.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass should be made by plugging the line at a point upstream of the pipe to be reconstructed and pumping the flow to a downstream point or adjacent system. The pump and bypass lines should be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

6.3.1 Public advisory services shall notify all parties whose service laterals will be out of commission and advise against water usage until the main line is back in service.

6.4 *Installation Methods:*

6.4.1 *Perforation of Resin-Impregnated Tube*—Prior to pulling the resin-impregnated fabric tube in place, the outer impermeable plastic coating may optionally be perforated. When the resin-impregnated fabric tube is perforated, this should allow resin to be forced through the perforations and out against the existing conduit by the force of the hydrostatic head or air pressure against the inner wall of the calibration hose. The perforation should be done after fabric tube impregnation with a perforating roller device at the point of manufacture or at the jobsite. Perforations should be made on both sides of the lay-flat fabric tube covering the full circumference with a spacing no less than 1.5 in. (38.1 mm) apart. Perforating slits should be a minimum of 0.25 in. (6.4 mm) long.

6.4.2 *Pulling Resin-Impregnated Tube into Position*—The wet-out fabric tube should be pulled into place using a power winch. The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point. Care should be exercised not to damage the tube as a result of friction during pull-in, especially where curvilinear alignments, multilinear alignments, multiple offsets, protruding services, and other friction-producing host pipe conditions are present. Once the fabric tube is in place, it should be attached to a vertical standpipe so that the calibration hose can invert into the center of the resin-impregnated fabric tube. The vertical standpipe should be of sufficient height of water head to hold the fabric tube tight to the existing pipe wall, producing dimples at side connections. A device such as a dynamometer or load cell should be provided on the winch or cable to monitor the pulling force. Measure the overall elongation of the fabric tube after pull-in completion. The acceptable longitudinal elongation shall not be more than 5 % of the overall length measured after the calibration hose has been installed, or exceed the recommended pulling force.

6.4.3 *Hydrostatic Head Calibration Hose Inversion*—The calibration hose should be inserted into the vertical inversion standpipe, with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the calibration hose should be turned inside out and attached to the standpipe so that a leakproof seal is created. The resin-impregnated fabric tube should also be attached to the standpipe so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion head should be adjusted to be of sufficient height of water head to cause the calibration hose to invert from the initial point of inversion to the point of termination and hold the resin-impregnated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the felt fiber. At the request of the purchaser, the fabric tube manufacturer should provide information on the maximum allowable axial and longitudinal tensile stress for the fabric tube.

6.4.3.1 An alternative method of installation is top inversion. In this case, the calibration hose and resin-impregnated fabric tube are attached to a top ring. In this case, the tube itself forms the standpipe for generation of the hydrostatic head. Other methods of installation are also available and should be submitted for acceptance by the purchaser.

6.4.4 *Using Air Pressure*—The resin-impregnated fabric tube should be perforated as described in 6.4.1. Once perforated, the wet-out fabric tube should be pulled into place using a power winch as described in 6.4.2. The calibration hose should be inserted through the guide chute or tube of the pressure containment device in which the calibration hose has been loaded, with the impermeable plastic membrane side out. At the end of the guide chute, the calibration hose should be turned inside out and attached so that a leakproof seal is created. The resin-impregnated tube should also be attached to the guide chute so that the calibration hose can invert into the center of the resin-impregnated tube. The inversion air pressure should be adjusted to be of sufficient pressure to cause the calibration hose to invert from point of inversion to point of termination and hold the resin saturated fabric tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the woven and nonwoven materials. Take suitable precautions to eliminate hazards to personnel in the proximity of the construction when pressurized air is being used.

6.5 *Lubricant During Installation* —The use of a lubricant during installation is recommended to reduce friction during inversion. This lubricant should be poured into the fluid in the standpipe in order to coat the calibration hose during inversion. When air is used to invert the calibration hose, the lubricant should be applied directly to the calibration hose. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube or boiler and pump system, and will not adversely affect the fluid to be transported.

6.6 *Curing:*

6.6.1 *Using Circulating Heated Water*—After installation is completed, suitable heat source and water recirculation equipment are required to circulate heated water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. The water temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.1.1 The heat source should be fitted with suitable monitors to measure the temperature of the incoming and outgoing water supply. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the CIPP appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller. During post-cure, the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.2 *Using Steam*—After installation is completed, suitable steam-generating equipment is required to distribute steam throughout the pipe. The equipment should be capable of delivering steam throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The temperature in the line during the cure period should be as recommended by the resin manufacturer or seller.

6.6.2.1 The steam-generating equipment should be fitted with a suitable monitor to measure the temperature of the outgoing steam. Temperature sensors should also be placed between the resin-impregnated tube and the host pipe invert at both termination points to monitor the temperatures during cure.

6.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature and held there for a period recommended by the resin manufacturer or seller, during which time the distribution and control of steam to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

6.6.3 *Using photoinitiated reaction*—After installation is completed, while the fabric tube is expanded under pressure, a light curing assembly may be drawn through the pipe. Prior to initiating the curing process, the installer shall use the closed-circuit television (CCTV) camera(s) in coordination with or mounted on the light curing assembly to verify that the fabric tube is properly positioned and fitted to the host pipe. Any anomalies shall be corrected prior to initiating the curing process.

6.6.3.1 The curing lights shall be tuned or optimized for the photoinitiated resin system; or conversely the photo initiators shall be optimized to the output of the curing lights.

6.6.3.2 *Processing*—Before the installation begins, for dynamic curing processes the CIPP system manufacturer shall provide the rate of travel for the light assembly through the pipe for each installation length, or as required for each specific fabric tube dimensions. The rate shall be optimized to initiate polymerization and facilitate the cure of the CIPP resin.

6.6.3.3 *Curing Control*—A full protocol shall be defined by the manufacturer and recorded and maintained as documentation verifying the curing process. Data collected may include time, rate of travel of the light curing assembly for dynamic curing processes, pressures, temperature in the tube and the power output of the light assembly.

6.6.4 *Required Pressures*—As required by the purchase agreement, the estimated maximum and minimum pressure required to hold the flexible tube tight against the existing conduit during the curing process should be provided by the seller and shall be increased to include consideration of external ground water, if present. Once the cure has started and dimpling for laterals is completed, the required pressures should be maintained until the cure has been completed. The pressure should be maintained within the estimated maximum and minimum pressure during the curing process. If the steam pressure or hydrostatic head drops below the recommended minimum during the cure, the CIPP should be inspected for lifts or delaminations and evaluated for its ability to fully meet the applicable requirements of 6.8 and Section 8.

6.7 *Cool-Down:*

6.7.1 *Using Cool Water after Heated Water Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Take care to cool down the CIPP in a controlled manner, as recommended by the resin manufacturer or the seller. Care should be taken to release the static head so that a vacuum will not be developed that could damage the newly installed CIPP.

6.7.2 *Using Cool Water after Steam Cure*—The new CIPP should be cooled to a temperature below 100 °F (38 °C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Take care to cool the CIPP in a controlled manner as recommended by the resin manufacturer or the seller. Care should be taken to release the air pressure so that a vacuum will not be developed that could damage the newly installed CIPP.

6.8 *Workmanship*—The finished CIPP should be continuous over the entire length of an installation and be free of dry spots, lifts, and delaminations. If these conditions are present, the CIPP will be evaluated for its ability to meet the applicable requirements of Section 8. Where the CIPP does not meet the requirements of Section 8 or specifically stated requirements of the purchase agreement, or both, the affected portions of CIPP will be removed and replaced with an equivalent repair.

6.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the full circumference of the CIPP exiting the existing host pipe or conduit should be sealed by filling with a resin mixture compatible with the CIPP.

6.9 *Service Connections*—After the new CIPP has been installed, the existing active (or inactive) service connections should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote-control cutting device. Service connections shall be reinstated to at least 90 % of the original area as it enters the host pipe or conduit.

NOTE 2—In many cases, a seal is provided where the formed CIPP dimples at service connections. However, this practice should not be construed to provide a 100 % watertight seal at all service connections. If total elimination of infiltration and inflow is desired, other means, which are beyond the scope of this practice, may be necessary to seal service connections and to rehabilitate service lines and manholes.

7. Material Requirements

7.1 *Fabric Tube Strength*—If required by the purchaser in the purchase agreement, the fabric tube, and seam (if applicable) as a quality control test, when tested in accordance with Test Method D1682 shall have a minimum tensile strength of 750 psi (5 MPa) in both the longitudinal and transverse directions.

7.2 *Chemical Resistance:*

7.2.1 *Chemical Resistance Requirements*—The cured resin/fabric tube matrix, with or without the calibration hose, shall be evaluated in a laminate form for qualification testing of long-term chemical exposure to a variety of chemical effluents and should be evaluated in a manner consistent with 6.4.1 of Specification D5813. The specimens shall be capable of exposure to the solutions in Table 2 at a temperature of 73.4 °F ± 3.6 °F (23 °C ± 2 °C), with a percentage retention of flexural modulus of elasticity of at least 80 % after one year exposure. Flexural properties, after exposure to the chemical solution(s), shall be based on dimensions of the specimens after exposure.

TABLE 2 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Nitric acid	1
Sulfuric acid	5
ASTM Fuel C[A]	100
Vegetable oil[B]	100
Detergent[C]	0.1
Soap[C]	0.1

[A]In accordance with Specification D4814.
[B]Cottonseed, corn, or mineral oil.
[C]In accordance with Test Method D543.

7.2.2 *Chemical Resistance Procedures*—The CIPP laminates should be constructed of identical fabric and resin components that will be used for anticipated in-field installations. The cured resin/fabric tube laminates, with or without the calibration hose should be exposed to the chemical agents in a manner consistent with Test Method D543. The edges of the test coupons should be left exposed and not treated with resin, unless otherwise specified by the purchaser. The specimen thicknesses should be in the range of 0.125 in. to 0.25 in. (3.2 mm to 6.4 mm), with the sample dimensions suitable for preparing a minimum of five specimens for flexural testing as described in 8.1.4. Flexural properties after exposure to the chemical solutions should be based on the dimensions of the specimen after exposure.

7.2.2.1 For applications other than standard domestic sewerage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test samples in the active pipe.

7.2.2.2 As required by the purchaser, additional chemical resistance requirements for the CIPP may be evaluated as described in 6.4 of Specification D5813.

8. Recommended Inspection Practices

8.1 For each installation length designated by the purchaser in the purchase agreement, the preparation of CIPP samples is required from one or both of the following two methods:

8.1.1 The samples should be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been installed through a like diameter section of pipe or other tubular restraining means which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 The sample should be fabricated from material taken from the fabric tube and the resin/catalyst system used, and cured in a clamped mold, placed in the downtube when heated circulated water is used, and in the silencer when steam is used. When the CIPP is constructed of oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, this method of sample preparation is recommended in order to allow testing in the axial (that is, along the length) and circumferential (that is, hoop) directions of the CIPP. This method is also recommended when large-diameter CIPP is installed that may otherwise not be prepared with a tubular restraint.

8.1.3 The CIPP samples for each of these cases should be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing for internal pressure applications. The flexural and tensile specimens should be prepared in a manner consistent with 8.3.1 of Specification D5813. For flexural and tensile properties, the full wall thickness of the CIPP samples shall be tested. Any plastic coatings or other CIPP layers not included in the structural design of the CIPP may be carefully ground off of the specimens prior to testing. If the sample is irregular or distorted such that proper testing is inhibited, attempts shall be made to machine any wall thickness from the inside pipe face of the sample. Any machining of the outside pipe face of the sample shall be done carefully so as to minimize the removal of material from the outer structural wall of the sample. Individual specimens should be clearly marked for easy identification and retained until final disposition or CIPP acceptance, or both, has been given.

8.1.4 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress should be measured for gravity and pressure pipe applications in accordance with Test Method D790, Test Method I, Procedure A and should meet the requirements of Table 1 within the 16:1 length to depth constraints. For specimens greater than 0.5 in. (12.7 mm) in depth, the width-to-depth ratio of the specimen should be increased to a minimum of 1:1 and should not exceed 4:1. For samples prepared in accordance with 8.1.1, determine flexural properties in the axial direction where the length of the test specimen is cut along the longitudinal axis of the pipe. Special consideration should be given to the preparation of flexural specimens to ensure opposite sides are parallel and adjacent edges are perpendicular. Flexural specimens should be tested such that the inside pipe face is tested in tension and the outside pipe face is in compression.

8.1.4.1 *Fiber-Reinforced CIPP Flexural Properties*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2, and flexural properties should be determined in accordance with 8.1.3 along the longitudinal axis and circumferential axis of the installed CIPP.

8.1.5 *Short-Term Tensile Properties*—The tensile strength should be measured for pressure pipe applications in accordance with Test Method D638. Specimens should be prepared in accordance with Types I, II, and III of Fig. 1 of Test Method D638. Specimens greater than 0.55 in. (14 mm) thick should maintain all dimensions for a Type III specimen, except the thickness will be that of the CIPP sample obtained. The rate of specimen testing should be carried out in accordance with Table 1 of Test Method D638. Specimens should be prepared in accordance with 8.1.1 and tested along the longitudinal axis of the installed CIPP.

8.1.5.1 *Fiber-Reinforced CIPP Tensile Testing*—Where the CIPP is reinforced with oriented continuous or discontinuous fibers to enhance the physical properties of the CIPP, specimens should be sampled in accordance with 8.1.2 and tensile properties should be determined in accordance with Test Method D3039/D3039M and tested along the longitudinal axis and circumferential axis of the installed CIPP.

8.1.6 *CIPP Wall Thickness*—The method of obtaining CIPP wall thickness measurements should be determined in a manner consistent with 8.1.2 of Specification D5813. Thickness measurements should be made in accordance with Practice D3567 for samples prepared in accordance with 8.1. Make a minimum of eight measurements at evenly spaced intervals around the circumference of the sample to ensure that minimum and maximum thicknesses have been determined. Deduct from the measured values the thickness of any plastic coatings or CIPP layers not included in the structural design of the CIPP. The average thickness should be calculated using all measured values and shall meet or exceed minimum design thickness as agreed upon between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5 % of the specified design thickness as agreed upon between purchaser and seller.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test should take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points should not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end should not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPa), and the water level inside of the inversion standpipe should be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than groundwater level, whichever is greater. The leakage quantity should be gaged by the water level in a temporary standpipe placed in the upstream plug. The test should be conducted for a minimum of 1 h.

NOTE 3—It is impractical to test pipes above 36 in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the purchaser in the purchase agreement, pressure pipes should be subjected to a hydrostatic pressure test. A pressure and leakage test at twice the known working pressure or at the working pressure plus 50 psi, whichever is less, is recommended. The pressure should initially be held at the known working pressure for a period not less than 12 h, then increased to the test pressure for an additional period of 2 to 3 h to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of 1 h. The allowable leakage during the pressure test should be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 4—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 *Delamination Test*—If required by the purchaser in the purchase agreement, a delamination test should be performed on each installation length specified. CIPP samples should be prepared in accordance with 8.1.2, except that a portion of the fabric tube material in the sample should be dry and isolated from the resin in order to separate tube layers for testing (consult the tube manufacturer for further information). Delamination testing should be in accordance with Test Method D903 with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip should be 1 in. (25 mm)/min.

8.4.2 Five test specimens should be tested for each installation specified.

8.4.3 The thickness of the test specimen should be minimized, but should be sufficient to adequately test delamination of nonhomogeneous CIPP layers.

8.5 The peel or stripping strength between any nonhomogeneous layers of the CIPP laminate should be a minimum of 10 lb/in. (178.60 g/mm) for typical CIPP applications.

NOTE 5—The purchaser may designate the similar layers between which the delamination test will be conducted.

NOTE 6—For additional details on conducting the delamination test, contact the seller.

8.6 *Inspection and Acceptance*—The installation may be inspected visually if appropriate, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater should be observed. All service entrances should be accounted for and be unobstructed.

8.6.1 *Ultrasonic Testing of Wall Thickness*— An alternative method to 8.1.6 for measuring the wall thickness may be performed within the installed CIPP at either end of the pipe by the ultrasonic pulse echo method as described in Practice E797. A minimum of eight (8) evenly spaced measurements should be made around the internal circumference of the installed CIPP with the host pipe at a distance of 12 to 18 inches from the end of the pipe. For pipe diameters of fifteen (15) inches or greater a minimum of 16 evenly spaced measurements shall be recorded . The ultrasonic method to be used in the flaw detector with A-scan display and direct thickness readout as defined in 6.1.2 of Practice E797. A calibration block shall be manufactured for the identical materials used in the installed CIPP to calibrate sound velocity through the liner. Calibration of the transducer shall be performed daily in accordance with the equipment manufacturer's recommendation. The average thickness should be calculated using all the measured values and shall meet or exceed minimum design thickness as agreed on between purchaser and seller. The minimum wall thickness at any point shall not be less than 87.5% of the specified design thickness as agreed upon between the purchaser and seller.

9. Keywords

9.1 cured-in-place pipe; installation—underground; plastic pipe—thermoset; rehabilitation; thermosetting resin pipe

APPENDIX

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *General Guidelines*—The design thickness of the CIPP is a function of the resin, materials of construction of the fabric tube, and the condition of the existing pipe. In addition, depending on the condition of the pipe, the design thickness of the CIPP may also be a function of groundwater, soil type, and influence of live loading surrounding the host pipe. For guidance relating to terminology of piping conditions and related design equations, see Appendix X1 of Practice F1216.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1743–17) that may impact the use of this standard.

(1) Practice C1920 was added to 2.1.

(2) Section 6.1.2 was revised.

CONTINUOUS MATERIAL INSTALLATION

Inverted "Continuous" Liner
ASTM F1216

7.4.2 Using Air Pressure…

*"The inversion air pressure shall be adjusted to be of sufficient pressure to cause the impregnated tube to invert from **point of inversion to point of termination** and hold the tube tight to the pipe wall, **(A) producing dimples at side connections."***

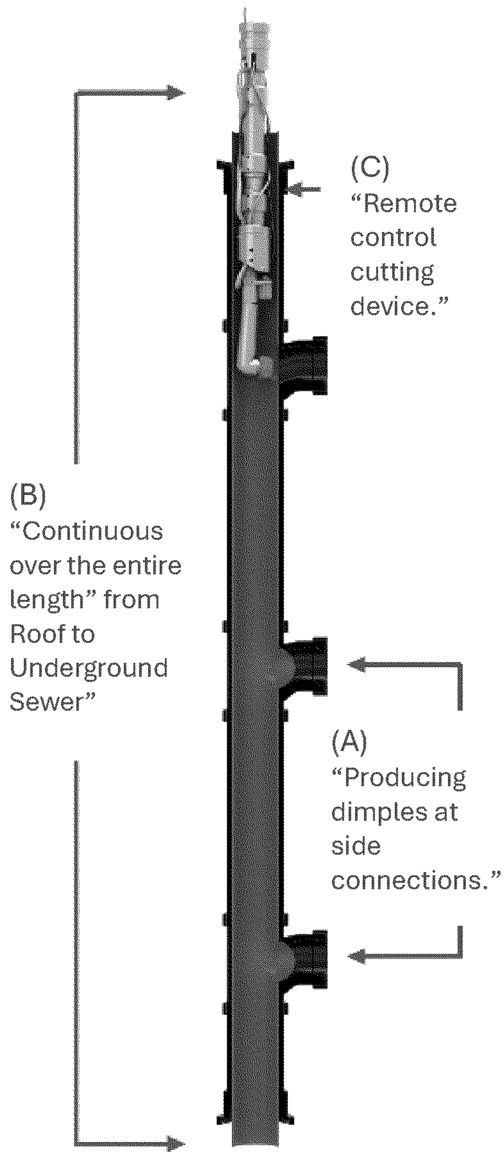
("Dimples" identify Branch Connections to be robotically reinstated not gapped.)

7.8 Workmanship

*"The finished pipe shall be **(B) continuous over the entire length** of an inversion run and be free of dry spots, lifts, and delamination."*

7.9 Service Connections

*"After the new pipe has been cured in place, the existing active service connections shall be reconnected. This should generally be done without excavation, and in the case of non-worker entry pipes, from the interior of the pipeline by means of a television camera and a **(C) remote-control cutting device."***



Pulled-in-Place "Continuous" Liner
ASTM F1743

6.4.2 Pulling Resin-Impregnated Tube into Position…

*"The saturated fabric tube should be pulled through an existing manhole or other approved access to fully extend to the next designated manhole or termination point… **(A) producing dimples at side connections."***

("Dimples" identify Branch Connections to be robotically reinstated not gapped.)

6.8 Workmanship

*"The finished CIPP should be **(B) continuous over the entire length** of an installation and be free of dry spots, lifts, and delamination."*

6.9 Service Connections

*"After the new CIPP has been installed, the existing active (or inactive) service connection should be reinstated. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a **(C) remote-control cutting device.** Service connections shall be reinstated to at least 90% of the original area as it enters the host pipe or conduit."*

EXHIBIT E
PG. 1 of 1

tested and certified as conforming to NSF 14. This includes all water service, water distribution, drainage piping and fittings and plastic piping system components, including but not limited to pipes, fittings, valves, joining materials, gaskets and appurtenances. This section does not apply to components that only include plastic parts such as brass valves with a plastic stem, or to fixture fittings such as fixture stop valves. NSF 14 requires that plastic piping systems, fittings and related components intended for use in the potable water supply system must comply with NSF 61.

303.4 Third-party certification. Plumbing products and materials required by the code to be in compliance with a referenced standard shall be listed by a *third-party certification agency* as complying with the referenced standards. Products and materials shall be identified in accordance with Section 303.1.

❖ The term "third-party certification agency" refers to an independent organization having no financial or other interest in the outcome of tests or inspections.

The code requirements for testing and certification have frequently confused code officials and manufacturers over the years. Securing and submitting the necessary documentation for certain products and materials is sometimes a challenge for contractors and engineers. The code official is also burdened with trying to keep up with the myriad of products he or she sees in the field and the documentation that has (or has not) been submitted. To simplify inspections and approvals, the code requires the products and materials required to be in compliance with standards in the code, be "examined" by a third-party certification agency and "listed" by that agency. The definitions for "Third-party certification agency" and "Third-party certified" in Chapter 2 provide additional insight.

The code does not have a definition for "listed." Other I-Codes such as the IBC, do have a definition for "listed." Listed means that a product or material is included on a list maintained by the third-party certification agency. Such lists are freely available to the public, usually on an internet website. A third-party certification agency will only place the product or material designations such as a model number, part number, material type, on their list after they have determined that the item complies with the standards applicable to the item. The product and material manufacturers pay the third-party certification agency for this service.

In practice, the code official who is interested in determining that a product or material complies with a standard need only request of the designer or contractor, the location of the listing (or a print-out of the listing) for the item. For large projects, this process can become laborious, slowing the construction process. Most, if not all, third-party certification agencies also offer a "labeling" service to manufacturers. Such labeling of a product or material is not required by this section. However, many manufacturers do purchase this service from the third-party certification agency along with the listing service in order to make it easier for the code official to identify that the product does indeed meet all applicable standards. The label is a symbol owned by the third-party certification agency that authorizes use of that symbol by the manufacturer. The manufacturer could apply (print) the symbol to an item's specification sheet, product package, or to the item itself. In many situations, the symbol is used in all three locations; however, in other situations, the symbol might not be applied directly on an item because of the size of the item (too small) or the type of finish (such as the decorative finish on a faucet). The symbol, wherever it is located, is an easily recognizable, fast method for the code official to determine the compliance of the product or material to the standard.

303.5 Cast-iron soil pipe, fittings and components. Cast-iron soil pipes and fittings, and the couplings used to join these products together, shall be third-party listed and labeled. Third-party certifiers or inspectors shall comply with the minimum inspection requirements of Annex A or Annex Al of the ASTM and CISPI product standards indicated in the code for such products.

❖ Section 303.4 already requires "listing," by a third-party certification agency, of plumbing products and materials required to be in accordance with code-referenced standards. This section adds the requirement for "labeling" for cast iron soil pipes and fittings, and the couplings for those products. See the Commentary for Section 303.4 for further insight.

Because not all third-party certification agencies or inspectors are familiar with the essential items, which must be inspected at the manufacturing location of these products, the annexes of the ASTM and CISPI standards are invoked to indicate the minimum requirements that are necessary for listing and labeling of these products.

SECTION 304
RODENTPROOFING

304.1 General. Plumbing systems shall be designed and installed in accordance with Sections 304.2 through 304.4 to prevent rodents from entering structures.

❖ Rodents are known to be carriers of diseases and present serious health risks to humans. To prevent the spread of disease, Sections 304.2 through 304.4 require plumbing systems to be installed in a manner that will reduce the potential for rodent entry into structures.

304.2 Strainer plates. Strainer plates on drain inlets shall be designed and installed so that all openings are not greater than $^1/_2$ inch (12.7 mm) in least dimension.

❖ Rodents often travel and live within sanitary sewer systems. The limitation for opening size in strainer plates for floor and shower drains as well as receptor strainers provides two forms of protection. If rodents are in the sewer system, strainer plates prevent them from entering the building through the floor or shower drain. If