Approval Standard for Underground Pipe Rehabilitation Systems

Class Number 1616

May 2020

Foreword

The FM Approvals certification mark is intended to verify that the products and services described will meet FM Approvals' stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of Approval Standards is to present the criteria for FM Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for certification by FM Approvals shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing shall ensure a consistently uniform and reliable product. Approval Standards strive to be performance-oriented. They are intended to facilitate technological development.

For examining equipment, materials and services, Approval Standards:

a) must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and
b) must be readily identifiable.

Continuance of Approval and listing depends on compliance with the Approval Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up audits of the manufacturing facility.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

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1 INTRODUCTION

1.1 Purpose

1.1.1 This standard states Approval criteria for pipe rehabilitation systems for use in underground fire service water mains. Rehabilitation of already installed underground pipe lengths / sections is a means to extend the useful life of existing fire service water mains.

1.1.2 Approval criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a follow-up program.

1.2 Scope

1.2.1 This standard encompasses the design and performance requirements for pipe rehabilitation systems for use in underground fire service water mains. Rehabilitation may be considered for all pipe sizes within the size ranges addressed in the FM Approval Standards outlined in Section 1.2.2. Rehabilitation of pipe outside the allowed size ranges is outside the scope of this standard. In cases where metric sized are to be examined for Approval, test criteria comparable to the United States equivalent size shall be used.

1.2.2 Requirements for the pipe rehabilitation systems addressed in this standard are for use in the rehabilitation of existing underground piping systems for fire protection service. FM Approval of new underground pipe is addressed in the following Approval Standards:

Class	***Underground Pipe***
1610	Ductile Iron Pipe and Fittings
1612	Polyvinyl Chloride (PVC) Pipe and Fittings
1613	Polyethylene (PE) Pipe and Fittings
1614	Fiber Reinforced Composite (FRC) Pipe and Fittings

1.2.3 Approval is limited to rehabilitation systems / sizes which have a rated working pressure of at least 150 psi (1035 kPa).

1.2.4 This Approval standard is intended to verify that the product described will meet stated conditions of performance, safety, and quality useful to the ends of property conservation.

1.2.5 Non-Structural pipe-lining systems are not addressed in this standard.

1.3 Basis for Requirements

1.3.1 The requirements of this standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, trade associations, jurisdictions and/or loss control specialists was also considered.

1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of underground pipe rehabilitation systems for the purpose of obtaining Approval. Underground pipe rehabilitation systems having characteristics not anticipated by this Standard may be FM Approved if performance equal, or superior, to that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, underground pipe rehabilitation systems which meet all of the requirements identified in this standard may not be FM Approved if other conditions which adversely affect performance exist or if the intent of this standard is not met.

1.4 Basis for FM Approval

FM Approval is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

1.4.1 Examination and tests on production samples shall be performed to evaluate

- the suitability of the product
- the performance of the product as specified by the manufacturer and required by FM Approvals; and as far as practical,
- the durability and reliability of the product.

1.4.2 An examination of the manufacturer's manufacturing facilities and audit of their quality control procedures shall be made to evaluate the manufacturer's ability to consistently produce the product that was examined and tested as part of the Approval examination. The audit shall review the facility and in-place quality control procedures used in the manufacturing of the product. Typically, areas of review are incoming inspection, work in progress, production testing, final quality control, marking, calibration of equipment, shipping procedures and document and drawing control. These audits are repeated quarterly as part of FM Approvals' Surveillance Audit Program. (Refer to Section 5.2)

1.5 Basis for Continued FM Approval

1.5.1 Continued Approval is based upon:

- Production or availability of the product as currently FM Approved;
- Continued use of acceptable quality assurance procedures;
- Satisfactory field experience;
- Compliance with the terms stipulated in the Master Agreement;
- Satisfactory re-examination of production samples for continued conformity to requirements; and
- Satisfactory Surveillance Audits conducted as part of FM Approvals' product surveillance audit program.

1.5.2 Also, as a condition of retaining Approval, manufacturers may not change an FM Approved product or service without prior authorization by FM Approvals. (Refer to Section 5.1.3 for further details regarding changes.)

1.6 Effective Date

The effective date of an Approval standard mandates that all products tested for Approval after the effective date shall satisfy the requirements of that standard. Products FM Approved under a previous edition shall comply with the new version by the effective date or forfeit Approval.

The effective date of this standard is the date of publication for full compliance with all requirements.

1.7 System of Units

Units of measurement used in this standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Conversion of U.S. customary units is in accordance with the Institute of Electrical and Electronics Engineers (IEEE) / American Society for Testing Materials (ASTM) SI 10-2010, *American National Standard for Metric Practice.*

1.8 Normative References

The following documents are referred to in the text in such a way that some or all of their contents constitutes requirements of this document. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies:

AWWA Standard C900, *Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. through 60 in. (100 mm through 1500 mm)*

ASTM International (ASTM) D638 – *Standard Test Method for Tensile Properties of Plastics*

ASTM D1599 – *Standard Test Method for Resistance to Short-Term Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings*

ASTM D2290 – *Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe*

ASTM D2990 – *Standard Test Methods for Tensile, Compressive and Flexural Creep and Creep-Rupture of Plastics*

ASTM D3039 – *Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials*

ASTM F2994-18, *Standard Practice for Utilization of Mobile, Automated Cured-in-Place (CIPP) Impregnation Systems*

IEEE/ASTM SI 10-2010, *American National Standard for Metric Practice*

International Standards Organization (ISO) 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*

NSF International (NSF) / American National Standards Institute (ANSI) Standard 61, *Standard for Drinking Water Systems Components – Health Effects*

1.9 Definitions

For purposes of this standard, the following terms apply:

Accepted

This term refers to installations acceptable to the authority enforcing the applicable installation rules. When the authority is FM Global, such locations are termed "FM Global Accepted." Acceptance is based upon an overall evaluation of the installation. Factors other than the use of FM Approved equipment impact upon the decision to accept, or not to accept. Acceptance is not a characteristic of a product. A product accepted for one installation may not be acceptable elsewhere. (Contrast with FM Approved.)

Close-Fit Lining (CFL)

A pipe rehabilitation system where the circular shape of the lining is temporarily modified to reduce the cross-section to enable insertion of the continuous lining into a deteriorated or damaged pipe after which a reversion process is performed to re-round the lining to its original design size and then expanded using heat and pressure to fit snugly onto the inner surface of the host pipe. These pipe relining systems have sufficient ring stiffness to be self-supporting when subjected to all hydrostatic and vacuum conditions, external buckling forces, internal pressures, and meet long-term design objectives for hole spanning applications.

Cured In-Place Pipe (CIPP) Lining

A pipe rehabilitation system where a resin saturated tube is inverted or pulled into a deteriorated or damaged host pipe, and then subjected to heat from the circulation of hot water or introduction of air/steam which cures the tube and forms a tight fit to the inner surface of the host pipe. CIPP rehabilitation systems are further discussed in ASTM International (ASTM) F1216, *Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube*, ASTM F1743, *Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in Place Installation or Cured-in-Place Thermosetting Resin Pipe (CIPP);* ASTM F2019, *Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP) and* ASTM F2994, *Standard Practice for Utilization of Mobile, Automated, Cured-in-Place (CIPP) Impregnations Systems.*

FM Approvals Certification Mark

Product markings, applied by the manufacturer, that identify the product as FM Approved. Their use is mandatory on all pipe rehabilitation systems. These registered marks cannot be used except as authorized by FM Approvals via the granting of Approval to a specific product.

FM Approved

This term refers to products FM Approved by FM Approvals. Such products are listed in the Approval Guide, an on-line resource of FM Approvals. All products so listed have been successfully examined by FM Approvals, and their manufacturers have signed and returned a Master Agreement to FM Approvals. These forms obligate the manufacturer to allow re-examination of the product and audit of facilities and procedures at FM Approval's discretion. It further requires the manufacturer not to deviate from the FM Approved configuration of the product without review by and agreement of FM Approvals.

Host Pipe

Installed underground pipe that will be rehabilitated. Rehabilitation of water mains is typically performed to address water quality issues as well as hydraulic and structural improvement as a result of leakage, corrosion build up or structural defects in the installed pipe.

Maximum Allowable Operating Pressure (MAOP)

See Rated Working Pressure.

Pipe Bursting

A pipe replacement system that requires special equipment to break down or "burst" the host pipe while simultaneously pulling a new replacement pipe, which may be larger than the host pipe into place.

Pipe Rehabilitation

This term refers to a variety of processes by which an installed pipe can be refreshed to extend its useful service life. Depending on the condition of the host pipe, the configuration of the pipe network, and the conditions at the site, different options for rehabilitation may or may not be possible or practical. Where possible, internal examination of the host pipe should be conducted in order to assess its condition so that a plan for rehabilitation can be determined.

Slip Lining

A pipe rehabilitation system where the rehabilitation pipe fits loosely within the host pipe. The void between the rehabilitation pipe and the host pipe can be filled with grout or sand. A slip lined pipe rehabilitation results in a reduced flow diameter.

Rated Working Pressure

The maximum sustained pressure at or below which the rehabilitated piping system shall operate trouble free. This pressure also sets the basis for the testing described in Section 4, Performance Requirements. This term is used interchangeably with the Maximum Allowable Operating Pressure (MAOP) which is often used in literature pertaining to pipe rehabilitation systems.

2 GENERAL INFORMATION

2.1 Product Information

2.1.1 Pipe rehabilitation systems covered by this standard include those designed for sizes 3, 4, 6, 8, 10, 12, 14, 16, 20 and 24 inch NPS. Pipe rehabilitation systems designed for other sizes shall be evaluated on a case-by-case basis.

2.1.2 Pipe rehabilitation systems shall have a minimum rated working pressure of at least 150 psi (1035 kPa).

2.1.3 In order to meet the intent of this standard, pipe rehabilitation systems must be examined on a model-by-model, type-by-type, manufacturer-by-manufacturer, and plant-by-plant basis. This is predicated on the basis that identical designs, fabricated in identical materials by different manufacturers or, even by different plants of the same manufacturer, have been seen to perform differently in testing. Sample pipe rehabilitation systems shall satisfy all of the requirements of this standard.

2.2 Approval Application Requirements

2.2.1 To apply for an Approval examination the manufacturer, or its authorized representative, should submit a request to information@fmapprovals.com.

2.2.2 The manufacturer shall provide the following preliminary information with any request for Approval consideration:

- A complete list of all products, sizes, resins, host pipe materials and options for the products or services being submitted for Approval consideration;
- Installation instructions that detail all necessary host pipe cleaning and preparation as well as procedures that detail the means by which the pipe rehabilitation system is inserted or applied to the host pipe;
- General Assembly drawings, hydrostatic design basis (HDB) calculations if applicable, anticipated marking format, brochures, sales literature, specifications sheets, installation, operation and maintenance procedures, and
- Number and location(s) of manufacturing facilities making the products submitted for FM Approval.

2.3 Requirements for Samples for Examination

2.3.1 Sample requirements are to be determined by FM Approvals following review of the preliminary information used in the preparation of the examination proposal. Sample requirements may vary depending on the size range of the product under consideration, design features, or results of prior testing. Following the authorization of the examination proposal, the manufacturer shall prepare samples using the information included with the proposal letter.

2.3.2 The manufacturer shall submit samples representative of production. Any decision to use data generated utilizing prototypes is at the discretion of FM Approvals. The manufacturer shall provide the test facility and any special test fixtures which may be required to evaluate the product.

2.3.3 If there are failures encountered during the examination testing, FM Approvals will provide the manufacturer with information regarding what testing will need to be repeated and any additional sample requirements.

3 GENERAL REQUIREMENTS

3.1 Review of Documentation

During the initial investigation and prior to physical testing, the manufacturer's specifications, technical data sheets, installation instructions and design details shall be reviewed to assess the ease and practicality of installation and use. The product shall be capable of being used within the limits of the Approval investigation. An Installation Manual addressing all aspects associated with use of the product, including host pipe cleaning, insertion, and curing shall be provided.

3.2 Physical or Structural Features

3.2.1 Pipe rehabilitation systems shall be able to withstand the normal rated working pressures found in fire service mains as well as vacuum conditions that occur during draining of water for maintenance and repair work.

3.2.2 The internal waterway of the reduced section shall not create a restriction more than one nominal pipe size smaller. For example, a rehabilitated 8 inch (200 mm) ductile iron pipe shall not result in a waterway diameter less than a 6 inch (150 mm) diameter ductile iron pipe made to the same standard.

3.2.3 Pipe rehabilitation systems are by nature used to correct defects in the host pipe. Manufacturers shall be able to provide guidance as to the type and size of defect that can be rehabilitated while maintaining the minimum required working pressure. In no instance shall the host pipe defects be greater than those shown in Figure 4.3.2.

3.2.4 For pipe rehabilitation systems that use the host pipe for any reason during installation, it shall be stated which material host pipes are suitable for repair using the rehabilitation system under evaluation.

3.2.5 Manufacturer shall state the minimum and maximum continuous lengths that a repair liner can be installed.

3.3 Materials

3.3.1 All materials used in the manufacture of pipe rehabilitation systems shall be suitable for the intended application. Raw materials shall be evaluated in accordance with the appropriate sections of the manufacturer’s Quality Assurance Manual plus any other national and/or international standards.

3.3.2 Because of the possibility of connection to potable water systems, the pipe rehabilitation systems addressed in this standard shall be suitable for potable water service, as listed for this service by the NSF International (NSF) or other nationally recognized and accredited testing laboratory. Tests shall be made in accordance with the requirements equivalent to those of NSF/ANSI Standard 61, *Standard for Drinking Water Systems Components – Health Effects*, at minimum.

3.4 Markings

3.4.1 The following markings shall appear on the product and be applied at intervals not more than 5 ft (1.5 m):

- Manufacturer’s name or logo;
- Model or type designation;
- Nominal size;
- Rated working pressure;
- Specific production code, including day, month, year, shift, plant if applicable;
- FM Approval’s Certification Mark

3.4.2 Pipe rehabilitation systems that are produced at more than one location shall be identified as the product of a particular location.

3.4.3 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the product as FM Approved. The manufacturer shall not place this model or type identification on any other product unless covered by a separate agreement.

3.4.4 The FM Approval's Certification Mark shall be displayed visibly and permanently on the product. The manufacturer shall not use this Mark on any other product unless such product is covered by separate agreement with FM Approvals.

3.4.5 All markings shall be legible and durable. Other methods of applying required markings will be evaluated on a case by case basis.

3.5 Manufacturer's Installation and Operation Instructions

Installation, engineering, post-rehabilitation maintenance and operation instructions including any special dimension requirements shall be furnished by the manufacturer for each pipe rehabilitation system.

3.6 Calibration

All equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage of the equipment. A copy of the calibration certificate for each piece of test equipment is required for FM Approvals records, indicating that the calibration was performed against working standards whose calibration is certified as traceable to the National Institute of Standards and Technology (NIST) or to other acceptable reference standards and certified by an ISO 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*, calibration laboratory. The test equipment shall be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the calibration service's accreditation certificate as an ISO 17025, calibration laboratory is required for FM Approvals records.

The calibration of new equipment is also required. Documentation indicating either the date of purchase or date of shipment, equipment description, model and serial number is required for identification. The new test equipment shall be clearly identified by label or sticker showing the date of initial calibration and the next due date.

When the inspection equipment and/or environment is not suitable for labels or stickers, other methods such as etching of control numbers on the measuring device are allowed, provided documentation is maintained on the calibration status of the equipment.

3.7 Tolerances

Tolerances on units of measurement shall be as described in Appendix A, unless otherwise specified.

4 PERFORMANCE REQUIREMENTS

4.1 Examination

4.1.1 Requirement

The pipe rehabilitation system shall conform to the manufacturer's drawings and specifications of the product submitted with supporting type testing, and to FM Approvals design requirements stated in Section 3. Documentation in accordance with Appendix C of this standard shall be provided for design validation.

4.1.2 Test/Verification

A sample pipe rehabilitation system shall be examined and compared to drawings and specifications. It shall be verified that the sample conforms to the physical and structural requirements described in Section 3, General Requirements.

4.2 Hydrostatic Strength

4.2.1 Requirements

Pipe bursting, slip lining and CFL pipe rehabilitation systems manufactured from polyvinyl chloride (PVC), polyethylene (PE) or fiber reinforced composite (FRC) shall meet the hydrostatic strength requirements as defined in the applicable FM Approval Standard shown in Section 1.2.2.

CIPP systems shall also maintain hydrostatic integrity when subject to a hydrostatic pressure equal to two times the rated working pressure of the pipe rehabilitation system for a period of 5 minutes without leakage, rupture, ballooning or weeping.

Resin impregnation of CIPP pipe rehabilitation systems shall be performed utilizing vacuum impregnation and automated systems with data logging capability that conform to the minimum requirements of Sections 3.2.2 and 3.2.5.1 of ASTM F2994-18. All samples provided for tests and verification shall require submittal of the data recorded during resin impregnation. The CIPP system manufacturer shall provide certification that the resin impregnation process meets the requirements of ASTM F2994-18.

4.2.2 Tests/Verification

For pipe bursting, slip lining and CFL pipe rehabilitation systems, consult applicable FM Approval Standard from Section 1.2.2 for details for required tests and verification.

CIPP pipe rehabilitation systems shall be installed in a section of AWWA C900 DR18 PVC pipe (or similar host pipe) and allowed to cure in accordance with the manufacturer's recommendations. The host pipe shall then be removed such that a section of the unsupported pipe rehabilitation system is a minimum length of three times the outside diameter of the host pipe. The unsupported sample shall then be subjected to a hydrostatic pressure equal to two times the rated working pressure of the close-fit pipe rehabilitation system for a period of 5 minutes without leakage, rupture, ballooning or weeping.

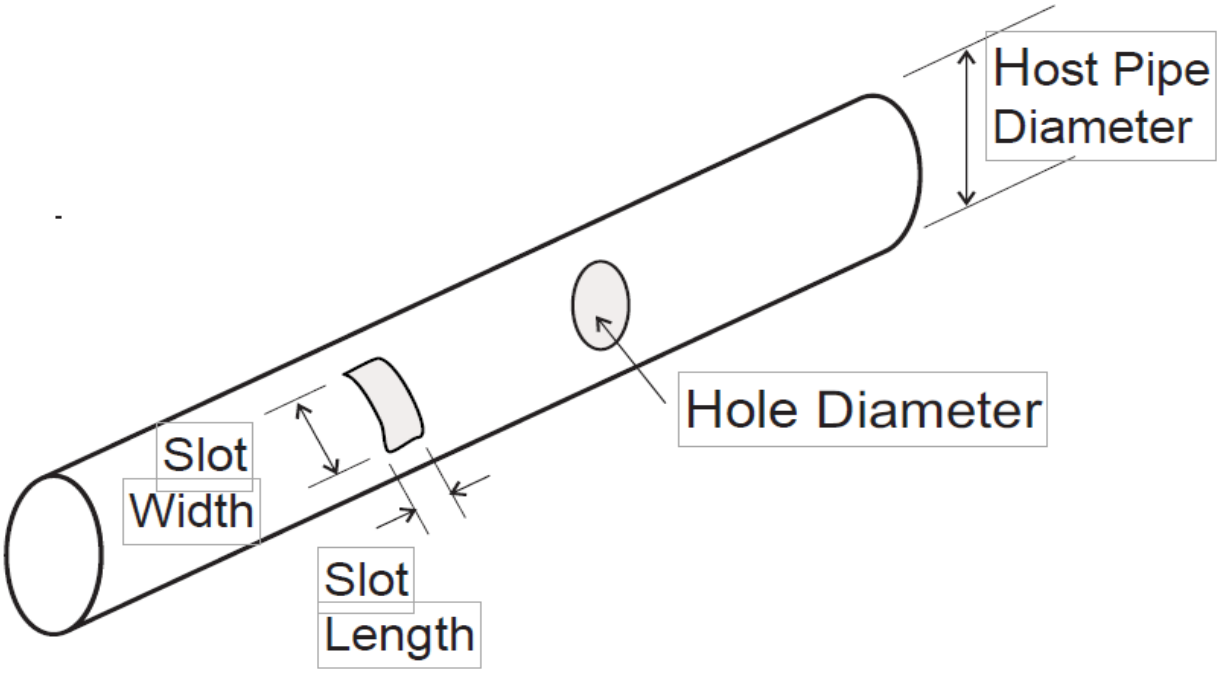
4.3 Vacuum Test

4.3.1 Requirements

CIPP pipe rehabilitation systems shall remain tightly fit to the host pipe defined in Figure 4.3.2 while subjected to a one-hour vacuum test. There shall be no collapse or apparent separation of the CIPP pipe rehabilitation system from the host pipe or any other type of failure, such as blistering, peeling, flaking or delamination from the host pipe as a result of this test.

4.3.2 Tests/Verification

A representative size of each rehabilitation system shall be installed in a length of host pipe, with a minimum length equal to three times the outside diameter of the host pipe, of the type for which the rehabilitation system is intended and allowed to cure in accordance with the manufacturer's recommendations. The length of host pipe shall include the imperfections shown in Figure 4.3.2. The cured sample shall then be subjected to a 22 inHg (75 kPa) vacuum for 60 minutes. Following this test there shall be no apparent separation of the rehabilitation system from the host pipe or any other type of failure, such as blistering, peeling, flaking or delamination from the host pipe.



Host Pipe Diameter, in.	***Hole Diameter in.***	***Slot Length in.***	***Slot Width in.***	***Minimum Distance between Irregularities in.***	***Minimum Sample Length In.***
4	1	0.5	2	4	12
6	1.5	0.75	3	4	18
8	2	1	4	5	24
10	2	1	5	5	30
12	3	1.5	6	6	36
14	3	1.5	7	6	42
16	4	2	8	8	48
20	4	2	10	8	60
24	4	2	12	12	72

Figure 4.3.2

4.4 High Flow Endurance Test

4.4.1 Requirement

CIPP pipe rehabilitation systems shall remain tightly fit to the host pipe while subjected to high flow rates common in fire protection systems. There shall be no apparent separation of the CIPP rehabilitation system from the host pipe or any other type of failure, such as blistering, peeling, flaking or delamination from the host pipe as a result of this test.

4.4.2 Test/Verification

A representative size of each pipe rehabilitation system shall be installed in a length of host pipe, with a minimum length equal to three times the outside diameter of the host pipe, of the type for which the rehabilitation system is intended and allowed to cure in accordance with the manufacturer's recommendations. The length of host pipe shall include the imperfections shown in Figure 4.3.2. The cured sample shall then be subjected to a flow rate producing a velocity of 30 ft/sec (9 m/sec) based in the internal diameter of the rehabilitation system. The test duration shall be 90 minutes. Following this test there shall be no apparent separation of the rehabilitation system from the host pipe or any other type of failure, such as blistering, peeling, flaking or delamination from the host pipe.

4.5 Additional Tests

Additional tests may be required, depending on design features, results of any tests, material application, or to verify the integrity and reliability of the underground pipe rehabilitation system, at the discretion of FM Approvals.

Unexplainable failures shall not be permitted. A re-test shall only be acceptable at the discretion of FM Approvals and with adequate technical justification of the conditions and reasons for failure.

5 OPERATIONS REQUIREMENTS

A quality control program is required to assure that pipe rehabilitation systems produced by the manufacturer at an authorized location, shall present the same quality and reliability as the samples examined. Design quality, conformance to design, and performance are the areas of primary concern. Design quality is determined during the Approval examination and tests, and is covered in the Approval Report. Conformance to design is verified by control of quality and is covered in the Surveillance Audit Program. Quality of performance is determined by field performances and by periodic re-examination and testing.

5.1 Demonstrated Quality Control Program

5.1.1 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- Existence of corporate quality assurance guidelines;
- Incoming quality assurance, including testing;
- In-process quality assurance, including testing;
- Final inspection and tests;
- Equipment calibration;
- Drawing and change control;
- Packaging and shipping;
- Construction practices, including installation, processing and acceptance testing;
- Handling and disposition of non-conformance materials; and,
- In order to assure adequate traceability of materials and products, the manufacturer shall maintain records of all quality control tests performed, and shall maintain these records for a minimum period of two years from the date of manufacture.

5.1.2 Documentation/Manual

There should be an authoritative collection of procedures and policies. Such documentation shall provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.3 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the Approval Report, must be reported to, and authorized by, FM Approvals prior to implementation for production.

- The manufacturer shall assign an appropriate person or group to be responsible for, and require that, proposed changes to FM Approved or Listed products be reported to FM Approvals before implementation. The manufacturer shall notify FM Approvals of changes in the product or of persons responsible for keeping FM Approvals advised by means of FM Approvals Form 619, *FM Approved Product/Specification-Tested Revision Report or Address/Main Contact Change Report*.

- Records of all revisions to all FM Approved products shall be maintained.

5.1.3.1 The table below has been included as a guide to manufacturers of what is considered to be a significant change to FM Approvals. To facilitate the Approval of significant changes, modifications that fit this category shall be documented by means of a letter stating the change, and requesting a quotation for an Approval examination.

Modification	*Description/ Example*
Change in pressure rating:	The product was originally FM Approved for a rated working pressure of 150 psi (1035 kPa) and now a 200 psi (1380 kPa) rating is desired.
Change in acceptable host pipe:	The product was originally FM Approved for use with ductile iron pipe and is now being submitted for use with steel pipes.
Addition or relocation of the manufacturing location:	The product was originally FM Approved when made in location A, and now it is desired to make the same product in locations A and B, or in location B only.
Changes to Critical Dimensions:	Modifications that would have an effect on the ability of the product to maintain the same performance as the originally FM Approved product. An example of this would be a change in CIPP liner construction which reduces glass content and tensile properties or reduces the thickness of a CIPP pipe rehabilitation system.

5.1.3.2 The table below has been included as a guide to manufacturers of modifications which may be submitted on FM Approvals Form 619, *FM Approved Products/Specification-Tested Revision Request Form*.

Modification	*Description/Example*
Change in Company Contact Information:	Company Name, Contact Name, Title, Phone Number, FAX Number, Office Address
Updating of Drawings:	Minor dimensional changes, or note changes, Re-creation of old drawing on CAD
Change in material or marking:	Where new material is superior, or to show proposed new marking

5.1.3.3 For the instances where the modification is difficult to categorize, manufacturers are encouraged to contact FM Approvals and to discuss the nature of the proposed change, and how to send the information to FM Approvals. The examples shown in Sections 5.1.3.1 and 5.1.3.2 are based on common examples of modifications as they relate to the manufacture of pipe rehabilitation systems.

5.1.3.4 FM Approvals, at its sole discretion, shall determine when additional testing is necessary to validate proposed changes.

5.2 Surveillance Audit Program

5.2.1 An audit of the manufacturing facility is part of the Approval investigation to verify implementation of the quality control program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to insure a consistently uniform and reliable product. Initial inspections of facilities already producing similar products may be waived at the discretion of FM Approvals.

5.2.2 These audits shall be conducted periodically but at least annually by FM Approvals or its representatives. The frequency of the surveillance audit is dependent on the product class, product complexity, jurisdictional requirements FM Approvals accreditation requirements and findings.

5.2.3 The client shall manufacture the product or service only at the location(s) audited by FM Approvals and as specified in the Approval Report. Manufacture of products bearing the FM Approval's Certification Mark is not permitted at any other locations without prior written authorization by FM Approvals.

5.3 Manufacturer's Responsibilities

The manufacturer shall notify FM Approvals of changes in product construction, design, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation of such changes.

5.4 Installation Inspections

Field inspections may be conducted to review an installation. The inspections are conducted to assess ease of installation and conformance to written specifications. When more than one application technique is used, one or all may be inspected at the discretion of FM Approvals.

5.5 Installation, Operating and Maintenance Manual

An installation, operation, and maintenance manual shall be provided with each pipe rehabilitation system, or be made available upon request. A copy of the manual shall be provided to FM Approvals as a reference prior to the examination and testing of the system. Subsequent to the successful completion of the examination, an electronic copy of the manual shall be provided to FM Approvals for reference. Updated electronic copies of the manual shall be provided to FM Approvals as revisions are made.

5.6 Manufacturing and Production Tests

5.6.1 Test Requirement No. 1 – *In–House Production Performance Test*

The manufacturer shall conduct a Hydrostatic Integrity Test at least once per production run using the specimen described in Section 4.2. A sample rehabilitation system shall be tested at a hydrostatic pressure equal to its rated working pressure for a period 1 minute without leakage, rupture, ballooning or weeping.

5.6.2 Test Requirement No. 2 – *On-Site Performance Test*

For linings produced to exacting dimensions of the host pipe or where complete processing or manufacture takes place in the field, acceptance testing including a Hydrostatic Integrity Test conducted at a hydrostatic pressure equal to its rated working pressure for a period 1 minute is acceptable in lieu of the requirements shown in Section 5.6.1. No leakage, rupture, ballooning or weeping is allowed.

APPENDIX A: Tolerances

Unless otherwise stated, the following tolerances shall apply:

Flow	+ 1/- 0 percent of value
Length:	± 2 percent of value
Volume:	± 2 percent of value
Volume Per Unit Area:	± 5 percent of value
Power	± 1.5 percent of value
Pressure:	± 1.0 percent of value
Temperature:	± 4°F (2°C)
Time:	+ 5/–0 seconds +0.1/–0 minutes

Unless stated otherwise, all tests shall be carried out at a room (ambient) temperature of 68 ± 9°F (20 ± 5°C).

APPENDIX B: Sample Listing

EMT Pipe Rehabilitation Company, 15 Mount Sinai Road, Coventry, RI 02866

Product	*Listing Country*	*Sizes, inch*	*Rated Working Pressure, psi (kPa)*	*Host Pipe*	*Maximum Span, inches*	*Remarks*	*Certification Type*
EMT1	USA	4, 6	150 (1035)	Ductile Iron	3	a	FM Approved
EMT2	USA	8, 10	150 (1035)	Ductile Iron	4	a	FM Approved
EMT3	USA	12	150 (1035)	Ductile Iron	6	a	FM Approved
EMT7	USA	4, 6	150 (1035)	Ductile Iron	3	b	FM Approved
EMT8	USA	8, 10	150 (1035)	Ductile Iron	4	b	FM Approved
EMT9	USA	12	150 (1035)	Ductile Iron	6	b	FM Approved

a. Slip lining
b. Cured-In-Place Pipe (CIPP) lining

APPENDIX C:
CIPP Rehabilitation System Working Pressure Verification

For design validation, Equations 3 and 6 must be satisfied (as guided by Equation 4) and, as a minimum, the following supporting documentation shall be provided by the CIPP manufacturer for each composite design:

Attribute	Test Method(s)	Requirements
Short-Term Burst Pressure	ASTM D1599	Test duration = 60-70 seconds at burst
Initial Tensile Properties	ASTM D2290 or ASTM D3039 or ASTM D638	Tests shall be conducted in the circumferential (hoop) direction
Long-Term Tensile Properties	ASTM D2990 (Tensile Creep)	A minimum of 3 representative stress levels are required for each composite design tested

Short-Term Performance:

Initial hoop tensile properties of representative CIPP samples shall be determined through ASTM D2290, ASTM D3039 or ASTM D638 testing.

Burst testing conducted in accordance with ASTM D1599 is a measure of thermoplastic or reinforced thermosetting plastic pipe's resistance to hydraulic pressures over a short time frame (60-70 seconds). This test is diameter specific, but results are scalable provided the material composition is consistent between sizes.

Short-term burst results can be applied to any CIPP diameter if the reinforcement scheme does not change. Note that increasing or decreasing wall thickness without adjusting reinforcing content (adding or reducing felt and resin only) will not impact the MAOP.

$$S_B = \frac{P_B \cdot (D - t_B)}{2 \cdot t_B} \qquad (1)$$

where: S_B = CIPP hoop stress at burst from ASTM D1599 testing, psi
P_B = short-term burst pressure of the CIPP per ASTM D1599, psi
D = outside diameter of the CIPP, in
t_B = composite thickness of the CIPP for burst testing, in

Rearranging Equation (1) to solve for P_B for any diameter CIPP designed with the same reinforcing scheme:

$$P_B = \frac{S_B \cdot (2 \cdot t_B)}{D - t_B} \qquad (2)$$

Design compliance can then be checked for each applicable diameter using Equations 3 and 6 (as guided by Equation 4).

$$\frac{P_B}{PRF} \geq P_w \qquad (3)$$

where: P_w = Rated Working Pressure - Maximum Allowable Operating Pressure (MAOP), psi
PRF = pressure rating factor (dimensionless) = 4.0 for CIPP in straight alignment

Further de-rating (i.e. a higher PRF or reduction in MAOP of the CIPP) may be necessary when lining through bends, hoop integrity is compromised, or the CIPP does not reflect the finished quality of ASTM D1599 test samples.

Appropriate documentation shall be provided by the CIPP manufacturer for each unique product, process or reinforced composite proposed to support assumptions utilized and fulfill design requirements. Examples include variations in resin formulation, liner construction, reinforcing material, curing method or combination thereof.

Long-Term Performance:

The equivalent CIPP hoop stress at MAOP for ASTM D2990 tensile creep testing is calculated using Equation 4.

$$S_{MAOP} = \frac{P_w \cdot (D - t_T)}{2 \cdot t_T} \quad (4)$$

where: S_{MAOP} = hoop stress at MAOP, psi
t_T = composite thickness of the CIPP sample for tensile testing, in

A representative hoop stress level and corresponding long-term retention value is then selected from ASTM D2990 tensile creep testing to satisfy Equation 5.

$$S_i \geq S_{MAOP} \quad (5)$$

ASTM D2990 test data generated from stress level S_1 is utilized since it meets the minimum design criteria. The MAOP of the CIPP can then be estimated and checked for design compliance using Equation 6:

$$P_{CIPP} = \frac{2 \cdot \sigma_{THL}}{\left(\frac{D}{t_T} - 1\right) \cdot N} \geq P_w \quad (6)$$

where P_{CIPP} = MAOP of the CIPP, psi
σ_{THL} = long-term tensile strength of the CIPP, hoop direction, psi = $\sigma_{THI} \cdot R_T \cdot \Delta_{T50}/100$
σ_{THI} = initial tensile strength of the CIPP, hoop direction, psi (from ASTM D2290, ASTM D3039 or ASTM D638 testing)
* R_T = reduction factor applied to CIPP initial tensile properties
Δ_{T50} = percentage retention of initial tensile properties at 50 yrs (from ASTM D2990 testing)
N = design factor of safety = 2.0

* A relevant reduction factor, R_T, should be applied to initial tensile properties to account for lab-to-lab variability and field conditions. For CIPP, an R_T = 0.80 is generally recommended.

A CIPP design is compliant since Equations 3 and 6 are satisfied (as guided by Equation 4). The greatest result from Equations 3 and 6 controls and establishes the MAOP of the CIPP.