

PMG LISTING CRITERIA FOR INTERNAL EPOXY BARRIER COATING MATERIAL FOR REHABILITATION OF METALLIC FUEL GAS PIPE

LCXXXX

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PREFACE

Plumbing, mechanical and fuel gas (PMG) listings issued by ICC Evaluation Service, Inc. (ICC-ES), are based upon performance features of the *International Plumbing Code*®, *International Mechanical Code*®, *International Residential Code*®, *Uniform Plumbing Code* and *Uniform Mechanical Code*. Section 105.2 of the *International Plumbing Code*® reads as follows:

Alternative materials, methods and equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material or method of construction shall be approved where the code official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

Similar provisions are contained in the Uniform Codes.

ICC-ES may consider alternate listing criteria, provided the listing applicant submits valid data demonstrating that the alternate listing criteria are at least equivalent to the listing criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria set forth in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria in this document and otherwise demonstrate compliance with the performance features of the codes, ICC-ES retains the right to refuse to issue or renew a listing, if the product, material, or type or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause unreasonable property damage or personal injury or sickness relative to the benefits to be achieved by the use of the product, material, or type or method of construction.

Listing criteria are developed solely for use by ICC-ES for purposes of issuing ICC-ES PMG listings.

1.0 INTRODUCTION

1.1 Purpose: The purpose of this listing criteria is to establish requirements for internal epoxy barrier pipe coating materials for rehabilitation of metallic fuel gas pipe to be recognized in an ICC Evaluation Service, Inc. (ICC-ES), listing.

1.2 Scope: This listing criteria is intended to establish the minimum criteria necessary for the use of a proprietary, mechanically mixed, blended, epoxy barrier coating that is mechanically applied to the interior of above and below ground ½" to 2" rigid metallic fuel gas pipe within the building footprint. This epoxy barrier coating is intended for use in pipelines that transport natural (NG) and liquid propane (LP) gases, where resistance to gas permeation, ground movement, internal corrosion, leaking joints, pinholes, and chemical attack are required. Any non-metallic pipe sections, and any gasketed connections or valves shall be removed before coating and replaced as applicable after coating installation. These criteria do not address the coating of plastic, corrugated, or other flexible gas pipe.

1.2.1 The coating shall not be installed on non-metallic pipe or main gas line applications.

1.2.2 In the case of a remediated metallic fuel gas pipe, the internal coating is intended to be adherent to the substrate and to act as a barrier coating with respect to the prevention of internal corrosion and the sealing of minor pinhole leaks. The coating is not intended (or expected) to function in any kind of structural capacity, other than the sealing of threaded joints and sealing of limited pin-hole corrosion (within the range of the calculated allowable leakage), with the primary gas pressure containment continuing to be provided by the structural host pipe.

1.3 Codes and Referenced Standards:

Note: Any standard referenced herein shall be the current edition of that standard. In instances where the applicable code references a different edition of a given standard, the applicant shall also provide documentation of conformance with the code referenced standard edition.

1.3.1 *International Fuel Gas Code*® (IFGC). International Code Council.

1.3.2 *International Residential Code*® (IRC). International Code Council.

1.3.3 ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM International.

1.3.4 ASTM D543, Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents, ASTM International.

- 1.3.5** ASTM D638, Standard Test Method for Tensile Properties of Plastics, ASTM International.
- 1.3.6** ASTM D714, Standard Test Method for Evaluation of Blistering of Paints, ASTM International.
- 1.3.7** ASTM D1434, Standard Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting, ASTM International.
- 1.3.8** ASTM D2240, Standard Test Method for Rubber Property — Durometer Hardness, ASTM International.
- 1.3.9** ASTM D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity, ASTM International
- 1.3.10** ASTM D3167, Standard Test Method for Floating Roller Peel Resistance of Adhesives, ASTM International
- 1.3.11** ASTM D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers, ATM International (see alternative ISO 4624)
- 1.3.12** ASTM D5402, Standard Practice for Assessing the Solvent Resistance of Organic Coatings using Solvent Rubs, ASTM International
- 1.3.13** ASTM E2105, Standard Practice for General Techniques of Thermogravimetric Analysis (TGA) Coupled with Infrared Analysis (TGA/IR), ASTM International.
- 1.3.14** ASTM G62, Standards Test Methods for Holiday Detection in Pipeline Coatings, ASTM International.
- 1.3.15** AWWA C210, Liquid-Epoxy Coating and Lining for Steel Water Pipe and Fittings, American Water Works Association.
- 1.3.16** CAN-CSA-Z245.20, Plant-Applied External Coatings for Steel Pipe, CSA Group.
- 1.3.17** ISO 8503-1, Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces, ISO.
- 1.4** Definitions: Definitions shall be in accordance with the referenced standards.

2.0 BASIC INFORMATION

2.1 Product Description: A proprietary, mechanically mixed, blended, epoxy barrier coating system that is applied by an air vortex to the interior of above and below ground rigid metallic fuel gas pipe within the building footprint.

2.1.1 Product and Packaging Identification: The product packaging shall be permanently and legibly marked with the manufacturer's name or trademark, and the product name. The product shall bear the PMG® listing mark. The ICC-ES listing number shall be placed on the listed product's packaging or installation instructions. The methods of field identification of the lined piping shall be specified.

2.2 Applicability for Use: The minimum barrier coating wall thickness, pipe sizes that can be coated and piping material and existing piping imperfections that can be coated shall be in accordance with the manufacturer's specifications.

2.3 Condition Assessment and Applicability for Use: The system manufacturer's installation instructions shall specify the required host pipe condition assessment measures.

2.3.1 Host Pipe Condition Assessment – External: A visual external piping survey of as close to 100% as possible of the existing, exposed (not concealed within the structure of the building) pipework to be coated shall be undertaken to identify any signs of external corrosion or damage.

2.3.1.1 Wall Thickness Loss – External: Where external corrosion is identified, an assessment of its extent shall be completed by estimating the % loss of wall thickness. The estimated % loss of wall thickness shall be calculated by dividing the depth of any external corrosion by the wall thickness of the pipe.

Example:

Depth of corrosion measured with a pit gauge = 2mm

Wall thickness of pipe without corrosion = 2.9mm

% loss of wall thickness = $(2/2.9) \times 100 = 68\%$

Any external corrosion location with calculated wall thickness loss greater than 50% shall be deemed unsuitable for coating. Note: Localized pin-holing that does not exceed the Permissible Leakage Limit requirements, as described below, may be coated.

2.3.1.2: **Inaccessible Pipes:** Where entry to any location within the building prevents the external visual inspection of the pipework, a decision will be made after consultation with the building and/or asset owner as to whether to proceed with the coating process.

2.3.2 Host Pipe Condition Assessment – Internal: By assessing the level of internal corrosion and cleaning requirements, combined with measuring the pre-renovation leakage rate of the pipe, the installing contractor can further assess the host pipe condition to determine applicability for coating.

2.3.2.1 **Permissible Leakage:** The coating system manufacturer's installation instructions shall include a means of Pressure Loss Analysis with Permissible Leakage Limit requirements for the host piping system as an additional assessment of the condition of the host pipe and the applicability for coating.

2.3.2.1.1 **Permissible Leakage Calculator:** The system manufacturer shall provide a scientifically validated Permissible Leakage Calculator for use with their coating system to determine whether the barrier coating can be successfully applied to the interior of a host pipe system. The Permissible Leakage Calculator shall rely upon site measured pressure drops in proportion to the volume of the pipe to determine a volume threshold ($\text{m}^3 \text{hr}^{-1}$) which shall dictate applicability for use.

2.3.2.1.2 **Leakage Point Repairs:** Localized host pipe repairs can be utilized to bring the permissible leakage within acceptable tolerances.

2.4 Installation Instructions: The barrier coating shall be installed in accordance with the manufacturer's instructions, and the applicable requirements of the relevant codes and reference standards in Section 1.3. The system manufacturer's installation instructions shall specify the certification requirements for the installing contractor (which shall include a training program) and the required equipment and means for proper installation. The system manufacturer's installation instructions shall specify the pre-coating field preparation measures, the parameters governing the proper application of the coating, and the post-installation pipe system labeling requirements.

2.4.1 Host Pipe Preparation for Coating: The system manufacturer's installation instructions shall include a description of the required methods of host pipe condition assessment and suitable methods of host pipe preparation (cleaning and ensuring an adequate "anchor tooth").

2.4.1.1 **Pipe Cleaning:** The manufacturer's installation instructions shall include guidance regarding the visual observation of the quality and cleanliness of the pipe to be coated.

2.4.1.1.1 As a minimum requirement, the cleaned surface, when viewed without magnification, shall be free of visible concentrations of oil, grease, dirt, mill scale, rust, and previously applied, disbonded coatings. Evenly dispersed, very light shadows, streaks, and discolorations caused by stains of mill scale, rust and old coatings shall be permitted to remain on no more than 33 percent of the surface. Slight residues of rust and old coatings shall be permitted to be left in the craters of pits if the original surface is pitted.

2.4.1.1.2 After host pipe preparation, the contractor shall use a visual field comparator as per ISO 8503-1 and manufacturer's specifications to verify proper anchor tooth at a minimum of either 4 locations or 25% of the entry and exit points, whichever is greater.

2.4.2 Pipe Coating: The manufacturer's installation instructions shall be followed and shall include instructions on proper resin mixing procedures, coating application parameters (including volume calculators and shot plans), identification of key "hold and witness" points for quality assurance during construction, and piping system reassembly and recommissioning requirements.

2.4.3 Post-Installation Labeling: The manufacturer's installation instructions shall include a requirement for labeling the system to indicate that an epoxy coating has been applied to the piping. The labeling shall include a prohibition on the use of flame or heat to repair any part of the piping system. The label shall indicate the name of the manufacturer of the coating and shall include a disclaimer not to replace the pipes without contacting the coating manufacturer. The labels can either be permanent decals or tags approved by the Authority Having Jurisdiction and shall be located outside of the pipe at all valves changed outs, at curb stop valves, at pipe access points and in systems along pipes at intervals not to exceed 20 feet except for existing piping located in concealed and inaccessible areas.

3.0 SYSTEM QUALIFICATION AND PERFORMANCE REQUIREMENTS

3.1 Test Samples: Qualification test pipe samples shall be prepared by the coating system manufacturer for each applicable host pipe material specified by the manufacturer; steel panels are also prepared by the coating system manufacturer for generalized representative qualification testing. Each of the samples shall be coated according to the manufacturer's installation instructions and allowed to cure for 24 hours at room temperature. The samples shall be subjected to the tests specified in Sections 4.2 through 4.5.

3.1.1 Sample Preparation: Manufacturer pipe samples and steel panels required for laboratory testing are to be suitably coated for use as representative samples to simulate the quality of the as-built coating system intended for use in the piping system. Preparation of the sample surface prior to coating may include abrasive blasting to achieve a proper surface profile. The desired “anchor tooth” reading will be determined by the manufacturer as per field application specifications. A wet film preparation device such as a Film Coating Applicator can be used to evenly apply the epoxy onto the surface of the test panel.

3.2 Qualification Testing Submittals: The qualification (validation) test data used to qualify a coating system for use is not project performance specific, but rather system design specific. These tests shall be recognized as qualification tests to be performed once for each class of installed coating and do not require repeating unless the materials and/or methods are altered; qualification testing requirements are explicitly not intended to be used as post-construction field verification requirements.

3.2.1 Thickness Measurement: After curing, the coating thickness shall be measured using an appropriate device for determining Dry Film Thickness (DFT) of coatings. Coatings shall meet the minimum required thickness within the allowable tolerance range [e.g. 250 microns (allowable tolerances of +1000/-90)]. DFT readings shall be taken from at least four points evenly distributed around the test sample. For example: 3, 6, 9, & 12 o'clock for pipe samples.

3.2.2 Pull-off Adhesion Strength Test: A manufacturer's plate sample shall be laboratory tested for resistance to pull-off of the epoxy barrier coating in accordance with ASTM D4541. The minimum pull-force adhesion shall be 2500 psi, as per Protocol 2. (Note that the precision and bias statements for this test show considerable variability across round robin testing results.)

3.2.3 Hardness Test: A manufacturer's plate sample shall be laboratory tested in accordance with ASTM D2240 for durometer hardness. The hardness of the coating shall comply with the manufacturer's published tolerances.

3.2.4 Chemical Resistance Test: Manufacturer prepared samples shall be laboratory tested according to ASTM D 543, Practice B for resistance to the chemicals listed in table 1. Weight of the test specimens shall not increase by more than 14% nor decrease by more than 3% and test specimens shall retain at least 80% both of its hardness, when measured in accordance with Test Method ASTM D2240, and of peeling strength, when measured in accordance with Test Method ASTM D3167.

Table 1: Chemical Resistivity List of Reagents

Liquids	Test Composition
Water (External and Internal)	Freshly prepared distilled water (in accordance with Practice D 543)
Gasoline (External)	Gasoline-Automotive Spark-Ignition Engine Fuel per Specification D 4814
Gas Condensate (Internal)	70 % volume isooctane + 30 % volume toluene
Methanol	20 % volume methanol + 80 % volume distilled water
Triethylene Glycol	10 % volume triethylene glycol + 90 % volume distilled water
Brine Solution	10 % mass NaCl solution made up with a balance of distilled water
Mineral Oil	100 % White Mineral Oil USP, specific gravity 0.830 to 0.860, Saybolt at 100°F: 125 to 135 s, in accordance with Practice D 543
Isopropanol	10 % volume isopropanol + 90 % volume distilled water
Sulfuric Acid	5 % weight (of total solution) H ₂ SO ₄ in distilled water
Surfactants	5 % mass (of solution weight) dehydrated pure white soap flakes (dried 1 h at 105°C) dissolved in distilled water, in accordance with Practice D 543
Mercaptans	2 % volume tertiary butyl mercaptan + 98 % volume mineral oil, white, USP

3.2.5 Gas Blistering: A manufacturer's test panel shall be laboratory tested for gas blistering and appearance in accordance with ASTM D714.

3.2.5.1 Humidity resistance: A manufacturer's test panel shall be laboratory tested with 100% relative humidity exposure as specified in ASTM D2247 for 500 hours. There shall be no blistering or delamination.

3.2.7 Salt spray resistance: A manufacturer's test panel shall be subjected to salt spray conditioning as specified in ASTM B117 for 500 hours. There shall be no blistering, delamination.

3.2.8 Gas Permeability: A manufacturer's test panel shall be subjected to laboratory testing for gas permeability in accordance with ASTM D1434. For reference data only because there is no pass or fail requirement.

3.2.9 Evolved Gas Analysis: A manufacturer's test panel shall be subjected to laboratory testing for evolved gas analysis in accordance with ASTM E2105.

3.2.10 Rating Class Determination: A manufacturer's test panel shall be subjected to micro-sectioning in accordance with CAN-CSA-Z245.20 to evaluate the rating class.

3.2.11 Cissing and Pin Holing: A manufacturer's test panel shall be subjected to laboratory testing for Holiday Detection in accordance with Method A of ASTM G62.

3.2.12 Cure Schedule Determination: The manufacturer's Recommended Cure Schedules shall be supported by laboratory validation testing in accordance with ASTM D5402 with a minimum of 10 "double rubs" using isopropyl alcohol in order to qualitatively validate an adequate cure schedule for safe return to service.

3.2.13 Validation of Construction Thickness: The ability to deliver the specified coating thickness shall be scientifically validated.

3.2.13.1 A test assembly simulating typical site conditions shall be set up for coating application utilizing a 1-inch-diameter pipe that is 50 feet in length. Fittings shall be used to simulate an actual installation.

3.2.13.2 The test assembly shall be coated in accordance with the coating tables in the manufacturer's installation instructions.

3.2.13.3 The coated assembly shall be allowed to cure at room temperature for 24 hours.

3.2.13.4 The thickness of the coating shall be measured at both the last fitting and at the outlet end of the test assembly. The minimum "as-built" coating thickness shall be as specified by the manufacturer [e.g. 250 microns] with an allowable tolerance of +1000 / -90 microns.

3.2.13.5 A mathematical evaluation of the coating tables in the manufacturer's installation instructions shall be performed, based on the test results for the 1-inch pipe, to confirm that the minimum coating thickness can be provided.

4.0 QUALITY CONTROL / VERIFICATION TEST METHODS AND REQUIREMENTS

Post-construction, representative samples from the project shall verify as-built compliance with the key performance property requirements.

4.1 Post-Construction Thickness Verification: Field thickness verification measurements shall be performed at every entry and exit point with Dry Film Thickness (DFT) readings taken from at least four points evenly distributed around the pipe ends to verify performance compliance of the epoxy barrier coating material with the required minimum thickness. The minimum "as-built" coating thickness shall be as specified by the manufacturer [e.g. 250 microns] with an allowable tolerance of +1000 / -90 microns.

4.2 Verifying Safe Return to Service

4.2.1 CCTV visual inspection: The contractor shall internally inspect as much of the coated piping system as is practical with a CCTV camera system to visually confirm proper application. A recording of the CCTV inspections shall be provided.

4.2.2 Epoxy cure verification: Adequate curing for safe return to service shall be field verified at every entry and exit point with 10 “double rubs” with isopropyl alcohol inside the coated pipe, as per ASTM D5402.

4.2.3 Pressure test: Prior to acceptance and return to operation, all sections of the coated piping system shall be pressure tested in accordance with the requirements of Section 406 (IFGS) “Inspection, Testing, and Purging” of the ICC International Fuel Gas Code.

5.0 LISTING RECOGNITION

5.1 The listing shall state that this coating process is not approved as a method for structurally repairing and concealing large fractures, holes, leaks or other structural imperfections in the piping system; the primary gas pressure containment will continue to be provided by the host pipe.

5.2 The listing shall specify the minimum thickness of the epoxy barrier coating material.

5.3 The listing shall specify the type of rigid pipe material allowed to be coated with the epoxy barrier coating and shall not be applied for operation across fittings or joints which are designed to allow mechanical flexibility in the system.

5.4 The listing shall specify the minimum and maximum pipe (1/2" to 2") which may be lined with the applicant's system.

5.5 The listing shall contain flow tables identifying the flow rate and pressure drop at various velocities.
(waiting to hear back if this is possible with coated pipes transporting gas)

5.6 The listing shall contain the minimum surface preparation requirements for the inside wall of the pipe prior to coating of the pipe or tubing.

5.7 The listing shall state that the installing contractor must be trained and certified by the coating manufacturer and only personnel or contractor's approved and authorized by the manufacturer of the coating system are allowed to use the process approved under the evaluation report.

5.8 The listing shall state that all non-metallic components, as well as gasketed joints, and valves shall be removed prior to installation of the coating.

5.9 The listing shall state that corrugated metal pipe are outside of the scope of evaluation.

5.10 The coating shall not be used on plastic, corrugated, or other flexible fuel gas pipe.

5.11 The SDS or TDS shall include the flashpoint data for the raw resin, as per the SDS or TDS for the raw material supplier's resin.

5.12 The listing shall state that the contractor shall internally inspect as much of the coated piping system as is practical with a CCTV camera system to visually confirm proper application and pressure tests for leaks in the presence of the code official or the official's designated representative. In addition, the system shall be approved for the intended purpose by the authority having jurisdiction. Technical documentation shall be submitted to the authority having jurisdiction.

5.13 The listing shall state that all appliances shall be disconnected prior to the installation of the coating and the appliances shall not be reinstalled until after full curing has occurred. Any older or damaged valves are to be replaced with applicable code approved valves for the flow and pressure demand in the system. Appliances shall be turned on and observed for proper operation after installation.

5.14 The listing shall state that the epoxy barrier coating shall only be used in pipelines that transport natural (NG) and liquid propane (LP) gases.