Designation: D 5813 – 04

An American National Standard

Standard Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems[1]

This standard is issued under the fixed designation D 5813; 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 (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers cured-in-place thermosetting resin pipe (CIPP), 4 through 132-in. (100 through 3353-mm) equivalent diameter, for use in gravity flow systems for conveying sanitary sewage, storm water, and certain industrial wastes. This specification is suited for the evaluation and testing of materials used in the rehabilitation of existing pipes by the installation and cure of a resin-impregnated fabric liner.

1.2 This specification can also be extended to cover manholes, pump stations, wetwells, vaults, storage tanks, and other similar structures where a cured in place liner using thermosetting resin is applicable.

1.3 The values given in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

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

1.4 The following safety hazards caveat pertains only to the test methods portion, Section 8, of this specification: *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 543 Test Method for Resistance of Plastics to Chemical Reagents

D 638 Test Method for Tensile Properties of Plastics

D 695 Test Method for Compressive Properties of Rigid Plastics

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastic and Electrical Insulating Materials

D 883 Terminology Relating to Plastics

D 1600 Terminology for Abbreviated Terms Relating to Plastics

D 1682 Test Methods for Breaking Load and Elongation of Textile Fabric

D 3039/D3039M Test Method for Tensile Properties of Fiber-Resin Composites

D 3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Thermosetting Resin) Pipe and Fittings

D 3681 Test Method for Chemical Resistance of "Fiberglass" (Glass-Fiber Reinforced Thermosetting Resin) Pipe in a Deflected Condition

D 4814 Specification for Automotive Spark—Ignition Engine Fuel

F 412 Terminology Relating to Plastic Piping Systems

F 1216 Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

F 1743 Practice for Rehabilitation of Exisiting Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)

F 2019 Practice for Rehabilitation of Exisiting Pipelines and Conduits by Pulled-in-Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP)

3. Terminology

3.1 *General*—Definitions are in accordance with Terminologies D 883 and F 412. Abbreviations are in accordance with Terminology D 1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cured-in-place pipe (CIPP)*—hollow cylinder or shape consisting of a fabric with cured (cross-linked) thermoset resin; interior or exterior plastic tube coatings, or both, may be included; this pipe is formed within and takes the shape of an existing conduit or structure.

3.2.2 *delamination*—separation of coating or layers of the CIPP, or both.

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

[1] This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is under the direct responsibility of Subcommittee D20.23 on Reinforced Plastic Piping Systems and Chemical Equipment.

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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.

3.2.4 *fabric tube*—a flexible material formed into a tubular shape which during the installation process is saturated with resin and holds the resin in place during the cure.

3.2.5 *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.

3.2.6 *lift*—a portion of the CIPP that has pulled away from the existing conduit wall and formed a reverse (inward) curvature of the CIPP relative to the existing conduit.

3.2.7 *partially deteriorated pipe*—the original pipe can support the soil and live 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 some distortion of the diameter.

3.2.8 *qualification test*—one or more tests used to prove the design of a product; not a routine quality control test.

3.2.9 *quality assurance test*—one or more tests used to verify the physical properties of the CIPP.

3.2.10 *quality control test*—one or more tests used by the manufacturer of the tube during manufacture or assembly.

3.2.11 *tube coating*—a plastic coating on the outside or inside surface, or both, of the fabric tube.

4. Classification

4.1 *Types of CIPP*:

4.1.1 *Type I*—Designed to provide chemical resistance and prevent exfiltration.

4.1.2 *Type II*—Installed in a partially deteriorated existing pipe or structure and is designed to provide chemical resistance, prevent exfiltration and infiltration, and support the external hydrostatic loads due to groundwater only (and internal vacuum, where applicable), since the soil and live loads can be supported by the original conduit or structure.

4.1.3 *Type III*—Installed in a fully deteriorated existing pipe or structure and designed to provide chemical resistance, prevent exfiltration and infiltration, and support all external hydraulic, soil, and live loads acting on the original conduit or structure.

4.2 *Grades of CIPP*:

4.2.1 *Grade 1*—Thermosetting polyester resin.

4.2.2 *Grade 2*—Thermosetting polyester resin.

4.2.3 *Grade 3*—Thermosetting epoxy resin.

NOTE 2—For the purposes of this specification, polyester includes vinyl ester resins.

NOTE 3—The purchaser should determine or consult the manufacturer for the proper type and grade CIPP to be used under the installation and operation conditions that will exist for the project in which the pipe/structure is to be used.

5. Materials and Manufacture

5.1 *General*—The resins, fabric tube, tube coatings, fillers, and other materials, when combined as a composite structure, shall produce a pipe/structure that meets the requirements of this specification.

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

5.2.1 *Resin*—A thermosetting polyester or epoxy resin.

5.2.2 *Fabric Tube*—This tube shall consist of one or more layers of fabric that are compatible with the resin system used and are capable of supporting and carrying resin. The tube should be capable of withstanding installation procedures and curing temperatures. Longitudinal and circumferential joints between multiple layers of a tube should be staggered to not overlap. The tube shall be fabricated to fit its final in-place position in the original conduit, with allowance for stretch as recommended by the tube manufacturer.

5.2.2.1 *Tube Coating*—The inside or outside surface, or both, of the fabric tube may be coated with a plastic flexible material that is compatible with the tube and the resin system used. The coating shall allow visual inspection of the proper impregnation of the tube fabric with resin.

5.2.3 *Filler*—An additive which alters the thixotropic or physical properties, or both, of a resin, and when incorporated into the CIPP will not detrimentally affect its ability to meet the requirements of this specification.

6. *Requirements* Requirements

6.1 *Fabric Tube Strength*—The fabric tube, as a quality control test, when tested in accordance with 8.4 shall have a minimum tensile strength of 750 psi (5 MPa) in both the longitudinal and transverse directions.

6.2 *Workmanship*—After installation, Types I, II, and III CIPP shall be free of dry spots, lifts, delamination of any CIPP layers or tube coating. If any of these conditions are present, repair the CIPP in these areas with materials compatible with the resin system and fabric tube and in a manner acceptable to the purchaser, or replace the CIPP so that it meets the requirements of these specifications.

6.3 *Dimensions*:

6.3.1 *Pipe Diameters*—Due to diametric shrinkage of the CIPP during cure, the minimum allowable outside diameter of Types I, II, and III CIPP should be 98 % of the inside diameter of the host or mold pipe used for sampling, when measured in accordance with 8.1.1.

6.3.2 *Lengths*—Types I, II, and III CIPP shall be designed to extend the full length of the existing pipe between the access points after installation and curing, unless otherwise required. The cured CIPP may be cut to project beyond the ends of the existing pipe as required by the owner.

6.3.3 *Wall Thickness*—The average wall thickness of Types I, II, and III CIPP shall not be less than the specified thickness. The minimum wall thickness at any point shall not be less than 87.5 % of the specified thickness when measured in accordance with 8.1.2.

6.4 *Chemical Resistance Requirements*:

6.4.1 Specimens of each grade for use in sewer applications shall be evaluated in a laminate form by qualification test in accordance with 8.2.1. The specimens shall be capable of exposure to the solutions in Table 1 at a temperature of 73.4 ± 3.6°F (23 ± 2°C) with a percentage retention of flexural modulus of elasticity, when tested in accordance with 8.3, of at least 80 % after one-year exposure. Flexural properties after exposure to the chemical solution shall be based on the dimensions of the specimen after exposure.

6.4.2 Specimens of each grade used in sanitary sewers shall be evaluated by qualification test in accordance with 8.2.2 at a

TABLE 1 Chemical Resistance Test Solutions

Chemical Solution	Grade 1	Grade 2 / Grade 3
Nitric acid, 1.0%	Yes	Yes
Sulfuric acid, 5.0%	Yes	Yes
ASTM Fuel C[A], 100%	Yes	Yes
Sodium Hydroxide, 0.5%	Not Recommended	Yes
Vegatable oil (cottenseed, corn, or mineral oil), 100%	Yes	Yes
Detergent[B], 0.1%	Yes	Yes
Soap[B], 0.1%	Yes	Yes

[A] In accordance with Specification D 4814.
[B] In accordance with Test Method D 543.

temperature of 73.4 ± 3.6°F (23 ± 2°C). The specimens shall be capable of being deflected to meet the strain requirements of 8.2.2 without failure when exposed to 1.0 *N* sulfuric acid solution.

6.4.3 For more specific service environments, such as industrial applications, CIPP specimens shall be tested in accordance with 8.2.1, and a suitable resin may be selected by agreement between the manufacturer and the purchaser.

6.5 *Physical Properties*—Types I, II, and III field-cured CIPP specimens when tested for quality assurance in accordance with 8.3 shall have minimum flexural modulus of elasticity of 250 000 psi (1724 MPa), minimum flexural strength of 4500 psi (31 MPa), and a minimum tensile strength of 2500 psi (17 MPa), or as specified, whichever is greater.

7. Sampling

7.1 *Production Tests*—The CIPP sample shall be tested as to the conformance of the material to the workmanship, dimensional, and flexural requirements of 6.1, 6.2, and 6.4.

7.2 *Sampling Techniques*:

7.2.1 For each CIPP length designated by the purchaser, CIPP samples shall be prepared in accordance with 8.1.1 of Practice F 1216.

7.2.2 In large-diameter applications and areas with limited access, CIPP samples shall be prepared in accordance with 8.1.2 of Practice F 1216.

7.2.3 For CIPPs reinforced with oriented continuous or discontinuous fibers with a modulus >3 × 10^6 psi (>20 GPa), CIPP samples shall be prepared in accordance with 8.1.2 of Practice F 1216.

7.3 *Qualification Tests*—Sampling for qualification tests is not required unless otherwise agreed upon between the purchaser and the supplier. These tests include the chemical requirements test in 6.4. For qualification tests, a certification and test report for any given combination of fabric tube type, resin grade, and filler shall be furnished when requested by the purchaser.

8. Test Methods

8.1 *Dimensions*:

8.1.1 *Diameter*—Take outside diameter measurements in accordance with Practice D 3567 of samples prepared in accordance with 7.2.

8.1.2 *Wall Thickness*—Take wall thickness measurements in accordance with Practice D 3567 for samples prepared in accordance with 7.2. 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. Calculate the average thickness using all measured values.

8.2 *Chemical Tests*:

8.2.1 Test the CIPP in accordance with the testing procedures of Test Method D 543. The edges of the test specimens shall be cut, left exposed, and not treated with resin.

8.2.2 In accordance with Test Method D 3681, test four specimens each at the 10 and 10 000-h minimum strains, and test five specimens each at the 100 and 1000-h minimum strains given in Table 2. Consider the product qualified if all 18 specimens are tested without failure for at least the prescribed times given in Table 2 (that is 10, 100, 1000, and 10 000 h, respectively).

8.2.2.1 Apply force to each test specimen within the pipe apparatus with a properly calibrated compression testing machine of the constant cross-rate-of-crosshead movement type in accordance with Test Method D 695. The rate of head approach shall not exceed 0.5 in./min (12.5 mm/min). When the required deflection is reached, maintain the load for a period of at least 5 min before locking the apparatus to maintain the specimen in the deflected position. Disengage the testing machine and transfer the test apparatus to the test area.

8.3 *Physical Properties*:

8.3.1 For flexural and tensile properties of samples prepared in accordance with 7.2.1 and 7.2.2, the full structural 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 specimen 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.

8.3.2 Flexural properties shall be determined in accordance with Test Methods D 790 (Test Method I—Procedure A) for samples prepared in accordance with 7.2.1 and 7.2.2 with the following exceptions:

8.3.2.1 For specimens greater than ½ in. (12.70 mm) in depth, the width-to-depth ratio of the specimen shall be increased to a minimum of 1:1 and shall not exceed 4:1.

8.3.2.2 For samples prepared in accordance with 7.2.1, determine flexural properties in the axial direction where the length of the test specimen is cut along the longitudinal axis of the sample.

TABLE 2 Strain Corrosion Requirements

Time	Minimum Strain, %[A]
10 h	0.72
100 h	0.69
1000 h	0.67
10 000 h	0.64

[A] The strain levels listed in this table were selected to provide reasonable assurance that the minimum strength of CIPP materials will be 1.5 times a service strain level of 0.40 %.

8.3.2.3 For samples prepared in accordance with 7.2.1, orient specimens on the testing machine with the interior surface of the CIPP in tension.

NOTE 4—For samples prepared in accordance with 7.2.1, the requirements of 8.3.2 and 8.3.3 involve the flexural and tensile testing of curved specimens which are the exceptions to Test Methods D 638 and D 790. Both flat and curved specimens have been tested with no statistical differences among the test results. Note that samples prepared in accordance with 7.2.2 and 7.2.3 are flat samples.

8.3.3 Tensile properties shall be determined in accordance with Test Method D 638 for samples prepared in accordance with 7.2.1 and 7.2.2. Specimens shall be prepared in accordance with Type I, II, and III of Fig. 1 in Test Method D 638. The following exceptions apply to Test Method D 638:

8.3.3.1 For CIPP samples greater than 0.55 in. (14 mm) thick, maintain all dimensions for a Type III specimen of 0.55 in. thick except the specimen thickness shall equal the CIPP sample thickness.

8.3.3.2 For samples prepared in accordance with 7.2.1, determine tensile properties in the axial direction where the length of the test specimen is cut along the longitudinal axis of the sample.

8.3.4 *For Samples Prepared in Accordance with 7.2.3*:

8.3.4.1 Tensile properties shall be determined in accordance with Test Method D 3039 along both axes (longitudinal and transverse) of the sample.

8.3.4.2 Flexural properties shall be determined in accordance with 8.3.2 along both axes (longitudinal and transverse) of the sample.

8.4 *Fabric Tube Tensile Properties*—Tensile properties of the fabric tube material shall be determined in accordance with Test Method D 1682 for both the longitudinal and the circumferential (transverse) directions.

9. Keywords

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