



**American Water Works
Association**

ANSI/AWWA C210-07
(Revision of ANSI/AWWA C210-03)

The Authoritative Resource on Safe Water®

AWWA Standard

Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines



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6666 West Quincy Avenue
Denver, CO 80235-3098
T 800.926.7337
www.awwa.org

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Committee Personnel

The Steel Water Pipe-Manufacturer's Technical Advisory Committee (SWPMTAC) Task Group on C210, which developed this revision, had the following personnel at the time:

Mike Bauer, *Chair*

F.D. Barnes, Barnes Group International, Windsor, Calif.	(AWWA)
M. Bauer, Themec Company Inc., Kansas City, Mo.	(AWWA)
R.M. Buchanan, Canusa-CPS, Toronto, Ont.	(AWWA)
T. Enoch, Carboline Company, Ottsville, Pa.	(AWWA)
A. Fletcher, Tyco Water Pipelines Technologies, Southbank, Victoria, Australia	(AWWA)
A.L. Mamish, Covalence Adhesives, Lexington, Mass.	(AWWA)
L. McKinney, Womble Company, Houston, Texas	(AWWA)
B. Murphy, Sherwin-Williams Company, Villanueva, N.M.	(AWWA)
R. Newby, ICI Devoe Coatings, Mandeville, La.	(AWWA)
F. Rampton, Trenton Corporation, Ann Arbor, Mich.	(AWWA)
M. Sangalli, Smith-Blair Inc., Texarkana, Texas	(AWWA)
R.N. Satyarthi, Baker Coupling Company Inc., Los Angeles, Calif.	(AWWA)
D. Seals, JCM Industries, Nash, Texas	(AWWA)
H.R. Stoner, Consultant, North Plainfield, N.J.	(AWWA)
D.R. Wagner, Wagner Consultants, St. Louis, Mo.	(AWWA)

The AWWA Standards Committee on Steel Pipe, which reviewed and approved this standard, had the following personnel at the time of approval:

John H. Bambei Jr., *Chair*

George J. Tupac, *Vice Chair*

Dennis A. Dechant, *Secretary*

General Interest Members

J.B. Allen,* Standards Engineer Liaison, AWWA, Denver, Colo.	(AWWA)
W.R. Brunzell, Brunzell Associates Ltd., Skokie, Ill.	(AWWA)
R.L. Coffey, HDR Engineering, Inc., Omaha, Neb.	(AWWA)

* Liaison, nonvoting

H.E. Dunham, MWH Inc., Bothell, Wash.	(AWWA)
S.N. Foellmi, Black & Veatch Corporation, Irvine, Calif.	(AWWA)
J.W. Green, McDonough Associates Inc., Chicago, Ill.	(AWWA)
M.B. Horsley,* Black & Veatch Corporation, Kansas City, Mo.	(AWWA)
J.K. Jeyapalan, Consultant, New Milford, Conn.	(AWWA)
J.L. Mattson, Corrosion Control Technologies, Sandy, Utah	(AWWA)
R. Ortega, Lockwood Andrews & Newnam, Houston, Texas	(AWWA)
A.E. Romer, Boyle Engineering Corporation, Newport Beach, Calif.	(AWWA)
H.R. Stoner, Consultant, North Plainfield, N.J.	(AWWA)
C.C. Sundberg, CH2M Hill Inc., Issaquah, Wash.	(AWWA)
G.J. Tupac, G.J. Tupac & Associates Inc., Pittsburgh, Pa.	(AWWA)
W.R. Whidden, Post Buckley Schuh & Jernigan, Orlando, Fla.	(AWWA)
K.E. Wilson,† Standards Council Liaison, Post Buckley Schuh & Jernigan, Tampa, Fla.	(AWWA)

Producer Members

S.A. Arnout, Hanson Pressure Pipe Inc., Dallas, Texas	(AWWA)
H.H. Bardakjian, Ameron International, Rancho Cucamonga, Calif.	(AWWA)
M. Bauer, Tnemec Company Inc., Kansas City, Mo.	(AWWA)
R.J. Card, Victaulic, Atlanta, Ga.	(AWWA)
R.R. Carpenter, American Spiralweld Pipe Company, Birmingham, Ala.	(MSS)
D. Dechant, Northwest Pipe Company, Denver, Colo.	(AWWA)
B.D. Keil, Continental Pipe Manufacturing Company, Pleasant Grove, Utah	(SPEA)
J.L. Luka,* American Spiral Weld Pipe Company, Columbia, S.C.	(AWWA)
B.F. Vanderploeg,* Northwest Pipe Company, Portland, Ore.	(AWWA)
J.A. Wise, Canus International Sales Inc., Surrey, B.C.	(AWWA)

User Members

A. Andersen, New York City Bureau of Water Supply, Little Neck, N.Y.	(AWWA)
J.H. Bambei Jr., Denver Water, Denver, Colo.	(AWWA)
D.W. Coppes, Massachusetts Water Resources Authority, Southborough, Mass.	(NEWWA)
R.V. Frisz, US Bureau of Reclamation, Denver, Colo.	(USBR)

* Alternate

† Liaison, nonvoting

G. George, Tacoma Water, Water Supply Section, Tacoma, Wash.	(AWWA)
T.J. Jordan, Metropolitan Water District of Southern California, La Verne, Calif.	(AWWA)
M. McReynolds,* Metropolitan Water District of Southern California, La Mirada, Calif.	(AWWA)
G. Oljaca, Greater Vancouver Regional District, Burnaby, B.C.	(AWWA)
V.B. Soto, Los Angeles Department of Water & Power, Los Angeles, Calif.	(AWWA)
G.P. Stine, San Diego County Water Authority, Escondido, Calif.	(AWWA)
J.V. Young, City of Richmond, Richmond B.C.	(AWWA)

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*Alternate

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA C210.

I. Introduction.

I.A. *Background.* This standard was developed to provide information for the use of liquid epoxy coatings for the exterior coating and interior lining of steel water pipe. The standard has been revised periodically to meet increasingly demanding environmental and health-effects regulations and to modify procedures based on technological advances.

I.B. *History.* The first edition of ANSI/AWWA C210 was approved for issue in May 1978 under the title “Coal-Tar Epoxy Coating System for the Interior and Exterior of Steel Water Pipe.” The second and third editions were approved on June 10, 1984, and June 18, 1992, respectively, and published under the title “Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.” The fourth edition of ANSI/AWWA C210 was approved by the AWWA Board of Directors on June 15, 1997. The fifth edition was approved on Jan. 19, 2003. This edition was approved on June 24, 2007.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for direct and indirect drinking water additives. Other members of the original consortium included the American Water Works Association Research Foundation (AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (AWWA) and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States, authority to regulate products for use in, or in contact with, drinking water rests with individual states.* Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. An advisory program formerly administered by USEPA, Office of Drinking Water, discontinued on Apr. 7, 1990.
2. Specific policies of the state or local agency.

* Persons outside the United States should contact the appropriate authority having jurisdiction.

3. Two standards developed under the direction of NSF, NSF*/ANSI† 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.

4. Other references, including AWWA standards, *Food Chemicals Codex*, *Water Chemicals Codex*,‡ and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI 61. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdiction. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

Annex A, “Toxicology Review and Evaluation Procedures,” to NSF/ANSI 61 does not stipulate a maximum allowable level (MAL) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of “unregulated contaminants” are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA C210 does not address additives requirements. Thus, users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements, including applicable standards.
2. Determine the status of certifications by parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

II. Special Issues. This standard provides guidance to the water industry in selecting and evaluating liquid epoxy coatings for use in potable water service, and sets minimum requirements for linings and coatings used on steel water pipe in the potable water supply industry.

Users of this standard are advised to consider additional lining thickness for pipe that handles water containing higher than normal levels of particulates or that operates at higher than normal velocities. A penstock carrying mountain water would be a viable example. The required finished coating thickness shall be specified by the purchaser. The specified thickness should not exceed the maximum recommended by the coating manufacturer.

Soluble salts and other inorganic contaminants on a prepared steel surface have been

*NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48113.

†American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

‡Both publications available from National Academy of Sciences, 500 Fifth Street, N.W., Washington, DC 20418.

known to influence coating performance. Procedures for determining the presence of these contaminants as well as the method of quantifying them are currently being evaluated by technical organizations serving the paint industry.

If an extended period of aboveground storage of the coated pipe is anticipated, consideration should be given to the ability of the coating to resist degradation by ultraviolet light and other atmospheric and environmental conditions. The purchaser should consult the manufacturer for specific conditions and limitations.

This standard does not describe materials and procedures that may be required for difficult conditions, such as those encountered in construction of some submarine lines, casing pipe, river crossings, and rocky areas.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

III.A. Purchaser Options and Alternatives. The following items should be provided by the purchaser:

1. Standard used—that is, ANSI/AWWA C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines, of latest revision.
2. Whether compliance with NSF/ANSI 61 Drinking Water System Components—Health Effects is required, in addition to the requirements of the Safe Drinking Water Act.
3. Any exceptions to the standard.
4. Diameter, length, and location of pipeline.
5. Materials and safety (Sec. 4.2).
6. Details of other federal, state or provincial, and local requirements (Sec. 4.2.2).
7. Government regulations (Sec. 4.2.2).
8. The minimum and maximum dry film thickness (DFT) of the lining or coating (Sec. 4.3.2).
9. Visual comparative standard for surface preparation (Sec. 4.4.2.3).
10. Profile determination (Sec. 4.4.2.2).
11. Requirements for coating application (Sec. 4.4.3).
12. Holdback for field welds (Sec. 4.4.3.2).
13. Requirements for field joint coating (Sec. 4.6).
14. Coating requirements for special connections and appurtenances (Sec. 4.7).
15. Provisions for bedding and trench backfill (Sec. 4.8.3).
16. Requirements for material inspection and rejection (Sec. 5.1 and 5.3).
17. Requirements for adhesion testing of coating (Sec. 5.1.6).
18. Packaging, handling, stacking, and storage (Sec. 6.2).

19. Affidavit of compliance, if required (Sec. 6.3).

III.B. *Modification to Standard.* Any modification to the provisions, definitions, or terminology in this standard must be provided by the purchaser.

IV. Major Revisions. Major changes made to the standard in this edition include the following:

1. Table 1 and Sec. 5.1.6—Minimum adhesion in accordance with ASTM D4541 has been increased.

2. Table 2 and Sec. 5.2—Cathodic disbondment qualification testing has been added.

3. Sec. 4.4.2—Pipe preparation was revised.

V. Comments. If you have any comments or questions about this standard, please contact the AWWA Volunteer & Technical Support Group at 303.794.7711, FAX at 303.795.7603, write to the group at 6666 West Quincy Avenue, Denver, CO 80235-3098, or e-mail at standards@awwa.org.

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American Water Works
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ANSI/AWWA C210-07
(Revision of ANSI/AWWA C210-03)

AWWA Standard

Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard sets minimum requirements for shop- and field-applied, liquid-epoxy interior linings and exterior coatings used in the water-supply industry for steel water pipelines installed underground or underwater, under normal construction conditions.

1.1.1 *Conditions not described in this standard.* The coating systems described in this standard are not intended for use on pipe that will be bent after the coating or lining system has been applied.

1.1.2 *Coating and lining systems.* The coating and lining systems may consist of any of the following three types: (1) a two-part, chemically cured epoxy primer and one or more coats of a different two-part, chemically cured epoxy top-coat; (2) two or more coats of the same two-part, chemically cured epoxy coating, in which case the first coat shall be considered as the prime coat; or (3) a single coat of a two-part, chemically cured epoxy coating.

1.1.2.1 Maximum temperature. AWWA steel pipe coating standards are based on the maximum service temperature of water. The purchaser shall consult the coating manufacturer for conditions and limitations.

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for liquid-epoxy coating systems for the interior and exterior of steel water pipelines, including material, application, inspection, testing, performance requirements, handling, and packaging requirements.

Sec. 1.3 Application

This standard can be referenced in specifications for liquid-epoxy coating systems for the interior and exterior of steel water pipelines. The stipulations of this standard apply when this document has been referenced and then only to liquid-epoxy coating systems for the interior and exterior of steel water pipelines.

SECTION 2: REFERENCES

This standard references the following documents. In their latest editions, they form a part of this standard to the extent specified within the standard. In any case of conflict, the requirements of this standard shall prevail.

ANSI*/AWWA C203—Coal-Tar Protective Coatings and Linings for Steel Water Pipelines—Enamel and Tape—Hot-Applied.

ANSI/AWWA C209—Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.

ANSI/AWWA C214—Tape Coating Systems for the Exterior of Steel Water Pipelines.

ANSI/AWWA C215—Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines.

ANSI/AWWA C216—Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.

ANSI/AWWA C217—Cold-Applied Petrolatum Tape and Petroleum Wax Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Buried or Submerged Steel Water Pipelines.

*American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

ANSI/AWWA C222—Polyurethane Coatings for the Interior and Exterior of Steel Water Pipelines and Fittings.

ASTM* D3359—Standard Test Methods for Measuring Adhesion by Tape Test.

ASTM D3363—Standard Test Method for Film Hardness by Pencil Test.

ASTM D4417—Standard Test Method for Field Measurement of Surface Profile of Blast Cleaned Steel.

ASTM D4541—Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

ASTM D4752—Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub.

ASTM G8—Test for Cathodic Disbonding of Pipeline Coatings.

NACE† RP0188—Discontinuity (Holiday) Testing of Protective Coatings.

SSPC-AB 1—Mineral and Slag Abrasives.

SSPC-AB 3—Steel Abrasives.

SSPC‡-PA 2—Measurement of Dry Paint Thickness with Magnetic Gages.

SSPC-PA 3—Guide to Safety in Paint Application.

SSPC-SP 1—Solvent Cleaning.

SSPC-SP 10/NACE No. 2—Near-White Blast Cleaning.

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. *Constructor*: The party that provides the work and materials for placement or installation.
2. *Manufacturer*: The party that manufactures, fabricates, or produces materials or products.
3. *Purchaser*: The person, company, or organization that purchases any materials or work to be performed.

*ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

†NACE International, 1440 South Creek Drive, Houston, TX 77084.

‡SSPC: The Society for Protective Coatings, 40 24th Street, Pittsburgh, PA 15222.

SECTION 4: REQUIREMENTS

Sec. 4.1 Equipment

The constructor's equipment for abrasive blast cleaning and coating shall be of such design, manufacture, and condition to permit the constructor to comply with the procedures and obtain the results prescribed in this standard.

Sec. 4.2 Materials and Safety

4.2.1 *Materials.* Materials shall comply with the requirements of the Safe Drinking Water Act and other federal requirements.

4.2.2 *Safety.* Necessary precautions shall be taken to protect personnel and property from accidents caused by falls, hazardous materials, fire, explosion, and other dangers. The methods and practices defined in SSPC-PA 3 shall be followed, along with those prescribed by applicable federal, provincial, state, and local regulations.

Sec. 4.3 Coating System

4.3.1 *Liquid-epoxy coatings.* The coatings used in this standard shall be based on liquid chemically cured epoxies. The curing agent may be an amine, amine-adduct, phenalkamine, polyamide, or other epoxy curing agents; the epoxy may be modified with coal tar, phenolic, or other modifiers. Materials used in both the primer and finish coat(s) shall be products of one manufacturer.

4.3.1.1 *Shelf life.* The component parts shall be stored in unopened original containers at temperatures not to exceed the manufacturer's recommendation. They shall show no instability or settling beyond a state permitting easy, complete redispersion to a smooth, homogeneous consistency. When properly mixed and applied, acceptable drying and curing will result. Stored material that has exceeded the manufacturer's stated shelf life shall not be used.

4.3.2 *Coating thickness.* The minimum and maximum dry film thickness (DFT) of the lining and external coating shall be specified by the purchaser. Dry film thickness shall conform to the manufacturer's printed data and shall be tested in accordance with SSPC-PA 2.

4.3.2.1 *Minimum thickness.* Unless otherwise specified by the purchaser, the minimum DFT provided shall be at least 16 mils (406 μm), as shown in Table 1.

Table 1. Coated pipe inspection tests

Test	Minimum Requirement	Method
Electrical inspection (holidays)		Sec. 5.1.5
Adhesion		
a. ASTM D3359 (Method A)	4A	Sec. 5.1.6
b. ASTM D4541 psi (kPa)	800 psi (5,515 kPa)	Sec. 5.1.6
Thickness, dry film, mils (μm)	16 mils (406 μm)	Sec. 4.3.2.1
		Sec. 5.1.4

Table 2. Qualification requirements of laboratory-applied epoxy coating system

Test	Minimum	Maximum	Method
Immersion and vapor phase, 30 days			Sec. 5.2.1.1
a. Deionized water	Pass		
b. Sulfuric acid, 1 percent by wt.	Pass		
c. Sodium hydroxide, 1 percent by wt.	Pass		
Cathodic disbondment		9.53 mm (0.38 in.) radius	Sec. 5.2.1.2

4.3.3 *Applied, cured coating requirements.* After curing but prior to burial, the coating system shall be a continuous film, free of thin spots and other imperfections as defined in Sec. 5.1, and shall pass electrical inspection for continuity defined in Sec. 5.1.5.

4.3.4 *Coated pipe inspection tests.* The inspection test requirements for shop or field-applied epoxy coating systems are stated in Table 1.

4.3.5 *Qualification requirements.* Minimum cured film requirements for laboratory-applied epoxy coating systems are stated in Table 2.

Sec. 4.4 Coating Application

4.4.1 *General.* The pipe coating shall be applied in accordance with the manufacturer's recommendations. Application by airless spray or centrifugal wheel equipment is preferred. Application by other methods is allowed for pipe connections and appurtenances in accordance with Sec. 4.7.

4.4.2 Pipe preparation.

4.4.2.1 *Cleaning.* Prior to abrasive blast cleaning, surfaces shall be inspected and, if required, cleaned according to SSPC-SP 1 to remove oil, grease, or other foreign matter. Only prevailing code safety solvents that do not leave a residue shall be used. Preheating to remove oil, grease, mill scale, water, and ice may be used, provided the pipe is preheated in a uniform manner to avoid

distorting the pipe.

4.4.2.2 Abrasive blast cleaning. Pipe surfaces shall be abrasive blast cleaned with mineral abrasives, slag abrasives, steel shot, or steel grit (reference SSPC Abrasive Specifications SSPC-AB 1 and SSPC-AB 3) in accordance with SSPC-SP 10/NACE No. 2. The blast anchor pattern or profile depth shall be 2.0 mils to 4.0 mils (50 μm to 100 μm) measured in accordance with ASTM D4417. When using steel abrasives, a sufficient quality of steel grit shall be provided to ensure an angular blast profile is achieved.

4.4.2.3 Visual comparative standards. Prior to abrasive blast cleaning, the constructor shall prepare a representative area of the abrasive blast-cleaned surface on the actual work surface, as well as a visual comparative standard on steel panels that are a minimum of 6 in. \times 6 in. \times 0.25 in. (150 mm \times 150 mm \times 6 mm) steel panels. On agreement with the purchaser and constructor that the visual standard meets the requirements of Sec. 4.4.2.2, the panels shall be wrapped in 4-mil to 6-mil (100- μm to 150- μm) thick plastic, sealed with tape or otherwise protected from surface contamination or corrosion, and maintained as visual reference standards throughout the coating operations. Alternatively, other industry-accepted visual comparative standards, such as those provided by NACE or SSPC and agreed on by the purchaser and constructor, may be used.

4.4.2.4 Abrasive working mix. When blasting equipment is employed using a recycled abrasive working mix, the abrasive working mix shall be maintained free of contaminants (oil, water, etc.).

4.4.2.5 Surface inspection. The cleaned exterior and interior pipe surfaces shall be inspected for conformance to Sec. 4.4.2.2 and 4.4.2.3. Surface imperfections, such as slivers, scabs, burrs, weld splatter, and gouges, shall be removed by grinding. Ground areas shall meet the profile (anchor pattern) requirements of the coating manufacturer. Imperfections may dictate that the pipe joint be rejected.

4.4.2.6 Interior cleaning. If abrasives or other loose foreign matter has entered the interior of the pipe, clean, dry, oil-free compressed air shall be used to remove the loose foreign matter in a manner that does not adversely affect the cleaned surface. Alternatively, vacuum cleaning or other methods may be used in place of compressed air.

4.4.2.7 Protection from moisture. Abrasive blast-cleaned pipe surfaces shall be protected from conditions of high humidity, rainfall, or surface moisture. Pipe shall not be allowed to flash rust before coating.

4.4.3 *Coating application.*

4.4.3.1 Materials preparation. Materials preparation shall be in accordance with the manufacturer's recommendations.

4.4.3.2 Holdback for field welds. When pipe sections are to be joined together by field welding, a band that is free of lining and coating shall be left on the inside and outside surfaces at the ends of the sections. This band shall be of sufficient widths, as specified by the purchaser, to permit the making of field joints without damage to the lining and coating (Sec. 4.6.1). The coating manufacturer should be consulted for holdback width.

4.4.3.3 Pipe ends for nonwelded field joints. When rubber-gasketed joints or mechanical couplings are used, the coating shall extend to the ends of the pipe. The coating thickness on the pipe surfaces that receive rubber sealing gaskets shall not exceed what is recommended by the manufacturer of the coupling. However, the coating system's dry film thickness shall not be less than 16 mils (406 μm). If the purchaser specifies steel pipe with rubber-gasketed joints, an interior lining of liquid epoxy meeting the requirements of this standard, and an external pipe coating of another material, such as those described in ANSI/AWWA C203, ANSI/AWWA C214, or ANSI/AWWA C215, the liquid-epoxy system shall be extended around the pipe end and shall cover the exterior pipe surface from the end to a point 4 in. (100 mm) past the sealing point of the rubber gasket.

4.4.3.4 Application temperature. Application shall be performed when the metal temperature is more than 5°F (3.0°C) above the dew point. The temperature of the mixed coating material shall not be lower than 50°F (10°C). The temperature of the pipe during application shall conform to the recommendations of the coating manufacturer. Preheating of the coating material, the use of in-line heaters to heat the coating material, or heating of the pipe, fittings, or pipe connections or appurtenances and dehumidification equipment may be used to facilitate the application. Heating shall conform to the recommendations of the coating manufacturer.

4.4.3.5 Application of epoxy coating system. The epoxy coating system shall be applied as recommended by the manufacturer. If more than one coat is applied, the second coat shall be applied within the time limits, surface conditions, and temperature recommended by the manufacturer. If the period between coats is exceeded, a repair procedure shall be obtained from the coating manufacturer and its recommendations followed.

4.4.3.6 Cure. The coating manufacturer shall be consulted to ascertain the proper cure time and methods. After application, the coating shall be tested for

cure in accordance with Sec. 5.1.3.

Sec. 4.5 Coating Repair

4.5.1 *Defective coating.* Coating shall be repaired in accordance with the following subsections.

4.5.1.1 *Surface preparation.* Accessible areas of pipe requiring coating repairs shall be cleaned to remove debris and damaged coating using surface grinders or other means acceptable to the purchaser. The adjacent coating shall be feathered by sanding, grinding, or other methods approved by the purchaser. Accumulated debris shall be removed by vacuum, blowing with contaminant-free air, or wiping with clean rags.

4.5.1.2 *Access.* Areas not accessible for coating repair, such as interior surfaces of small-diameter pipe, shall be reprocessed and recoated as described in Sec. 4.4.3.

4.5.1.3 *Coating application.* The coating system shall be applied to the prepared areas in accordance with the procedures stated in Sec. 4.4.3.

4.5.1.4 *Repair inspection.* Repairs shall be electrically inspected using a holiday detector in accordance with Sec. 5.1.5. The coated pipe shipped from the plant shall be holiday-free.

Sec. 4.6 Welded Field Joints

4.6.1 *Preparation.* The weld joint shall be cleaned so that all surfaces are free of mud, oil, grease, welding flux, weld splatter, and other foreign contaminants. The cleaned metal surfaces of the weld joint shall then be abrasive blast cleaned, vacuum blasted, or abraded using rotary abrading pads to provide a surface that complies with SSPC-SP 10/NACE No. 2, as defined in Sec. 4.4.2.3. The adjacent liquid-epoxy coating shall be feathered by abrading the coating surface for a distance of 1 in. (25 mm) minimum.

4.6.2 *Coating application.* The coating system shall be applied to the weld joint in accordance with Sec. 4.3 and Sec. 4.4. At the option of the purchaser, external weld areas may be protected with materials and methods conforming to ANSI/AWWA C203, ANSI/AWWA C209, ANSI/AWWA C216, ANSI/AWWA C217, or ANSI/AWWA C222.

4.6.3 *Electrical inspection.* After curing, the coating system applied to the welded joints shall be holiday tested in accordance with Sec. 5.1.5. Any holidays indicated by the detector shall be marked with chalk or felt-tip marker to identify the area for repair. When alternate materials are used, as in Sec. 4.4.3.3, holiday

detection should conform to those standards.

Sec. 4.7 Coating Special Pipe Connections and Appurtenances

4.7.1 *General.* This section describes the application of liquid-epoxy coatings to mechanical couplings, flanges, and similar appurtenances for steel pipe fittings, as well as to nuts, bolts, and other items used in conjunction with connections and attachments.

4.7.2 *Surface preparation.* Surfaces of pipe connections and appurtenances to be coated shall be prepared in accordance with Sec. 4.4.2.

4.7.3 *Coating application.*

4.7.3.1 *Application.* Unless otherwise required by the purchaser, coatings shall be applied in accordance with Sec. 4.3 and Sec. 4.4.

4.7.3.2 *Coating threaded connections.* Prior to shipping, threaded connections and appurtenances that must be assembled and operated in the field shall be left uncoated and shipped with rust-preventing compounds or strippable protective coatings applied to the threads only. After final field assembly, the compound shall be completely removed. The exposed threads shall be coated as provided in Sec. 4.4.3. The purchaser should specify the coating requirements for flange faces and other mating surfaces of other types of mechanical connections.

4.7.3.3 *Cure.* The coating manufacturer shall be consulted to ascertain the proper cure time and methods. After application, the coating shall be tested for cure in accordance with Sec. 5.1.3.

4.7.3.4 *Electrical inspection for continuity.* After the coating has cured, but prior to installation, the coated pipe, fittings, and specials shall be tested for holidays in accordance with Sec. 5.1.5. Holidays indicated by the detector shall be marked with chalk or felt-tip marker to identify the area to be repaired.

4.7.3.5 *Coating repair.* Coating repair shall be performed in accordance with Sec. 4.5.

Sec. 4.8 Field Procedures

During construction of the pipeline, the constructor shall take precautions to minimize damage to the protective coating. No metal tools or heavy objects shall be permitted to come into contact with the finished coating. Workers shall be permitted to walk on the coating only when necessary, in which case only shoes with rubber or composition soles and heels shall be worn. Coating damaged during installation shall be repaired in accordance with Sec. 4.5.

4.8.1 *Hoisting.* Coated articles shall be hoisted using wide-belt slings.

Chains, cables, tongs, or other equipment that causes damage to the coating will not be permitted, nor will dragging or skidding of the pipe. The constructor shall allow for inspection of the coating on the underside of coated articles while the articles are suspended. Any coating damage shall be repaired in accordance with Sec. 4.5.

4.8.2 *Protection during welding.* A heat-resistant material with a minimum width of 18 in. (460 mm) shall be draped over the top half of the pipe on each side of the coating holdback during welding to avoid damage to the coating by hot weld spatter.

4.8.3 *Bedding and trench backfill.* Backfilling shall be performed in a manner that avoids abrasion or other damage to both factory and field-applied coatings. Unless otherwise specified by the purchaser, the following requirements shall be met:

Where the trench traverses rocky ground containing hard objects that could penetrate the protective coating, a layer of screened earth, sand, or rounded river-run gravel no less than 6 in. (150 mm) thick with a maximum particle size of 0.75 in. (19 mm) shall be placed in the bottom of the trench prior to installation of the coated article.

Backfill shall be placed around the exterior of the coated pipe only after the purchaser has made the final inspection and has accepted the exterior coating. If rocks or other hard objects are present in the backfill material along any section of the pipeline, screened backfill shall be placed around the coated pipe to a minimum depth of 6 in. (150 mm) above the coated pipe before backfilling the remainder of the trench. Other rock-shield materials approved by the purchaser may be used.

Compaction of bedding and backfill in the trench shall be as specified by the purchaser. Rodding with metal rods or other metal tools that could contact and damage the coating shall not be permitted.

SECTION 5: VERIFICATION

Sec. 5.1 Inspection and Testing

The coating system shall be inspected for adhesion (to the steel and between coats), thickness, blisters, cracks, bubbles, under-film voids, holidays, pinholes, discontinuities, and mechanical damage. Imperfections shall be identified and marked for repair with chalk or felt-tip marker.

5.1.1 *Purchaser's inspection option.* At the purchaser's option, the entire

procedure of applying the liquid-epoxy coating system shall be inspected from the time of surface preparation to completion of the coating application. Lack of inspection by the purchaser shall not relieve the constructor of responsibility to provide materials and perform work in accordance with this standard.

5.1.2 *Coating application inspection.* When inspection is required by the purchaser, coating work not done in the presence of the purchaser may be subject to rejection. Coating work may be rejected if the procedure used in applying the liquid-epoxy coating material does not comply with this standard.

5.1.3 *Cure.* The cure test shall be performed in accordance with the solvent rub procedures as outlined in ASTM 4752 (solvent rub test), ASTM D3363 (pencil hardness), or both, as required by the purchaser. A coating system that has not cured in accordance with the manufacturer's written instructions may be rejected.

5.1.4 *Thickness test.* The thickness of the cured coating system shall be determined in accordance with SSPC-PA 2 (see Sec. 4.3.2.1).

5.1.5 *Electrical inspection for continuity.* After curing, but prior to installation, the coating system applied to the pipe shall be tested for holidays according to the procedures and using the voltage settings outlined in NACE RP0188 for the specified thickness. Any holidays indicated by the detector shall be marked with chalk or felt-tip marker to identify the area to be repaired.

5.1.6 *Adhesion.* The adhesion or bond of the coating to the steel and the intercoat adhesion of succeeding coats after curing shall be determined in the shop or field in accordance with ASTM D3359, Method A (shear adhesion). Shear adhesion will be considered satisfactory if a rating of 4A is achieved. The adhesion of the coating system may also be performed in accordance with ASTM D4541 (tensile adhesion). Tensile adhesion will be considered satisfactory if a minimum tensile adhesion rating of 800 psi (5,515 kPa) is achieved. In the shop, the adhesion test may be conducted on the coated pipe or on the coating applied at the same time to test panels of the same substrate and surface preparation as the pipe.

Sec. 5.2 Performance Testing of Laboratory-Applied Epoxy Coating System

5.2.1 *Coating material tests.* Prior to acceptance and application of the coating material, samples of material requested by the purchaser and submitted by the constructor may be tested by the purchaser in the purchaser's laboratory or in an independent commercial laboratory designated by the purchaser.

5.2.1.1 *Immersion.* Steel panels of dimensions 2 in. × 6 in. × ¼ in. (50 mm × 150 mm × 3.2 mm) shall be prepared, coated, and cured in accordance

with Sec. 4.4.2. The uncoated side and edges shall be sealed with hot wax or other resistant material. Suitable containers shall be filled to a depth of 4 in. (100 mm), one with deionized water, one with 1 percent by weight solution sulfuric acid and one with 1 percent by weight solution sodium hydroxide. The panels shall be placed in the containers to allow exposure to both the liquid and vapor phases of the fluids. If multiple panels are placed in the same container, a distance of at least 1 in. (25 mm) shall be maintained between panels. The containers shall be covered, but not sealed, and allowed to stand at 75°F± 2°F (24°C ± 1°C) for 30 days, maintaining liquid levels as required. The panels shall be removed, rinsed, and allowed to dry for 24 hr. Blistering, peeling, or disbondment shall constitute failure to pass the test.

5.2.1.2 *Cathodic disbondment.* Cathodic disbondment is measured following the procedure of ASTM G8. Steel test pipes 2-in. (50-mm) in diameter shall be prepared by abrasive blast cleaning in accordance with Sec. 4.4.2.1. The liquid epoxy coating, with or without primer depending on the coating system, shall be applied to the exterior of the test pipes, at the thickness and by the method recommended by the manufacturer. The coating shall be cured according to the manufacturer's recommendations prior to testing. An average value greater than the limits specified in Sec. 4.3.5, Table 2, shall constitute failure of the coating to meet the requirements.

Sec. 5.3 Rejection

5.3.1 *Pipe.* The purchaser may reject pipe if the surface condition does not comply with the requirements of Sec. 4.4.2.2 and 4.4.2.3. Pipe rejected because of inadequate cleaning shall be re-cleaned.

5.3.2 *Coating materials.* If any sample of coating material does not comply with this standard, the coating material represented by such a sample shall be rejected.

SECTION 6: DELIVERY

Sec. 6.1 Marking

This standard has no applicable information for this section.

Sec. 6.2 Packaging, Handling, Stacking, and Storage

6.2.1 *General.* Coated pipe and other articles shall be packaged, handled, and stored in a manner that will minimize damage. Pipe or coating damaged in

handling or other operations shall be repaired in accordance with Sec. 4.5.

6.2.2 *Packaging.* Coating materials shall be supplied to the jobsite in the manufacturer's original, unopened containers. Each container shall be plainly marked with the name and address of the manufacturer, type of material, batch or lot number, date of manufacture (unless contained in the batch or lot number), storage conditions, and information as required by current applicable federal, provincial, state, and local regulations.

6.2.3 *Storage of materials.* Materials shall be stored and protected from the elements as required by current applicable federal, provincial, state, and local regulations. Temperature ranges in the storage area shall be maintained within the limits recommended by the manufacturer.

6.2.4 *Stacking.* Stacking of coated pipe shall be in accordance with industry-accepted safety practices and in accordance with the purchaser's instructions.

Sec. 6.3 Affidavit of Compliance

The purchaser may require an affidavit from the manufacturer or supplier that the material provided complies with applicable requirements of this standard. The purchaser may also require an affidavit that the coating material supplied is of the same formulation(s) that was laboratory tested by the manufacturer and found to meet or exceed the performance requirements of this standard (Table 2 and Sec. 5.2).

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