Internal Pipe Technologies
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Abilene, TX 79602

SPECIFICATIONS AND PROPERTIES OF INTERNAL PIPE TECHNOLOGIES (IPT) CURED-IN-PLACE PIPE (CIPP) LINING SYSTEM

Internal Pipe Technologies (IPT) is the leading manufacturer of liners, resins, tools, and equipment for small diameter pipe rehabilitation industry. With decades of combined experience in the small diameter pipe manufacturing, IPT is continually successful in providing innovative technologies to its clients.

Internal Pipe Technologies (IPT) manufactures Cured-In-Place Pipe (CIPP) materials under the strict surveillance of the International Association of Plumbing and Mechanical Officials (IAPMO) and International Code Council Evaluation Service (ICC-ES). Two agencies audit the plant to ensure consistent quality CIPP materials are manufactured.

MATERIAL

CIPP Lateral Lining Tube:

1. The lateral tube manufactured by IPT will consist of one or more layers of flexible needled felt or an equivalent nonwoven material, capable of carrying resin, withstanding installation pressures, and curing temperatures. The tube will be continuous in length, and wall thickness shall be uniform. Overlapping sections shall be allowed in the length of the lateral liner. The tube will be capable of conforming to offset joints, bells, 45° bends, 90° bends, and deteriorated pipe sections.
2. The fabric tube outer layer will have an impermeable flexible plastic film that is compatible with the resin. The plastic film will contain the resin during and after fabric tube impregnation.
3. The fabric tube will have an inflatable bladder inside; the bladder will be made from materials compatible with the felt and resin systems and will withstand the required installation pressure. The bladder will not absorb resin and is capable of being removed from the CIPP.
4. The CIPP lateral liner installation will be accomplished remotely using cables to pull the product into place and filled with air or hot water for curing. The CIPP will tightly fit the internal circumference of the original pipe. The cured-in-place pipe shall provide a smooth bore interior and shall conform to the existing pipe.

5. This specification references the American Society for Testing and Materials (ASTM) standards that are made a part hereof by reference and shall be the latest edition and revision.

    - D543 Testing Method of Plastics to Chemical Reagents.
    - D638 Standard Test Method for Tensile Properties of Plastics.
    - D790 Test Methods for Flexural Properties of Un-reinforced and Reinforced Plastics.
    - F1216 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube.
    - F1743 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured –in- Place Thermosetting Resin Pipe (CIPP).

6. IPT CIPP is Compliant with the following codes:

    - Uniform Plumbing Code (UPC).
    - International Plumbing Code (IPC).
    - International Residential Code (IRC).
    - National Plumbing Code of Canada (NPC).

Resin:

1. The epoxy and hardener manufactured by IPT to impregnate the fabric tube shall produce a cured tube that shall be resistant to shrinkage, shall not corrode or oxidize, and shall also be resistant to abrasion from solids.
2. The resin shall have proven resistance to ultra-violet light (sunlight) at any stage prior to installation.
3. The resin shall be an epoxy resin and shall be solvent-free.
4. The resin system proposed shall not contain silicones, stearates, and/or natural waxes that would adversely affect the adhesives properties or any other chemical or physical properties of the CIPP liner.

CIPP Properties:

1. The CIPP after curing shall meet the minimum structural properties listed below:

CIPP Initial Structural Properties

Property	ASTM Test Method	Minimum Value
Flexural Strength	D790	4,500 psi
Flexural Modulus	D790	250,000 psi
Tensile Strength*	D638	3,000 psi

** For pressure pipes only*

INTERNAL PIPE TECHNOLOGIES (IPT)
LIMITED CURED-IN-PLACE PIPE MATERIALS WARRANTY

Internal Pipe Technologies ("IPT") manufactures Cured-In-Place Pipe Materials under the strict surveillance of the International Association of Plumbing and Mechanical Officials (IAPMO) and International Code Council Evaluation Service (ICC-ES). IPT warrants the cured-in-place pipe materials (the "Materials") when properly maintained and installed by the Customer ("Customer"). Will be free from defects in material and workmanship for ten (10) years from the date of delivery to IPT's Customer or delivery to such other party as IPT's Customer may direct. IPT warrants to Customer that, when installed in accordance with applicable IPT Standard Operating Procedures (SOP), the Materials are manufactured and supplied to the requirements of ASTMF1216, Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube. THE FOREGOING WARRANTIES ARE THE SOLE AND EXCLUSIVE WARRANTIES GIVEN BY IPT WITH RESPECT TO THE MATERIALS AND ARE IN LIEU OF AND EXCLUDE ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, ARISING BY OPERATION OF LAW OR OTHERWISE, INCLUDING WITHOUT LIMITATION, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE WHETHER OR NOT THE PURPOSE OF USE HAS BEEN DISCLOSED TO IPT, AND WHETHER OR NOT THE MATERIALS ARE SPECIFICALLY DESIGNED AND OR MANUFACTURED BY IPT FOR CUSTOMER'S USE OR PURPOSE. Customer assumes all other responsibility and liability for any loss, damage, or injury to persons or property arising out of, connected with, or resulting from the use of the Materials, either alone or in combination with other products/components. IPT neither assumes nor authorizes any person to assume for it any other liability in connection with the sale or use of the Materials, and there is no oral agreements or warranties collateral to or affecting this warranty statement or the contract to which this warranty statement is incorporated. No claim by Customer alleging defects with respect to the Materials provided hereunder shall be valid unless reasonably verified by IPT to have resulted from a defect covered hereunder.

The warranties contained herein do not extend to any losses or damages due to acts of God, misuse, accident, abuse, neglect, normal wear and tear, corrosion, abrasion, use of unsuitable lubricants, negligence (other than IPT's), modification, or alteration not performed by IPT, improper installation, improper repair, improper handling, or improper application, improper or insufficient maintenance, storage outside of the recommended temperature range, infringement of a third party's intellectual property rights, or IPT's reliance on the drawings, specifications, samples, descriptions and or other requirements, including performance specifications, provided to IPT by Customer or at Customer's direction or on Customer's behalf, or any other cause, not the fault of IPT (collectively, the "Warranty Exclusions"). Without limiting any installation requirements, the Customer must only install the Materials in gravity-fed pipes no deeper than the depth approved by a certified engineer licensed to make such determinations (or such greater depth as may be approved in advance by IPT). The pipe must consist of normal, standard sanitary sewer flow. The installation and operation of the Materials must be consistent with technicians using the approved method of Cured-in-Place installation by IPT and, when not in conflict, consistent with industry practice. The occurrence of any of the Warranty Exclusions shall render the warranties provided hereunder null and void. Customer understands and agrees that the Materials shall be used only as directed and that Customer shall not modify the Materials in any way or use the Materials in any manner other than as intended by IPT. Further, the Customer understands and agrees that any modification of the Materials or any part or portion thereof presents a severe risk of personal and property damage. If the Customer has any questions regarding this provision, the Customer should contact IPT.

IPT shall, at its sole option and as Customer's exclusive remedy for breach of any warranty provided hereunder, repair or replace the defective Materials or refund the purchase price received by IPT for the defective Materials. The correction of such defects by repair or replacement, or the refund of the purchase price for the defective Materials, shall constitute the complete fulfillment of IPT obligations to the Customer under the warranties provided herein. The term of the warranties for any Materials repaired or replaced according to these Standard Terms shall continue for the remainder, if any, of the original, defective Material's warranty period, notwithstanding the exclusive remedies provided hereunder. If ultimately determined that such remedies fail in their essential purpose. Then any action which the Customer may bring against IPT subject to this Limited Cured-in-Place Pipe Materials Warranty will be limited to 100% of the purchase price received by IPT for such portion of the Materials for which the exclusive remedy has so failed. IPT assumes no responsibility and shall have no liability for any repairs or replacements by Customer without IPT's prior written authorization (including, without limitation, the costs of removing or segregating any defective Materials so that the Customer can make the repairs or replacements).

IAPMO RESEARCH AND TESTING, INC.

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ANSI ACCREDITED
ISO/IEC 17065
Product Certification Body
#0202

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CERTIFICATE OF LISTING

UPC C ®

IAPMO Research and Testing, Inc. is a product certification body which tests and inspects samples taken from the supplier's stock or from the market or a combination of both to verify compliance to the requirements of applicable codes and standards. This activity is coupled with periodic surveillance of the supplier's factory and warehouses as well as the assessment of the supplier's Quality Assurance System. This listing is subject to the conditions set forth in the characteristics below and is not to be construed as any recommendation, assurance or guarantee by IAPMO Research and Testing, Inc. of the product acceptance by Authorities Having Jurisdiction.

Issued To:

INTERNAL PIPE TECHNOLOGIES (IPT)

1001 ENERGY DR. ABILENE, TX 79602 , United States

Product:

Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

Products are in compliance with the following code(s):
Uniform Plumbing Code (UPC®)

Products are in compliance with the following standard(s)
ASTM F1216-2016

File Number: 12950

Effective Date: February 2021

Void After: February 2026*

Tim Collings
Chairman, Product Certification Committee

IAPMO RESEARCH AND TESTING, INC. NON-PROFIT CORPORATION CALIFORNIA

Chief Technical Service Officer

*This certificate is not evidence of current listing. To verify listing status, visit the IAPMO R&T Product Listing Directory at pld.iapmo.org

This listing period is based upon the last date of the month indicated on the Effective Date and Void After Date shown above. Any change in material, manufacturing process, marking or design without having first obtained the approval of the Product Certification Committee, or any evidence of non-compliance with applicable codes and standards or of inferior workmanship, may be deemed sufficient cause for revocation of this listing. Production of or reference to this form for advertising purposes may be made only by specific written permission of IAPMO Research and Testing, Inc. Any alteration of this certificate could be grounds for revocation of the listing. This document shall be reproduced in its entirety.

IAPMO RESEARCH AND TESTING, INC.

CERTIFICATE OF LISTING

Issued To: INTERNAL PIPE TECHNOLOGIES (IPT)

Effective Date: February 2021

File Number: 12950

Product: Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

Void After: February 2026

This certificate is not evidence of current listing.To verify listing status, visit the IAPMO R&T Product Listing Directory at pld.iapmo.org

Identification:
Manufacturer's name or trademark, model description of woven or nonwoven material, and associated thermosetting resin shall bear the cUPC® certification mark.

Characteristics:
Materials for the reconstruction of pipeline and conduits (3 to 108-in diameter) by the installation of a resin impregnated flexible tube which is inserted into the existing conduit by use of a hydrostatic head of air pressure. For replacement of existing sewers only. To be installed in accordance with the manufacturer's instructions and the requirements of the latest edition of the Uniform Plumbing Code.

Products listed on this certificate have been tested by an IAPMO R&T recognized laboratory. This recognition has been granted based upon the laboratory's compliance to the applicable requirements of ISO/IEC 17025.

IAPMO RESEARCH AND TESTING, INC.

CERTIFICATE OF LISTING

Issued To: INTERNAL PIPE TECHNOLOGIES (IPT)

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Models

Model Number	Description
IPT-B100	Base Resin Part A
IPT-M102	Medium Catalyst Part B

ICC-ES PMG Product Certificate

PMG-1609

Effective Date: December 2020

This listing is subject to re-examination in one year.

www.icc-es-pmg.org | (800) 423-6587 | (562) 699-0543 *A Subsidiary of the International Code Council®*

CSI: DIVISION: 22 00 00—PLUMBING
Section: 22 13 16—Sanitary Waste and Vent Piping

Product certification system:

The ICC-ES product certification system includes testing samples taken from the market or supplier's stock, or a combination of both, to verify compliance with applicable codes and standards. The system also involves factory inspections, and assessment and surveillance of the supplier's quality system.

Product: IPT® CIPP Lining System

Listee: Internal Pipe Technologies (IPT)
1001 Energy Dr.
Abilene TX 79602

Compliance with the following codes:

2021, 2018, 2015, 2012 and 2009 *International Plumbing Code*® (IPC)
2018, 2015, 2012 and 2009 *International Residential Code*® (IRC)
2021, 2018, 2015 and 2012 *Uniform Plumbing Code*® (UPC)*
2015 and 2010 *National Plumbing Code of Canada*® (NPC)**

**Uniform Plumbing Code is a copyrighted publication of the International Association of Plumbing and Mechanical Officials*
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Compliance with the following standards:

ASTM F1216-2016, Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of Resin-Impregnated Tube, ASTM International.
NSF/ANSI 14-2019, Plastic Piping System Components and Related Materials, National Sanitation Foundation.
ICC-ES LC1011 (October 2010), PMG Listing Criteria for the Rehabilitation of Existing Building Drains and Building Sewers by the Inversion and Curing of Resin-impregnated Tube.

Identification:

IPT® CIPP Lining System; model number IPT-B100 & IPT-M102 Each container bears a label marked model number, with the manufacturer's name (IPT®), ICC-ES PMG listing mark. Each container is stamped on the top with the date of manufacture and the batch number.

Installation:

Installation must comply with the manufacturer's published installation instructions and the applicable codes.

The IPT® Cured-in-place pipe (CIPP) Lining System must be applied by installers trained and certified by IPT. The following steps comprise installation sequence

1. Determine the liner thickness, diameter and length needed for the pipe rehabilitation.
2. Cut the liner tube to the desired length.
3. Cut the rubber bladder 16 inches longer than the length of the liner tube.
4. Cut the plastic tube at least 56 inches longer than the length of the liner tube.
5. With pull-end and "air-fill" fitting attached to air hose, pull air hose through the rubber tube using string inside the rubber tube.
6. Secure rubber tube to pull-end with two band-it clamps and electrical tape.
7. From the other end of the rubber tube, pull air hose so it straight inside the rubber bladder; secure this end of the rubber tube to the air hose with two band-it clamps and electrical tape.
8. Inversion tank is prepared with the plastic tubing.
9. Scan one of the QR Codes on the liner to quickly and accurately provide to the installer, the weight of epoxy and catalyst needed for the length of the liner and thickness.
10. Weigh into a clean mixing pail, the weight of Part A needed for the liner. Into the same pail with Part A, add the weight of Part B needed for the liner. Part A and B are mixed for approx. two minutes or until the mixture is homogeneous.
11. Immediately after mixing, pour the mixed epoxy into the liner tube.
12. Using two wet-out rollers, impregnate the liner tube with mixed epoxy by forcing the epoxy into the fabric material. This is done in small increments with rollers working towards each other. This will ensure the slug of epoxy is moved along the liner tube for proper impregnation. Squeeze the excess epoxy into plastic bag made of plastic tube.
13. Using the inversion tank, invert the plastic tube through the epoxy impregnated liner tube.
14. Cut the plastic tube at each end so it is 28" longer at each end of the liner tube. Do not cut the string.
15. Attach the string through the plastic tube to the pull-end and pull hose through the liner tube.
16. With electrical tape, attach the ends of the plastic tube to each end of the rubber tube
17. Fold liner and tape with low tack tape for easy insertion into pipe. Ensure the pull end is properly taped with low tack tape.
18. Install liner into place.
19. Connect air hose to compressor and inflate rubber tube. Set pressure gauge to 18psi.
20. After curing, deflate and pull rubber bladder with plastic tube using the air hose.
21. Perform a post CCTV inspection to ensure liner is properly installed. Record a video.
22. Pre-Cleaning, Pre-Lining and Post-Lining videos are part of the deliverables to the client.

Models:

IPT® Cured-in-place pipe (CIPP) Lining System: The system consists of components tested to comply with ASTM F1216 and NSF/ANSI 14. The material properties of the CIPP Lining system have been verified through testing with the result reported in Table 1. The system consists of the IPT-B100 and IPT-M102.

Table 1 – Material Properties of IPT® CIPP Lining System

Property Tested	Result (Average)
Tensile Strength (psi)	5,252
Tangent Modulus (psi)	437,600
Flexural Strength (psi)	6,668
Flexural Modulus (psi)	343,124

Conditions of listing:

1. The IPT® CIPP Lining System must be installed in accordance with this listing and the manufacturer's published installation instructions. In the event of a conflict, the instructions in this listing govern.
2. The IPT® CIPP Lining System may be used to line pipe with minimum diameter of 2 inches (50 mm) to maximum diameter of 96 inches (2400 mm).
3. The rehabilitation of existing pipe by using IPT® CIPP Lining System is suitable to be used in a variety of gravity and pressure applications such as sanitary sewers, building drains, storm sewers, process piping, electrical conduits, and ventilation systems.
4. IPT® CIPP lining System are manufactured under a quality control program with annual inspection by ICC-ES.

Designation: F1216 – 16

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 (ε) 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 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 or introducing controlled steam within the tube. When cured, the finished pipe will be continuous and tight-fitting. This reconstruction process can 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.

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 and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 7.4.2.

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:*

Manual on Cleaning and Lining Water Mains, M 28[4]

2.3 *NASSCO Standard:*

Recommended Specifications for Sewer Collection System Rehabilitation[5]

3. Terminology

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

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.

[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. 1, 2016. Published August 2016. Originally approved in 1989. Last previous edition approved 2009 as F1216 – 09. DOI: 10.1520/F1216-16.

[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, 2470 Longstone Lane, Suite M Marriottsville, MD 21104. http://www.nassco.org/

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

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.

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 should 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 should be compatible with the resin system used. The material should be able to stretch to fit irregular pipe sections and negotiate bends. The outside layer of the tube should be plastic coated with a material that is compatible with the resin system used. The 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 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 should 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 can be expected to have as a minimum the initial structural properties given in Table 1. These physical strength properties should be determined in accordance with Section 8.

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.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value	
		psi	(MPa)
Flexural strength	D790	4 500	(31)
Flexural modulus	D790	250 000	(1 724)
Tensile strength (for pressure pipes only)	D638	3 000	(21)

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

7.1.2 *Cleaning of Pipeline*—All internal debris should be removed from the original pipeline. Gravity pipes should be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment (see NASSCO Recommended Specifications for Sewer Collection System Rehabilitation). Pressure pipelines should be cleaned with cable-attached devices or fluid-propelled devices as shown in AWWA Manual on Cleaning and Lining Water Mains, M 28.

7.1.3 *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.

7.1.4 *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 will prevent the insertion of the resin-impregnated 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.

7.2 *Resin Impregnation*—The tube should be vacuum-impregnated with resin (wet-out) under controlled conditions. The volume of resin used should be sufficient to fill all voids in the tube material at nominal thickness and diameter. The volume should be adjusted by adding 5 to 10 % 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.

7.3 *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.

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 should 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 should be inserted into the vertical inversion standpipe with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the tube should be turned inside out and attached to the standpipe so that a leakproof seal is created. The inversion head should 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 should 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 1—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 should 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 should 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 should be turned inside out. The inversion air pressure should 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 should be taken during the inversion so as not to overstress the woven and nonwoven materials. **Warning—**Suitable precautions should 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.

7.5 *Lubricant*—The use of a lubricant during inversion is recommended to reduce friction during inversion. This lubricant should be poured into the inversion water in the downtube or applied directly to the tube. The lubricant used should be a nontoxic, oil-based 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 should 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 should be as recommended by the resin manufacturer.

7.6.1.1 The heat source should be fitted with suitable monitors to gage the temperature of the incoming and outgoing water supply. Another such gage should 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 should be raised to the post-cure temperature recommended by the resin manufacturer. The post-cure temperature should 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 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.

7.6.2.1 The steam-generating equipment should be fitted with a suitable monitor to gage the temperature of the outgoing steam. The temperature of the resin being cured should be monitored by placing gages 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 should be raised to post-cure temperatures recommended by the resin manufacturer. The post-cure temperature should be held for a period as recommended by the resin manufacturer, 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).

7.6.3 *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 the 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. For water or steam, 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 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 should 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 should 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 should 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 should be sealed by filling with a resin mixture compatible with the CIPP.

7.9 *Service Connections*—After the new pipe has been cured in place, the existing active service connections should be reconnected. 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.

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 the size of the host pipe.

8.1.1 For pipe sizes of 18 in. or less, the sample should 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 should 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 should 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 should 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 should be measured for gravity and pressure pipe applications in accordance with Test Methods D790 and should meet the requirements of Table 1.

8.1.3.2 *Tensile Properties*—The tensile strength should 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 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 higher than the 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 one hour.

NOTE 2—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 should 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 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 3—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 should be performed on each inversion length specified. The CIPP samples should be prepared in accordance with 8.1.2, except that a portion of the 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 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 should be a minimum of 10 lb/in. (178.60 g/mm) of width for typical CIPP applications.

NOTE 4—The purchaser may designate the dissimilar layers between which the delamination test will be conducted.

NOTE 5—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 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 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 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 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 should be made around the internal circumference of the installed CIPP within the host pipe at a distance of 12 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 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.

8.7 *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.

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 (see Note 1).

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:

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

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

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

or

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

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:

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

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:

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

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

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:

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

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.

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

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).

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

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.

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

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 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

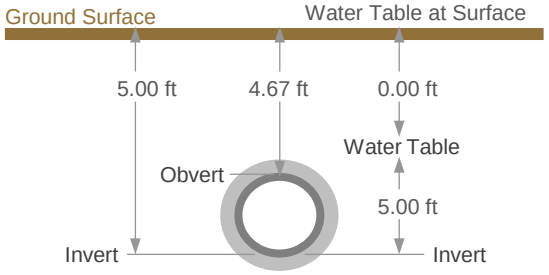
SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1217–09) that may impact the use of this standard.

(1) Revised 1.1 and Note X1.7 to include pipe diameter sizes 2-in. to 108-in.

PROJECT INFORMATION **Design Date:** May 29, 2020
Pipe Rehabilitation System

Internal Pipe Technologies (IPT) Rehabilitation System
CIPP Lateral Liner Design
Trenchless Design 4 inch



Existing Pipe: 4 in ID; Ovality: 5%
Fully Deteriorated Design
Required Liner Thickness: 1.8 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	4 in
Depth to Invert	5 ft
Water Table below Surface	0 ft
Ovality of Existing Pipe, Δ	5.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	1,000 psi
Live Load, Ws	HS-20
Other Load	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus Short-term Test, Es	250,000 psi
For 50 Year Long-term Load Use	50% of Es
Flexural Strength Short-term Test, σs	4,500 psi
For 50 Year Long-term Load Use	50% of σs
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
DESIGN BY ASTM F1216 VERSION	F1216-16

CIPP liner design by Appendix X1 method of ASTM F1216-16

KEY FACTORS: FULLY DETERIORATED CONDITION DESIGN		
Flexural Modulus, E, 50 Year Design	125,000 psi	50% of Es
Flexural Strength, σ, 50 Year Design	2,250 psi	50% of σs
Minimum Diameter for Existing Pipe	3.80 in	For 5% ovality
Maximum Diameter for Existing Pipe	4.20 in	For 5% ovality
Ovality Reduction Factor, C	0.640	For 5% ovality
Water Buoyancy Factor, Rw	0.670	Lower Limit
Coeffecient of Elastic Support, B'	0.253	
Water Pressure, Invert	2.17 psi	5.00 ft Head
Total Design Pressure at Invert	**2.17 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	2.02 psi	4.67 ft Head
Soil Pressure, Obvert	2.61 psi	4.67 ft Cover
Live Load Pressure Ws, Obvert	2.10 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure at Obvert	**6.73 psi**	**For X1.3**

NOTES: E and σ correspond with E_L and σ_L in F1216 Appendix X1
Note 1: AASHTO HS-20. Refer AWWA M11/M23/M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation		**Required t mm**	**Required t in**	**Required DR**
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater hydrostatic pressure		1.5 mm	0.060 in	66.7
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality		1.2 mm	0.048 in	83.3
X1.3: qt=[1/N] x [32 x Rw x B' x E's x C x (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads	Governs	1.8 mm	0.069 in	58.0
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum CIPP liner stiffness		1.7 mm	0.066 in	60.6
Required in Place Liner Thickness - Fully Deteriorated		**1.8 mm**	**0.069 in**	**58.0**

t in is rounded-up to 3 decimal places; t mm = t in x 25.4; DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 250000 psi (ASTM D790); σs ≥ 4500 psi (ASTM D790); Thickness ≥ 1.8 mm (ASTM D5813).
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		**FLOW COMPARISON FOR 1.8 mm LINER**	
Liner Thickness for flow comparison	1.8 mm	Inside Diameter before Lining	4.00 in
Manning n used for before lining	0.0120	Inside Diameter after Lining	3.86 in
Manning n used for after lining	0.0100	Flow Capacity after Lining	109% of before lining flow

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-16**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$ Note: E corresponds with E_L in F1216 Appendix X1

P is the maximum allowed external pressure on the liner from groundwater (or any external hydrostatic pressure)

Determine P for liner thickness of t = 0.069 in = 1.8 mm t is from summary page

K = Enhancement factor = 7 As entered

E = Design Flexural Modulus = (Flexural Modulus Short-term Test, Es) x (% of Es used for 50 Year Design E)
E = 250000 x 50% = 125000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 4/0.069 = 57.97 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 5%
C = ([1- 5/100]/[1+5/100]^2)^3 = 0.64

N = Safety Factor = 2 As entered.

$P = [2KE/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$ Note: E corresponds with E_L in F1216 Appendix X1

P = [(2 x 7 x 125000)/(1-0.3^2)] x [1/(57.97-1)^3] x [0.64/2] = 3.33 psi

Determine actual external pressure on liner, Pa

Pa = Ground water pressure, Pgw

Pgw = 0.433 x H = 0.433 x 5 ft = 2.17 psi. Where H is height of water over invert.

Pa = Pgw = 2.17 psi

Compare Pa to P

Pa, Actual external pressure on liner = 2.17 psi

P, Allowed external pressure on 0.069 in liner by Eq. X1.1= 3.33 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.069 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 57.97 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 58

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma)/(P \times N)$ Note: σ corresponds with σ_L in F1216 Appendix X1

Check X1.2 for liner thickness of t = 0.069 in = 1.8 mm t is from summary page

Δ = 5 As entered.

DR, calculated above for X1.1 = 57.97

σ = Design Flexural Strength = (Flexural Strength Short-term Test, σs) x (% of σs used for 50 Year Design σ) =4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 2.17 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

$t = [3 \times (\Delta/100) \times D] / [0.5 + \{0.25 + (6 \times (\Delta/100)) \times [\sigma/(P \times N \times (1+(\Delta/100)))]\}^{.5}]$ Note:σ corresponds with σ_L in F1216 Appendix X1

t = [3 x (5/100) x 4] / [0.5 + {0.25 + (6 x (5/100)) x [2250/(2.17 x 2 x (1+(5/100)))]}^0.5] = 0.048 in

Compare liner t to t required by Equation X1.2

Liner t:	0.069 in	t is from summary page
Required t:	0.048 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.069 in liner thickness.

Fully Deteriorated calculation details continued on next page...

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 1.8 mm LINER

Flow = Q = Area x Velocity = $[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, imperial units 1.8 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 4 in = 0.333 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 3.86 in = 0.322 ft

= {[(3.142 x (0.322^2)/4] x [(1.486/0.01)] x (0.322/4)^(2/3)} / {[(3.142 x (0.333)^2)/4] x [(1.486/0.012)] x (0.333/4)^(2/3) = 1.09

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 109% of before lining capacity.

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-16**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(EI/D^3)]^{1/2}$ F1216-07a **-** Note: E corresponds with E_L in F1216 Appendix X1

$q_t = [1/N] \times [32R_wB'E'_sC(EI/D^3)]^{1/2}$ F1216-16 **Using** Note: E corresponds with E_L in F1216 Appendix X1

Design is by F1216-16

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.069 in = 1.8 mm t is from summary page

C = Ovality Reduction Factor = 0.64 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(4.67/4.67) = 0.67 Lower Limit

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.253 Where H = 4.67 and e = 2.718

E's = Modulus of soil reaction = 1000 psi. As entered.

E = Design Flexural Modulus = 125000 psi. See calculation on previous page. Note: E corresponds with E_L in F1216 Appendix X1

I = Moment of inertia for liner = (t^3)/12 = (0.069^3)/12 = 0.00002738

D = Inside diameter of existing pipe = mean OD of liner = 4 in

qt=[1/N] x [32 x Rw x B' x E's x C x (E x I/D^3)]^(1/2) Note: E corresponds with E_L in F1216 Appendix X1

qt = [1/2] x [32 x 0.67 x 0.253 x 1000 x 0.64 x (125000 x 0.00002738/4^3)]^(1/2) = 6.81 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 4.67 = 2.02 psi Hw is water height over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 4.67 x 0.67)/144) = 2.61 psi H is soil height over top of pipe

Ws = Live load = 2.1 psi Note 1: AASHTO HS-20. Refer AWWA M11/M23/M55.

-

Wo = Other load = 0 psi, entered

qa = 2.02 + 2.61 + 2.1 + 0 = 6.73 psi -

Compare qa to qt

qa =	6.73 psi	Actual external pressure on liner
qt =	6.81 psi	Allowed external pressure for 0.069 in liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.069 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$ Note: Es corresponds with initial modulus in F1216 Appendix X1

Determine for liner thickness t of: t = 0.069 in = 1.8 mm t is from summary page

Es = Flexural Modulus short-term test = 250000 psi Note: Es corresponds with initial modulus in F1216 Appendix X1

DR = liner dimension ratio = D/t = 4 / 0.069 = 57.97

Es / (12 x (DR^3)) = 250000/(12 x 57.97^3) = 0.1069

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.069 in liner thickness

Summary of Equations for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

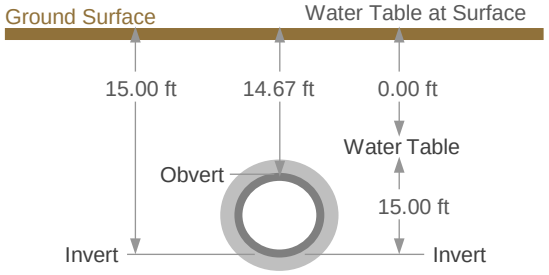
Eq X1.1	Satisfied by 0.069 in liner thickness
Eq X1.2	Satisfied by 0.069 in liner thickness
Eq X1.3	Satsified by 0.069 in liner thickness
Eq X1.4	Satisfied by 0.069 in liner thickness

Required liner thickness for fully deteriorated design is 0.069 in 1.8 mm

.

PROJECT INFORMATION **Design Date:** May 29, 2020
Pipe Rehabilitation System

Internal Pipe Technologies (IPT) Rehabilitation System
CIPP Lateral Liner Design
Trenchless Design 4 inch



Existing Pipe: 4 in ID; Ovality: 5%
Fully Deteriorated Design
Required Liner Thickness: 2.6 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	4 in
Depth to Invert	15 ft
Water Table below Surface	0 ft
Ovality of Existing Pipe, Δ	5.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	1,000 psi
Live Load, Ws	HS-20
Other Load	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus Short-term Test, Es	250,000 psi
For 50 Year Long-term Load Use	50% of Es
Flexural Strength Short-term Test, σs	4,500 psi
For 50 Year Long-term Load Use	50% of σs
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
DESIGN BY ASTM F1216 VERSION	F1216-16

CIPP liner design by Appendix X1 method of ASTM F1216-16

KEY FACTORS: FULLY DETERIORATED CONDITION DESIGN		
Flexural Modulus, E, 50 Year Design	125,000 psi	50% of Es
Flexural Strength, σ, 50 Year Design	2,250 psi	50% of σs
Minimum Diameter for Existing Pipe	3.80 in	For 5% ovality
Maximum Diameter for Existing Pipe	4.20 in	For 5% ovality
Ovality Reduction Factor, C	0.640	For 5% ovality
Water Buoyancy Factor, Rw	0.670	Lower Limit
Coeffecient of Elastic Support, B'	0.3934	
Water Pressure, Invert	6.50 psi	15.00 ft Head
Total Design Pressure at Invert	**6.50 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	6.35 psi	14.67 ft Head
Soil Pressure, Obvert	8.19 psi	14.67 ft Cover
Live Load Pressure Ws, Obvert	0.33 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure at Obvert	**14.87 psi**	**For X1.3**

NOTES: E and σ correspond with E_L and σ_L in F1216 Appendix X1
Note 1: AASHTO HS-20. Refer AWWA M11/M23/M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation		**Required t mm**	**Required t in**	**Required DR**
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater hydrostatic pressure		2.2 mm	0.086 in	46.5
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality		2.0 mm	0.080 in	50.0
X1.3: qt=[1/N] x [32 x Rw x B' x E's x C x (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads	Governs	2.6 mm	0.101 in	39.6
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum CIPP liner stiffness		1.7 mm	0.066 in	60.6
Required in Place Liner Thickness - Fully Deteriorated		**2.6 mm**	**0.101 in**	**39.6**

t in is rounded-up to 3 decimal places; t mm = t in x 25.4; DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 250000 psi (ASTM D790); σs ≥ 4500 psi (ASTM D790); Thickness ≥ 2.6 mm (ASTM D5813).
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		**FLOW COMPARISON FOR 2.6 mm LINER**	
Liner Thickness for flow comparison	2.6 mm	Inside Diameter before Lining	4.00 in
Manning n used for before lining	0.0120	Inside Diameter after Lining	3.80 in
Manning n used for after lining	0.0100	Flow Capacity after Lining	105% of before lining flow

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-16**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$ Note: E corresponds with E_L in F1216 Appendix X1

P is the maximum allowed external pressure on the liner from groundwater (or any external hydrostatic pressure)

Determine P for liner thickness of t = 0.101 in = 2.6 mm t is from summary page

K = Enhancement factor = 7 As entered

E = Design Flexural Modulus = (Flexural Modulus Short-term Test, Es) x (% of Es used for 50 Year Design E)
E = 250000 x 50% = 125000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 4/0.101 = 39.6 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 5%
C = ([1- 5/100]/[1+5/100]^2)^3 = 0.64

N = Safety Factor = 2 As entered.

$P = [2KE/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$ Note: E corresponds with E_L in F1216 Appendix X1

P = [(2 x 7 x 125000)/(1-0.3^2)] x [1/(39.6-1)^3] x [0.64/2] = 10.7 psi

Determine actual external pressure on liner, Pa

Pa = Ground water pressure, Pgw

Pgw = 0.433 x H = 0.433 x 15 ft = 6.5 psi. Where H is height of water over invert.

Pa = Pgw = 6.5 psi

Compare Pa to P

Pa, Actual external pressure on liner = 6.5 psi

P, Allowed external pressure on 0.101 in liner by Eq. X1.1= 10.7 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.101 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 39.6 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 39.6

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma)/(P \times N)$ Note: σ corresponds with σ_L in F1216 Appendix X1

Check X1.2 for liner thickness of t = 0.101 in = 2.6 mm t is from summary page

Δ = 5 As entered.

DR, calculated above for X1.1 = 39.6

σ = Design Flexural Strength = (Flexural Strength Short-term Test, σs) x (% of σs used for 50 Year Design σ) =4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 6.5 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

$t = [3 \times (\Delta/100) \times D] / [0.5 + \{0.25 + (6 \times (\Delta/100)) \times [\sigma/(P \times N \times (1+(\Delta/100)))]\}^{.5}]$ Note:σ corresponds with σ_L in F1216 Appendix X1

t = [3 x (5/100) x 4] / [0.5 + {0.25 + (6 x (5/100)) x [2250/(6.5 x 2 x (1+(5/100)))]}^0.5] = 0.08 in

Compare liner t to t required by Equation X1.2

Liner t:	0.101 in	t is from summary page
Required t:	0.080 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.101 in liner thickness.

Fully Deteriorated calculation details continued on next page...

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 2.6 mm LINER

Flow = Q = Area x Velocity = $[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, imperial units 2.6 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 4 in = 0.333 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 3.8 in = 0.317 ft

= {[(3.142 x (0.317^2)/4] x [(1.486/0.01)] x (0.317/4)^(2/3)} / {[(3.142 x (0.333)^2)/4] x [(1.486/0.012)] x (0.333/4)^(2/3) = 1.05

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 105% of before lining capacity.

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-16**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(EI/D^3)]^{1/2}$ F1216-07a **-** Note: E corresponds with E_L in F1216 Appendix X1

$q_t = [1/N] \times [32R_wB'E'_sC(EI/D^3)]^{1/2}$ F1216-16 **Using** Note: E corresponds with E_L in F1216 Appendix X1

Design is by F1216-16

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.101 in = 2.6 mm t is from summary page

C = Ovality Reduction Factor = 0.64 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(14.67/14.67) = 0.67 Lower Limit

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.3934 Where H = 14.67 and e = 2.718

E's = Modulus of soil reaction = 1000 psi. As entered.

E = Design Flexural Modulus = 125000 psi. See calculation on previous page. Note: E corresponds with E_L in F1216 Appendix X1

I = Moment of inertia for liner = (t^3)/12 = (0.101^3)/12 = 0.00008586

D = Inside diameter of existing pipe = mean OD of liner = 4 in

qt=[1/N] x [32 x Rw x B' x E's x C x (E x I/D^3)]^(1/2) Note: E corresponds with E_L in F1216 Appendix X1

qt = [1/2] x [32 x 0.67 x 0.3934 x 1000 x 0.64 x (125000 x 0.00008586/4^3)]^(1/2) = 15.04 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 14.67 = 6.35 psi Hw is water height over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 14.67 x 0.67)/144) = 8.19 psi H is soil height over top of pipe

Ws = Live load = 0.33 psi Note 1: AASHTO HS-20. Refer AWWA M11/M23/M55.

-

Wo = Other load = 0 psi, entered

qa = 6.35 + 8.19 + 0.33 + 0 = 14.87 psi -

Compare qa to qt

qa =	14.87 psi	Actual external pressure on liner
qt =	15.04 psi	Allowed external pressure for 0.101 in liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.101 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$ Note: Es corresponds with initial modulus in F1216 Appendix X1

Determine for liner thickness t of: t = 0.101 in = 2.6 mm t is from summary page

Es = Flexural Modulus short-term test = 250000 psi Note: Es corresponds with initial modulus in F1216 Appendix X1

DR = liner dimension ratio = D/t = 4 / 0.101 = 39.6

Es / (12 x (DR^3)) = 250000/(12 x 39.6^3) = 0.3355

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.101 in liner thickness

Summary of Equations for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

Eq X1.1	Satisfied by 0.101 in liner thickness
Eq X1.2	Satisfied by 0.101 in liner thickness
Eq X1.3	Satsified by 0.101 in liner thickness
Eq X1.4	Satisfied by 0.101 in liner thickness

Required liner thickness for fully deteriorated design is 0.101 in 2.6 mm

.

SAFETY DATA SHEET

Date of Issue : 07/21/2021

1. IDENTIFICATION AND COMPANY INFORMATION

Product name: Epoxy Resin IPT - B100

MANUFACTURER
INTERNAL PIPE TECHNOLOGIES
1001 Energy Drive
Abilene, TX 79602
United States

EMERGENCY TELEPHONE CONTACT
24-Hour Emergency Contact: 1-800-424-9300

2. HAZARDS IDENTIFICATION

Hazard classification
GHS classification in accordance with 29 CFR
1910.1200 Skin irritation - Category 2
Eye irritation - Category 2B
Skin sensitization - Sub-category 1B

Label elements
Hazard pictograms

Signal word: **WARNING!**

Hazards
Causes skin and eye irritation.
May cause an allergic skin reaction.

Precautionary statements

Prevention
Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
Wash skin thoroughly after handling.
Contaminated work clothing should not be allowed out of the workplace.
Wear protective gloves.

Response
IF ON SKIN: Wash with plenty of soap and water.
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
If skin irritation or rash occurs: Get medical advice/ attention.
If eye irritation persists: Get medical advice/ attention.
Take off contaminated clothing and wash before reuse.

Disposal
Dispose of contents/ container to an approved waste disposal plant.

Other hazards
No data available

3. COMPOSITION/INFORMATION ON INGREDIENTS

Synonyms: Liquid Epoxy Resin
This product is a substance.

Component	CASRN	Concentration
Propane, 2,2-bis[p-(2,3-epoxypropoxy)phenyl]-, polymers	25085-99-8	>100.0%
1,4-bis[p-(2,3-epoxypropoxy)butane	2425-79-8	>5.0%

4. FIRST AID MEASURES

Description of first aid measures
General advice:
First Aid responders should pay attention to self-protection and use the recommended protective clothing (chemical resistant gloves, splash protection).

Inhalation: Move person to fresh air; if effects occur, consult a physician.

Skin contact: Remove material from skin immediately by washing with soap and plenty of water. Remove contaminated clothing and shoes while washing. Seek medical attention if irritation persists. Wash clothing before reuse. Discard items which cannot be decontaminated, including leather articles such as shoes, belts and watchbands.

Eye contact: Flush eyes thoroughly with water for several minutes. Remove contact lenses after the initial 1-2 minutes and continue flushing for several additional minutes. If effects occur, consult a physician, preferably an ophthalmologist. Suitable emergency eye wash facility should be available in work area.

Ingestion: No emergency medical treatment necessary.

Most important symptoms and effects, both acute and delayed:
Aside from the information found under Description of first aid measures (above) and Indication of immediate medical attention and special treatment needed (below), any additional important symptoms and effects are described in Section 11: Toxicology Information.

Indication of any immediate medical attention and special treatment needed
Notes to physician: No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

5. FIREFIGHTING MEASURES

Extinguishing media

Suitable extinguishing media: Water fog or fine spray.. Dry chemical fire extinguishers.. Carbon dioxide fire extinguishers.. Foam.. Alcohol resistant foams (ATC type) are preferred. General purpose synthetic foams (including AFFF) or protein foams may function, but will be less effective.. Water fog, applied gently may be used as a blanket for fire extinguishment..

Unsuitable extinguishing media: Do not use direct water stream.. May spread fire..

Special hazards arising from the substance or mixture

Hazardous combustion products: During a fire, smoke may contain the original material in addition to combustion products of varying composition which may be toxic and/or irritating.. Combustion products may include and are not limited to:. Phenolics.. Carbon monoxide.. Carbon dioxide..

Unusual Fire and Explosion Hazards: Container may rupture from gas generation in a fire situation.. Violent steam generation or eruption may occur upon application of direct water stream to hot liquids.. Dense smoke is emitted when burned without sufficient oxygen..

Advice for firefighters

Fire Fighting Procedures: Keep people away. Isolate fire and deny unnecessary entry.. Use water spray to cool fire exposed containers and fire affected zone until fire is out and danger of reignition has passed.. Fight fire from protected location or safe distance. Consider the use of unmanned hose holders or monitor nozzles.. Immediately withdraw all personnel from the area in case of rising sound from venting safety device or discoloration of the container. Do not use direct water stream. May spread fire.. Move container from fire area if this is possible without hazard.. Burning liquids may be moved by flushing with water to protect personnel and minimize property damage.. Water fog, applied gently may be used as a blanket for fire extinguishment. Contain fire water run-off if possible. Fire water run-off, if not contained, may cause environmental damage.. Review the "Accidental Release Measures" and the "Ecological Information" sections of this SDS.

Special protective equipment for firefighters: Wear positive-pressure self-contained breathing apparatus (SCBA) and protective fire fighting clothing (includes fire fighting helmet, coat, trousers, boots, and gloves).. Avoid contact with this material during fire fighting operations. If contact is likely, change to full chemical resistant fire fighting clothing with self-contained breathing apparatus. If this is not available, wear full chemical resistant clothing with self-contained breathing apparatus and fight fire from a remote location.. For protective equipment in post-fire or non-fire clean-up situations, refer to the relevant sections..

6. HANDLING AND STORAGE

Precautions for safe handling: Avoid prolonged or repeated contact with skin. Avoid contact with eyes, skin, and clothing. Wash thoroughly after handling. Spills of these organic materials on hot fibrous insulations may lead to lowering of the autoignition temperatures possibly resulting in spontaneous combustion.

Storage stability

Storage temperature:	Shelf life: Use within
2 - 43 °C (36 - 109 °F)	24 Month

7. PERSONAL PROTECTION

Eye/face protection: Use safety glasses.

Skin protection: Use chemical resistant gloves, example butyl, nitrile, vinyl, and neoprene gloves.

Other protection: Use protective clothing chemically resistant to this material. Long sleeve shirts and apron (if necessary).

8. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	
Physical state	viscous Liquid.
Color	White
Odor	Odorless to mild
Odor Threshold	No test data available
pH	No test data available
Melting point/range	Not applicable
Freezing point	No test data available
Boiling point (760 mmHg)	320 °C (608 °F) *Differential Scanning Calorimetry (DSC)* Decomposition
Flash point	**closed cup** 264 - 268 °C (507 - 514 °F) at 102.89 hPa *EC Method A9*
Evaporation Rate (Butyl Acetate = 1)	No test data available
Flammability (solid, gas)	Not Applicable
Lower explosion limit	Not applicable
Upper explosion limit	Not applicable
Vapor Pressure	< 0.0000001 Pa *EC Method A4*
Relative Vapor Density (air = 1)	No data available
Relative Density (water = 1)	1.16 at 20 °C (68 °F) / 20 °C *Literature*
Water solubility	5.4 - 8.4 mg/l at 20 °C (68 °F) *EU Method A.6 (Water Solubility)*
Partition coefficient: n-octanol/water	log Pow: 3.242 *Estimated.*
Auto-ignition temperature	Not applicable
Decomposition temperature	> 320 °C (> 608 °F)
Dynamic Viscosity	11,000 - 14,000 mPa.s at 25 °C (77 °F) *ASTM D 445*
Kinematic Viscosity	No test data available
Explosive properties	No *EEC A14*
Oxidizing properties	No
Liquid Density	1.16 g/cm3 at 25 °C (77 °F) *ASTM D4052*
Molecular weight	Not determined
Particle size	Not determined

NOTE: The physical data presented above are typical values and should not be construed as a specification.

9. TOXICOLOGICAL INFORMATION

Toxicological information appears in this section when such data is available.

Acute toxicity

Acute oral toxicity
Very low toxicity if swallowed. Harmful effects not anticipated from swallowing small amounts.

LD50, Rat, > 15,000 mg/kg

Acute dermal toxicity
Prolonged skin contact is unlikely to result in absorption of harmful amounts.

LD50, Rabbit, 23,000 mg/kg

Acute inhalation toxicity
At room temperature, exposure to vapor is minimal due to low volatility. Vapor from heated material, mist or aerosols may cause respiratory irritation.
The LC50 has not been determined.

Skin corrosion/irritation
Prolonged contact may cause skin irritation with local redness.
Repeated contact may cause skin irritation with local redness.

Serious eye damage/eye irritation
May cause eye irritation.
Corneal injury is unlikely.

Sensitization
For similar material(s):
Has caused allergic skin reactions in humans.
Has demonstrated the potential for contact allergy in mice.

For respiratory sensitization:
No relevant data found.

Specific Target Organ Systemic Toxicity (Single Exposure)
Evaluation of available data suggests that this material is not an STOT-SE toxicant.

Specific Target Organ Systemic Toxicity (Repeated Exposure)
Except for skin sensitization, repeated exposures to low molecular weight epoxy resins of this type are not anticipated to cause any significant adverse effects.

Carcinogenicity
Many studies have been conducted to assess the potential carcinogenicity of diglycidyl ether of bisphenol A (DGEBPA). Indeed, the most recent review of the available data by the International Agency for Research on Cancer (IARC) has concluded that DGEBPA is not classified as a carcinogen.

Although some weak evidence of carcinogenicity has been reported in animals, when all of the data are considered, the weight of evidence does not show that DGEBPA is carcinogenic.

Teratogenicity
Resins based on the diglycidyl ether of bisphenol A (DGEBPA) did not cause birth defects or other adverse effects on the fetus when pregnant rabbits were exposed by skin contact, the most likely route of exposure, or when pregnant rats or rabbits were exposed orally.

Reproductive toxicity
In animal studies, did not interfere with reproduction.

Mutagenicity
In vitro genetic toxicity studies were negative in some cases and positive in other cases. Animal genetic toxicity studies were negative.

Aspiration Hazard
Based on physical properties, not likely to be an aspiration hazard.

COMPONENTS INFLUENCING TOXICOLOGY:

Propane, 2,2-bis[p-(2,3-epoxypropoxy)phenyl]-, polymers

Acute inhalation toxicity
The LC50 has not been determined.

10. DISPOSAL CONSIDERATIONS

Disposal methods: AS YOUR SUPPLIER, WE HAVE NO CONTROL OVER THE MANAGEMENT PRACTICES OR MANUFACTURING PROCESSES OF PARTIES HANDLING OR USING THIS MATERIAL. THE INFORMATION PRESENTED HERE PERTAINS ONLY TO THE PRODUCT AS SHIPPED IN ITS INTENDED CONDITION AS DESCRIBED IN SDS SECTION: Composition Information. All disposal practices must be in compliance with all Federal, State/Provincial and local laws and regulations. Regulations may vary in different locations. Waste characterizations and compliance with applicable laws are the responsibility solely of the waste generator. DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER. FOR UNUSED & UNCONTAMINATED PRODUCT, the preferred options include sending to a licensed, permitted: Incinerator or other thermal destruction device.

11. TRANSPORT INFORMATION

DOT

Not regulated for transport

Classification for SEA transport (IMO-IMDG):

Proper shipping name	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S.(Epoxy resin)
UN number	UN 3082

Class	9
Packing group	III
Marine pollutant	Epoxy resin
Transport in bulk according to Annex I or II of MARPOL 73/78 and the IBC or IGC Code	Consult IMO regulations before transporting ocean bulk

Classification for AIR transport (IATA/ICAO):

Proper shipping name	Environmentally hazardous substance, liquid, n.o.s.(Epoxy resin)
UN number	UN 3082
Class	9
Packing group	III

This information is not intended to convey all specific regulatory or operational requirements/information relating to this product. Transportation classifications may vary by container volume and may be influenced by regional or country variations in regulations. Additional transportation system information can be obtained through an authorized sales or customer service representative. It is the responsibility of the transporting organization to follow all applicable laws, regulations and rules relating to the transportation of the material.

12. REGULATORY INFORMATION

Superfund Amendments and Reauthorization Act of 1986 Title III (Emergency Planning and Community Right-to-Know Act of 1986) Sections 311 and 312
Skin corrosion or irritation
Serious eye damage or eye irritation
Respiratory or skin sensitisation

Superfund Amendments and Reauthorization Act of 1986 Title III (Emergency Planning and Community Right-to-Know Act of 1986) Section 313
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

Pennsylvania Worker and Community Right-To-Know Act:
To the best of our knowledge, this product does not contain chemicals at levels which require reporting under this statute.

California Proposition 65 (Safe Drinking Water and Toxic Enforcement Act of 1986)
This product contains no listed substances known to the State of California to cause cancer, birth defects or other reproductive harm, at levels which would require a warning under the statute.

United States TSCA Inventory (TSCA)
All substances listed as active on the TSCA Inventory or are not required to be listed.

Safety Data Sheet

Issue Date: 07/21/2021

1. IDENTIFICATION AND COMPANY INFORMATION

Product name: Hardener IPT - M102

MANUFACTURER
INTERNAL PIPE TECHNOLOGIES
1001 Energy Drive
Abilene, TX 79602
United States

EMERGENCY TELEPHONE CONTACT

24-Hour Emergency Contact: 1-800-424-9300

2. HAZARDS IDENTIFICATION

Emergency Overview

Color: Blue
Physical State: Liquid.
Odor: Ammoniacal
Hazards of product:

OSHA Hazard Communication Standard

This product is a “Hazardous Chemical” as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Potential Health Effects

Eye Contact: May cause severe irritation with corneal injury which may result in permanent impairment of vision, even blindness. Chemical burns may occur. Vapor may cause lacrimation (tears).
Skin Contact: Brief contact may cause skin burns. Symptoms may include pain, severe local redness and tissue damage.
Skin Absorption: Prolonged or widespread skin contact may result in absorption of potentially harmful amounts.
Skin Sensitization: A component in this mixture has caused allergic skin reactions in humans. Contains component(s) which have caused allergic skin sensitization in guinea pigs.
Inhalation: Excessive exposure may cause irritation to upper respiratory tract (nose and throat). May cause central nervous system depression. Symptoms may include headache, dizziness and drowsiness, progressing to incoordination and unconsciousness. Prolonged excessive exposure may cause serious adverse effects, even death.
Ingestion: Low toxicity if swallowed. Swallowing may result in gastrointestinal irritation or ulceration. Swallowing may result in burns of the mouth and throat.
Aspiration hazard: Based on physical properties, not likely to be an aspiration hazard.
Effects of Repeated Exposure: For the component(s) tested: In animals, effects have been reported on the following organs: Central nervous system. Muscles. Thymus. Urinary tract. Respiratory tract. Liver.
Birth Defects/Developmental Effects: The data presented are for the following material: Benzyl alcohol. Has been toxic to the fetus in laboratory animals at doses toxic to the mother.

3. COMPOSITION INFORMATION

Component	CAS #	Amount
3-Aminomethyl-3,5,5-trimethylcyclohexylamine (isophoronediamine)	2855-13-2	35.0 - 55.0 %
Benzyl alcohol	100-51-6	40.0 - 50.0 %
5-Amino-1,3,3-trimethylcyclohexanemethanamine reaction products with 2,2'-[(1-methylethylidene)bis(4,1-phenyleneoxymethylene)]bis[oxirane]homopolymer	68609-08-5	10.0 - 20.0 %

4. FIRST AID MEASURES

Description of first aid measures

General advice:
First Aid responders should pay attention to self-protection and use the recommended protective clothing (chemical resistant gloves, splash protection).

Inhalation: Move person to fresh air. If not breathing, give artificial respiration; if by mouth to mouth use rescuer protection (pocket mask, etc). If breathing is difficult, oxygen should be administered by qualified personnel. Call a physician or transport to a medical facility.

Skin contact: Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing. Seek medical attention if symptoms occur or irritation persists. Wash clothing before reuse. Discard items which cannot be decontaminated, including leather articles such as shoes, belts and watchbands. Suitable emergency safety shower facility should be immediately available.

Eye contact: Wash immediately and continuously with flowing water for at least 30 minutes. Remove contact lenses after the first 5 minutes and continue washing. Obtain prompt medical consultation, preferably from an ophthalmologist. Suitable emergency eye wash facility should be immediately available.

Ingestion: Do not induce vomiting. Give one cup (8 ounces or 240 ml) of water or milk if available and transport to a medical facility. Do not give anything by mouth unless the person is fully conscious.

Most important symptoms and effects, both acute and delayed

Aside from the information found under Description of first aid measures (above) and Indication of immediate medical attention and special treatment needed (below), any additional important symptoms and effects are described in Section 11: Toxicology Information.

Indication of immediate medical attention and special treatment needed

Maintain adequate ventilation and oxygenation of the patient. Chemical eye burns may require extended irrigation. Obtain prompt consultation, preferably from an ophthalmologist. If burn is present, treat as any thermal burn, after decontamination. Due to irritant properties, swallowing may result in burns/ulceration of mouth, stomach and lower gastrointestinal tract with subsequent stricture. Aspiration of vomitus may cause lung injury. Suggest endotracheal/esophageal control if lavage is done. No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

5. FIREFIGHTING MEASURES

Extinguishing media
Water fog or fine spray. Dry chemical fire extinguishers. Carbon dioxide fire extinguishers. Foam. Alcohol resistant foams (ATC type) are preferred. General purpose synthetic foams (including AFFF) or protein foams may function, but will be less effective.

Extinguishing Media to Avoid: Do not use direct water stream. May spread fire.

Special hazards arising from the substance or mixture

Hazardous Combustion Products: During a fire, smoke may contain the original material in addition to combustion products of varying composition which may be toxic and/or irritating. Combustion products may include and are not limited to: Nitrogen oxides. Carbon monoxide. Carbon dioxide. Ammonia.

Unusual Fire and Explosion Hazards: Container may vent and/or rupture due to fire. Violent steam generation or eruption may occur upon application of direct water stream to hot liquids.

Advice for firefighters

Fire Fighting Procedures: Keep people away. Isolate fire and deny unnecessary entry. Burning liquids may be extinguished by dilution with water. Do not use direct water stream. May spread fire. Burning liquids may be moved by flushing with water to protect personnel and minimize property damage.

Special Protective Equipment for Firefighters: Wear positive-pressure self-contained breathing apparatus (SCBA) and protective fire fighting clothing (includes fire fighting helmet, coat, trousers, boots, and gloves). Avoid contact with this material during fire fighting operations. If contact is likely, change to full chemical resistant fire fighting clothing with self-contained breathing apparatus. If this is not available, wear full chemical resistant clothing with self-contained breathing apparatus and fight fire from a remote location. For protective equipment in post-fire or non-fire clean-up situations, refer to the relevant sections.

6. HANDLING AND STORAGE

Handling
General Handling: Keep away from heat, sparks and flame. Do not get in eyes, on skin, on clothing. Avoid prolonged contact with eyes, skin and clothing. Avoid breathing vapor. Do not swallow. Keep container closed. Use with adequate ventilation. Wash thoroughly after handling. Containers, even those that have been emptied, can contain vapors. Do not cut, drill, grind, weld, or perform similar operations on or near empty containers.

Storage
Store in a cool, dry place. Do not store in: Zinc. Aluminum. Copper. Galvanized containers.

Shelf life: Use within	Storage temperature:
24 Months	-20 - 37.8 °C -4 - 100 °F

7. PERSONAL PROTECTION

Eye/Face Protection: Use safety glasses.

Skin Protection: Use chemical resistant gloves, example butyl, nitrile, vinyl, and neoprene gloves

Other Protection: Use protective clothing chemically resistant to this material. Long sleeve shirts and apron (if necessary).

Ventilation: Use with adequate ventilation.

8. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	
Physical State	Liquid.
Color	Blue
Odor	Ammoniacal
Odor Threshold	No test data available
pH	Not applicable
Melting Point	Not applicable
Freezing Point	No test data available
Boiling Point (760 mmHg)	195 °C (383 °F) *Literature* .
Flash Point - Closed Cup	93 °C (199 °F) *Pensky-Martens Closed Cup ASTM D 93*
Evaporation Rate (Butyl Acetate = 1)	No test data available
Flammability (solid, gas)	Not applicable to liquids
Flammable Limits In Air	**Lower**: No test data available **Upper**: No test data available
Vapor Pressure	0.07 mbar @ 20 °C *Literature* (benzyl alcohol)
Vapor Density (air = 1)	No test data available
Specific Gravity (H2O = 1)	0.99 *Literature*
Solubility in water (by weight)	< 1 % *Literature*
Partition coefficient, n-octanol/water (log Pow)	No data available for this product. See Section 12 for individual component data.
Autoignition Temperature	No test data available
Decomposition Temperature	No test data available
Dynamic Viscosity	70 - 90 cps *Literature*
Explosive properties	No
Oxidizing properties	No
Molecular Weight	No test data available

9. STABILITY AND REACTIVITY

Reactivity
No dangerous reaction known under conditions of normal use.

Chemical stability
Unstable at elevated temperatures.

Possibility of hazardous reactions
Polymerization will not occur.

Conditions to Avoid: Avoid temperatures above 250°C (482°F) Exposure to elevated temperatures can cause product to decompose.

Incompatible Materials: Avoid contact with: Strong acids. Strong oxidizers. Avoid contact with metals such as: Aluminum. Zinc. Copper. Galvanized metals. Avoid unintended contact with: Halogenated hydrocarbons.

Hazardous decomposition products
Decomposition products depend upon temperature, air supply and the presence of other materials. Decomposition products can include and are not limited to: Ammonia. Nitrogen oxides.

10. TOXICOLOGICAL INFORMATION

Acute Toxicity
Ingestion

Single dose oral LD50 has not been determined. Estimated. LD50, rat > 1,030 mg/kg

Dermal

The dermal LD50 has not been determined. Estimated. LD50, rabbit 1,257 mg/kg

Inhalation

The LC50 has not been determined.

Eye damage/eye irritation
May cause severe irritation with corneal injury which may result in permanent impairment of vision, even blindness. Chemical burns may occur. Vapor may cause lacrimation (tears).

Skin corrosion/irritation
Brief contact may cause skin burns. Symptoms may include pain, severe local redness and tissue damage.

Sensitization
Skin

A component in this mixture has caused allergic skin reactions in humans. Contains component(s) which have caused allergic skin sensitization in guinea pigs.

Respiratory

No relevant information found.

Repeated Dose Toxicity
For the component(s) tested: In animals, effects have been reported on the following organs: Central nervous system. Muscles. Thymus. Urinary tract. Respiratory tract. Liver.

Chronic Toxicity and Carcinogenicity
The data presented are for the following material Benzyl alcohol. Did not cause cancer in laboratory animals.

Developmental Toxicity
The data presented are for the following material: Benzyl alcohol. Has been toxic to the fetus in laboratory animals at doses toxic to the mother. Contains component(s) which did not cause birth defects in laboratory animals.

Reproductive Toxicity
No relevant data found.

Genetic Toxicology
The data presented are for the following material: Benzyl alcohol. In vitro genetic toxicity studies were negative in some cases and positive in other cases. Contains a component(s) which were negative in in vitro genetic toxicity studies. Contains component(s) which were negative in animal genetic toxicity studies.

11. DISPOSAL CONSIDERATIONS

DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER. All disposal practices must be in compliance with all Federal, State/Provincial and local laws and regulations. Regulations may vary in different locations. Waste characterizations and compliance with applicable laws are the responsibility solely of the waste generator. AS YOUR SUPPLIER, WE HAVE NO CONTROL OVER THE MANAGEMENT PRACTICES OR MANUFACTURING PROCESSES OF PARTIES HANDLING OR USING THIS MATERIAL. THE INFORMATION PRESENTED HERE PERTAINS ONLY TO THE PRODUCT AS SHIPPED IN ITS INTENDED CONDITION AS DESCRIBED IN MSDS SECTION: Composition Information. FOR UNUSED & UNCONTAMINATED PRODUCT, the preferred options include sending to a licensed, permitted: Incinerator or other thermal destruction device.

12. TRANSPORT INFORMATION

DOT Non-Bulk
Proper Shipping Name: ISOPHORONEDIAMINE SOLUTION
Hazard Class: 8 **ID Number:** UN2289 **Packing Group:** PG III

DOT Bulk
Proper Shipping Name: ISOPHORONEDIAMINE SOLUTION

Hazard Class: 8 **ID Number:** UN2289 **Packing Group:** PG III

IMDG
Proper Shipping Name: ISOPHORONEDIAMINE SOLUTION
Hazard Class: 8 **ID Number:** UN2289 **Packing Group:** PG III
EMS Number: F-A,S-B
Marine pollutant: No

ICAO/IATA
Proper Shipping Name: ISOPHORONEDIAMINE SOLUTION
Hazard Class: 8 **ID Number:** UN2289 **Packing Group:** PG III
Cargo Packing Instruction: 856
Passenger Packing Instruction: 852

This information is not intended to convey all specific regulatory or operational requirements/information relating to this product. Additional transportation system information can be obtained through an authorized sales or customer service representative. It is the responsibility of the transporting organization to follow all applicable laws, regulations and rules relating to the transportation of the material.

13. REGULATORY INFORMATION

OSHA Hazard Communication Standard

This product is a “Hazardous Chemical” as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Superfund Amendments and Reauthorization Act of 1986 Title III (Emergency Planning and Community Right-to-Know Act of 1986) Sections 311 and 312

Immediate (Acute) Health Hazard	Yes
Delayed (Chronic) Health Hazard	Yes
Fire Hazard	Yes
Reactive Hazard	No
Sudden Release of Pressure Hazard	No

Superfund Amendments and Reauthorization Act of 1986 Title III (Emergency Planning and Community Right-to-Know Act of 1986) Section 313

To the best of our knowledge, this product does not contain chemicals at levels which require reporting under this statute.

Pennsylvania (Worker and Community Right-To-Know Act): Pennsylvania Hazardous Substances List and/or Pennsylvania Environmental Hazardous Substance List:

The following product components are cited in the Pennsylvania Hazardous Substance List and/or the Pennsylvania Environmental Substance List, and are present at levels which require reporting.

Component	CAS #	Amount
Benzyl alcohol	100-51-6	40.0 - 50.0 %

Pennsylvania (Worker and Community Right-To-Know Act): Pennsylvania Special Hazardous Substances List:

To the best of our knowledge, this product does not contain chemicals at levels which require reporting under this statute.

California Proposition 65 (Safe Drinking Water and Toxic Enforcement Act of 1986)

This product contains no listed substances known to the State of California to cause cancer, birth defects or other reproductive harm, at levels which would require a warning under the statute.

US. Toxic Substances Control Act

All components of this product are on the TSCA Inventory or are exempt from TSCA Inventory requirements under 40 CFR 720.30