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An American National Standard

Standard Specification for Cured-in-Place Pipe Lining System for Rehabilitation of Metallic Gas Pipe[1]

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1. Scope

1.1 This specification covers requirements and method of testing for materials, dimensions, hydrostatic burst strength, chemical resistance, adhesion strength and tensile strength properties for cured-in-place (CIP) pipe liners installed into existing metallic gas pipes, ¾ to 48 in. nominal pipe size, for renewal purposes. The maximum allowable operating pressure (MAOP) of such renewed gas pipe shall not exceed a pressure of 300 psig (2060 kPa). The cured-in-place pipe liners covered by this specification are intended for use in pipelines transporting natural gas, petroleum fuels (propane-air and propane-butane vapor mixtures), and manufactured and mixed gases, where resistance to gas permeation, ground movement, internal corrosion, leaking joints, pinholes, and chemical attack are required.

1.2 The medium pressure (up to 100 psig) cured-in-place pipe liners (Section A) covered by this specification are intended for use in existing structurally sound or partially deteriorated metallic gas pipe as defined in 3.2.10. The high pressure (over 100 psig up to 300 psig) cured-in-place pipe liners (Section B) covered by this specification are intended for use only in existing structurally sound steel gas pipe as defined in 3.2.10. CIP liners are installed with limited excavation using an inversion method (air or water) and are considered to be a trenchless pipeline rehabilitation technology. The inverted liner is bonded to the inside wall of the host pipe using a compatible adhesive (usually an adhesive or polyurethane) in order to prevent gas migration between the host pipe wall and the CIP liner and, also, to keep the liner from collapsing under its own weight.

1.2.1 Continued growth of external corrosion, if undetected and unmitigated, could result in loss of the host pipe structural integrity to such an extent that the liner becomes the sole pressure bearing element in the rehabilitated pipeline structure. The CIP liner is not intended to be a stand-alone pipe and relies on the structural strength of the host pipe. The operator must maintain the structural integrity of the host pipe so that the liner does not become free standing.

1.3 MPL CIP liners (Section A) can be installed in partially deteriorated pipe as defined in 3.2.10. Even for low pressure gas distribution systems, which typically operate at less than 1 psig, MPL CIP liners are not intended for use as a stand-alone gas carrier pipe but rely on the structural integrity of the host pipe. Therefore, the safe use of cured-in-place pipe lining technology for the rehabilitation of existing cast iron, steel, or other metallic gas piping systems, operating at pressures up to 100 psig, is contingent on a technical assessment of the projected operating condition of the pipe for the expected 30 to 50 year life of the CIP liner. Cured-in-place pipe liners are intended to repair/rehabilitate structurally sound pipelines having relatively small, localized defects such as localized corrosion, welds that are weaker than required for service, or loose joints (cast iron pipe), where leaks might occur.

1.3.1 HPL CIP liners (Section B) are intended for use only in existing structurally sound steel gas pipe as defined in 3.2.10. HPL CIP liners are not intended for use as a stand-alone gas carrier pipe but rely on the structural integrity of the host pipe. Therefore, the safe use of cured-in-place pipe lining technology for the rehabilitation of existing steel gas piping systems, operating at pressures up to 300 psig, is contingent on a technical assessment of the projected operating condition of the pipe for the expected 30 to 50 year life of the CIP liner.

1.4 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *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.*

1.6 *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.*

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[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.60 on Gas.

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D763 Specification for Raw and Burnt Umber Pigments

D883 Terminology Relating to Plastics

D1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure

D1600 Terminology for Abbreviated Terms Relating to Plastics

D1763 Specification for Epoxy Resins

D2240 Test Method for Rubber Property—Durometer Hardness

D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

D3167 Test Method for Floating Roller Peel Resistance of Adhesives

D3892 Practice for Packaging/Packing of Plastics

D4814 Specification for Automotive Spark-Ignition Engine Fuel

D4848 Terminology Related to Force, Deformation and Related Properties of Textiles

D4850 Terminology Relating to Fabrics and Fabric Test Methods

F412 Terminology Relating to Plastic Piping Systems

2.2 *Other Standards:*

CFR 49 Part 192 [3]

3. Terminology

3.1 *General*—Definitions are in accordance with those set forth in Terminologies D123, D883, D4848, D4850, and F412. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *adhesive system*—the adhesive system is typically a two-part adhesive or polyurethane consisting of a resin and a hardener. The flexible tubing, after wet-out, is inserted into the pipeline to be rehabilitated using an inversion method. After the inversion is complete, the adhesive is cured using either ambient or thermal processes.

3.2.2 *cleaned pipe*—pipe whose inside wall, that which is bonded to the CIP pipe liner, has been cleaned down to bare metal and is free of tars, pipeline liquids, oils, corrosion by-products, and other materials that could impair the bonding of the liner to the pipe wall.

3.2.3 *composite*—the composite is the combination of the cured adhesive system, the elastomer skin, and the jacket.

3.2.4 *elastomer skin*—the elastomer skin is a membrane, typically made of polyurethane or polyester, allowing for both inversion of the liner during the installation process and pressure tight in-service operation. When the flexible tubing is inverted into the pipeline to be rehabilitated, the elastomer skin becomes the inside surface of the newly rehabilitated pipeline, directly exposed to the gas being transported.

3.2.5 *expansion ratio table*—a table of measured diameters of the flexible tubing at increments of pressure, supplied by the manufacturer. The expansion ratio is used to calculate the pressure required to fit the flexible tubing against the pipe wall and to determine the applicable range of pipe I.D. for a given diameter flexible tubing.

3.2.6 *flexible tubing*—the flexible tube is the tubing material inverted into the host pipe and is used to carry and distribute the adhesive. For a two-component system, the flexible tubing consists of a cylindrical jacket coated with an elastomer skin. For a three-component system, it is the same as the elastomer skin.

3.2.7 *high-pressure liner (HPL)*—a CIP liner only intended for structurally sound steel pipe in sizes 4 in. and larger with an MAOP greater than 100 psig up to 300 psig. High pressure liners (HPL) are only intended for steel pipe that has a maintained cathodic protection system with annual reads per local codes, such as CFR 49 Part 192, and other mandated maintenance, such as leak surveys. The PDB testing conducted on high pressure liners is intended for the extreme case if holes occur in the steel pipe that are not detected by the cathodic protection maintenance system. Corrosion monitoring per CFR 49 Part 192 shall be conducted annually to track changes in required readings and confirm there is no active corrosion

3.2.8 *jacket*—the jacket is a textile product that is manufactured into a cylindrical form. It is made of synthetic materials, typically polyester, and provides the tensile strength and flexibility necessary to resist the specified sustained pressure when installed in partially deteriorated pipe as defined in 3.2.10.

3.2.9 *medium-pressure liner (MPL)*—a CIP liner intended for all types of structurally sound or partly deteriorated metal pipes and for all applicable sizes of pipe with an MAOP of 100 psig or less. MPL liners are relatively flexible.

3.2.10 *partially deteriorated metallic pipe*—pipe that has either been weakened or is leaking because of localized corrosion, welds that are weaker than required for service, deteriorated joints (cast iron), etc. Partially deteriorated pipe can support the soil and internal pressure throughout the design life of the composite except at the relatively small local points identified above.

3.2.11 *three-component system*—a CIP pipe lining system comprised of three separate components, which are the elastomer skin, the jacket, and the adhesive.

3.2.12 *two-component system*—a CIP pipe lining system comprised of two separate components, which are the flexible tube and the adhesive.

3.2.13 *wet-out*—the process of placing the adhesive system into the flexible tubing and uniformly distributing it prior to the inversion process.

[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] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.

4. Materials

4.1 The materials shall consist of the flexible tubing, jacket, and the adhesive system. The combination of materials used in both the flexible tubing and the adhesive system shall depend on the desired design characteristics of the composite. All materials shall be compatible for natural gas service. Because CIP pipe liners are both multi-component and multi-material systems, it becomes necessary to specify minimum material performance requirements for the liner composite rather than specific material testing requirements for the individual components. These requirements are outlined in Section 5.

4.1.1 *Flexible Tubing*—For a two-component system, the flexible tubing consists of a jacket with an elastomer skin that functions as a gas barrier. For a three-component system, the elastomer skin is the flexible tubing. The elastomer skin in both systems is typically made of polyurethane or polyester. The flexible tubing is fit tightly against the inner surface of the existing pipe by diametrical expansion using air or water pressure and bonded to the inner pipe wall with an adhesive.

4.1.2 *Jacket*—The jacket is made of polyester or other synthetic materials compatible with the application. The jacket provides the necessary strength to the composite to meet the required design characteristics, for example, resistance to internal and external pressure, resistance to earth movement, and diametrical expandability.

4.1.3 *Elastomer Skin*—The elastomer skin holds the adhesive system inside the flexible tubing during the wet-out, inversion, and curing. During the inversion and curing, the elastomer skin holds the air, water, or steam pressure inside the flexible tubing. When the flexible tubing is inverted into the existing pipe, the elastomer skin becomes the inside surface of the lined pipe. Upon completion of the installation, the elastomer skin is directly exposed to the gas being transported and forms a gas barrier. The elastomer skin shall have a high chemical resistance to the materials it is in contact with as defined in 5.1.3. For two-component systems, the elastomer skin is extruded or otherwise placed on the outside of the jacket during the manufacture of the flexible tubing.

4.1.4 *Adhesive System*—The adhesive is a two-part system composed of a resin and a hardener. The adhesive formulation can be modified as necessary to meet the curing time, strength, and application requirements specified for the lining installation. The cured adhesive system, in combination with the flexible tubing, forms the composite. Either ambient or thermal curing of the adhesive system may be used.

5. Requirements

5.1 *Jacket and Elastomer Skin (Pre-Installation):*

5.1.1 *Workmanship*—Both the jacket and the elastomer skin shall be free from defects such as tears, bubbles, cracks, and scratches that could cause the liner to not be able to hold inversion and expansion pressures and, therefore, fail during installation. For two-component systems, the flexible tubing shall be rolled onto a reel designed to provide protection during shipping and handling. For three-component systems, the elastomer skin shall be rolled onto reels designed to provide protection during shipping and handling. The jacket may either be rolled onto reels or folded into boxes.

5.1.2 *Dimensions*—An expansion ratio table, as defined in 3.2.5, including nominal size and length, shall be attached to each roll of flexible tubing or jacket and elastomer skin prior to shipment from the manufacturer. All material dimensions and physical properties must at least meet the minimum specifications, requirements, or tolerances assumed in establishing the strength tests under Section 6.

5.1.3 *Chemical Resistance*—The jacket and the elastomer skin materials shall be compatible with the liquids listed in Table 1 and tested in accordance with Practice D543, Practice A, Procedure I. Neither tensile strength nor elongation of any of the components shall change more than 20 %. Weight of the test specimen after testing shall not have increased by more than 14 % or decreased by more than 3 %. This test shall be a qualification test to be performed once for each class or pressure rating of installed pipe liner.

NOTE 1—These tests are only an indication of what will happen as a result of short-term exposure to these chemicals. For long-term results, additional testing is required.

5.1.4 *Elastomeric Peeling Strength*—The peeling strength between the jacket and the elastomer skin shall meet or exceed 7.0 lb/in. (1.2 kg/cm) when measured in accordance with Test Method D3167.

5.1.5 *Physical Properties*—For two-component systems, the design pressure of the flexible tubing shall be sufficient to withstand the required installation, testing, and operating pressures and to form the required composite. For three-component systems, the design pressure of the elastomer skin

TABLE 1 Chemical Resistivity List of Reagents

Liquids	Test Composition
Water (External and Internal)	Freshly prepared distilled water (in accordance with Practice D543)
Gasoline (External)	Gasoline-Automotive Spark-Ignition Engine Fuel per Specification D4814
Gas Condensate (Internal)	70 % volume isooctane + 30 % volume toluene
Methanol	20 % volume methanol + 80 % volume distilled water
Triethylene Glycol	10 % volume triethylene glycol + 90 % volume distilled water
Brine Solution	10 % mass NaCl solution made up with a balance of distilled water
Mineral Oil	100 % White Mineral Oil USP, specific gravity 0.830 to 0.860, Saybolt at 100°F: 125 to 135 s, in accordance with Practice D543
Isopropanol	10 % volume isopropanol + 90 % volume distilled water
Sulfuric Acid	5 % weight (of total solution) H_2SO_4 in distilled water
Surfactants	5 % mass (of solution weight) dehydrated pure white soap flakes (dried 1 h at 105°C) dissolved in distilled water, in accordance with Practice D543
Mercaptans	2 % volume tertiary butyl mercaptan + 98 % volume mineral oil, white, USP