ANSI/AWWA C229-08
(First Edition)

American Water Works Association

The Authoritative Resource for Safe Water®

AWWA Standard

Fusion-Bonded Polyethylene Coating for the Exterior of Steel Water Pipelines

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AWWA Standard

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Committee Personnel

The Steel Water Pipe Manufacturer's Technical Advisory Committee (SWPMTAC) for AWWA C229, which developed this standard, had the following personnel at the time:

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Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

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Foreword

This foreword is for information only and is not part of ANSI/AWWA C229.

I. Introduction.

I.A. *Background.* This standard describes the minimum material and application requirements for fusion-bonded polyethylene (FBPE) coating to be factory applied to the exterior and the joint region (of rubber-gasketed field joints) of steel water and wastewater pipes.

I.B. *History.* Fusion-bonded polyethylene pipe coatings were first applied to steel pipes in the 1960s in Europe. In 1972, FBPE was introduced to Australia, and in 1990 to South Africa. FBPE has been used as an external coating for water, wastewater, oil, and gas pipelines. The coating system became available for use in the United States in 2006.

In March 2006, the AWWA Standards Council authorized the Steel Pipe Committee to develop a new standard for fusion-bonded polyethylene coating. This is the first edition of this standard.

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.

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* 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 C229 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.

II.A. *Advisory Information on Product Application.* This standard defines the minimum requirements of fusion-bonded polyethylene coating for long-term corrosion protection. It is intended for use as an exterior coating and for the joint region (of rubber gasketed field joints) of steel water pipelines for underground, underwater, and aboveground installations conveying water and wastewater.

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* NSF International, 789 N. Dixboro Rd., 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 20001.

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 specified by the purchaser:

1. Standard used—that is, ANSI/AWWA C229, Fusion-Bonded Polyethylene Coating for the Exterior of Steel Water Pipelines, of latest revision.
2. Whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects, is required.
3. Any exceptions to the standard.
4. Diameter, length, weld configuration, and location of pipeline.
5. Temperature of conveyed water (Sec. 1.1.1).
6. If an alternative coating color is required (Sec. 4.3.1).
7. Requirements for FBPE cutback at pipe ends, if different (Sec. 4.4.3.5).
8. Requirements for coating thickness, if different (Sec. 4.4.3.9).
9. Requirements for coating repair, if different (Sec. 4.6).
10. Requirements for coating of field joints (Sec. 4.7.4).
11. Requirements for pipeline bedding and trench backfill (Sec. 4.7.5).
12. Requirements for inspection and testing (Section 5).
13. Requirements for handling, transport, and storage (Sec. 6.2).
14. Affidavit of compliance (Sec. 6.3).

IV. Major Revisions. This is the first edition of this standard.

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

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AWWA Standard

Fusion-Bonded Polyethylene Coating for the Exterior of Steel Water Pipelines

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes the materials and application requirements for factory-applied, fusion-bonded polyethylene (FBPE) coating, to the exterior of steel water pipes and fittings and the joint region of rubber-gasket field-jointed steel water pipes and fittings.

1.1.1 *Maximum temperatures.* AWWA steel pipe coating standards are written for and based on the service temperature of potable water. Consult the manufacturer for conditions and limitations.

1.1.2 *Conditions not described in this standard.* This standard does not discuss the additional materials and procedures that may be required for difficult installation conditions, such as those encountered in the construction of submerged lines, casing pipe, or river crossings. The manufacturer should be consulted for specific recommendations when these conditions exist.

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for FBPE coating for steel water pipe, including material, application, inspection, testing, marking, handling, and packaging requirements.

Sec. 1.3 Application

This standard can be referenced in documents used as a guide for applying, inspecting, and testing FBPE coating. The requirements of this standard apply when this document has been referenced and then only to FBPE coating used for steel water pipelines.

SECTION 2: REFERENCES

This standard references the following documents. In their current 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.

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

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

ASTM† D149—Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

ASTM D570—Test Method for Water Absorption of Plastics.

ASTM D638—Test Method for Tensile Properties of Plastics.

ASTM D1000—Pressure-Sensitive Adhesive-Coated Tapes used for Electrical and Electronic Applications.

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

ASTM D1603—Test Method for Carbon Black in Olefin Plastics.

ASTM D1505—Test Method for Density of Plastics by the Density-Gradient Technique.

ASTM D1693—Test Method for Environmental Stress-Cracking of Ethylene Plastics.

ASTM D3895—Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry.

ASTM E96—Test Methods for Water Vapor Transmission of Materials.

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

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

ASTM G8—Test Method for Cathodic Disbonding of Pipeline Coatings.

ASTM G12—Test Method for Nondestructive Measurement of Film Thickness of Pipeline Coatings on Steel.

ASTM G14—Test Method for Impact Resistance of Pipeline Coatings.

ASTM G17—Test Method for Penetration Resistance of Pipeline Coatings.

NACE* RP0274—High-Voltage Electrical Inspection of Pipeline Coatings Prior to Installation.

SSPC† AB-1—Mineral and Slag Abrasives.

SSPC AB-3—Ferrous Metallic Abrasive.

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

EN‡ 12068—Cathodic protection. External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathodic protection. Tapes and shrinkable materials.

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. *Constructor:* The party that provides the work and materials for placement and 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.

4. *Modified polyethylene:* Polyethylene that is modified by the addition of a chemical additive (such as maleic anhydride or ethylene vinyl acetate) to produce a material that can be applied to adhere to steel by fusion bonding at an application temperature lower than for polyethylene.

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

† SSPC: The Society for Protective Coatings, 40 24th St., Pittsburgh, PA 15222.

‡ European Committee for Standardization Standard, 36 rue de Stassart, B-1050 Brussels, Belgium.

SECTION 4: REQUIREMENTS

Sec. 4.1 Equipment

Equipment for blast cleaning and coating application shall be designed, manufactured, and maintained to comply with the procedures and to obtain the results prescribed in this standard.

Sec. 4.2 Materials and Workmanship

Materials provided shall meet the provisions of this standard. The entire operation of applying the FBPE coating shall be performed by personnel trained in the application of FBPE coating.

Materials shall comply with the requirements of the Safe Drinking Water Act and other federal, state or provincial, and local regulations for potable water and wastewater systems as applicable.

Sec. 4.3 Laboratory Qualification Tests for the Polyethylene Material and Coating

4.3.1 *General.* The polyethylene material shall consist of polyethylene, antioxidants, and carbon black, fully compounded and supplied in powder form. It shall not contain any fillers.

Although carbon black provides the best ultraviolet ray stabilization for aboveground exposure, the purchaser has the option of specifying a color other than black. In that case, alternative ultraviolet ray stabilizers shall be incorporated in the polyethylene material, which shall meet all the requirements of this standard, other than the carbon black content.

4.3.2 *Properties of polyethylene material.* The polyethylene material shall meet the requirements specified in Table 1.

Table 1 Properties of polyethylene material

	Property	Requirement		Test Method
		Minimum	Maximum	
1.	Density, g/cm^3	0.920	—	Sec. 5.3.1.1
2.	Carbon black content, % w/w	2.0	3.0	Sec. 5.3.1.2
3.	Oxygen induction time (thermal aging resistance), min	20	—	Sec. 5.3.1.3

Table 2 Properties of laboratory applied coating

	Property	Requirement: Minimum	Requirement: Maximum	Test Method
1.	Dielectric strength	500 V/mil (20kV/mm)		Sec. 5.3.2.1
2.	Water vapor transmission		0.3 perm (1.6×10^{-11} kg/Pa-s m^2)	Sec. 5.3.2.2
3.	Environmental stress-cracking resistance, condition B, F_{50}, 100% Igepal	300 hr		Sec. 5.3.2.3
4.	Impact resistance	160 lbf-in. (18N-m)		Sec. 5.3.2.4
5.	Penetration resistance		5% penetration at 72°F (22°C), 10% penetration at 158°F (70°C)	Sec. 5.3.2.5
6.	Water absorption (24 hr)		0.1% w/w	Sec. 5.3.2.6
7.	Tensile strength at yield	2,500 psi (17 MPa)		Sec. 5.3.2.7
8.	Cathodic disbondment		1,000 mm^2 (1.55 $in.^2$) area	Sec. 5.3.2.8
9.	Adhesion	17 lbf/in. width (3.0 N/mm)		Sec. 5.3.2.9

4.3.3 *Properties of laboratory applied coating.* The laboratory applied coating shall meet the requirements specified in Table 2.

Sec. 4.4 Coating Application

4.4.1 *General.* FBPE coating shall be produced by applying polyethylene material to a preheated, abrasive-blast-cleaned pipe. As elevated temperatures are required during coating application, FBPE coating shall be applied prior to the application of other coatings or linings, unless those coatings or linings are resistant to the processing heat.

4.4.2 *Surface preparation.*

4.4.2.1 Abrasive blast cleaning. Pipe surfaces shall be abrasive blast cleaned with mineral abrasives, slag abrasives, or steel grit (reference SSPC Abrasive Specification SSPC AB-1 or SSPC AB-3 in accordance with SSPC-SP 10/NACE No. 2. The blast anchor pattern or profile depth shall be 1.5 mil to 5.0 mil (38 μm to 127 μm), measured in accordance with ASTM D4417.

4.4.2.2 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 visual standards on steel panels that are a minimum

of 6 in. × 6 in. × 0.25 in. (150 mm × 150 mm × 6 mm). On agreement between the purchaser and constructor that the visual standards meet 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 and corrosion, and maintained as visual reference standards throughout the coating operations. Alternatively, other industry-accepted visual comparative standards, such those provided by NACE or SSPC and agreed on by the purchaser and constructor, may be used.

4.4.2.3 Abrasive working mix. When blasting equipment is employed using recycled abrasive working mix, the abrasive working mix shall be maintained free of contaminants.

4.4.2.4 Surface inspection. The cleaned exterior and end surfaces shall be inspected for conformance to Sec. 4.4.2.2 and 4.4.2.3. Surfaces that do not comply shall be reworked by reblasting or by grinding. Ground areas shall meet the profile (anchor pattern) requirements of the manufacturer.

4.4.2.5 Protection from moisture. Pipe shall not be allowed to rust bloom prior to coating.

4.4.3 *Coating application.*

4.4.3.1 Preheating. After pipe has been cleaned in accordance with Sec. 4.4.2, it shall be preheated for coating application in accordance with the manufacturer's recommendations and within the temperature range of 570°F (299°C) to 752°F (400°C).

4.4.3.2 Application. Polyethylene material shall be applied to the pipe by immersion in fluidized material, strew coating, electrostatic spray, air spray, or a combination of these techniques, at temperatures in accordance with the manufacturer's recommendations.

4.4.3.3 Finish. A smooth outer surface with the outer polyethylene particles being melted through shall be produced either with or without the use of postheating.

4.4.3.4 Cooling. The coating shall be allowed to cool prior to inspection.

4.4.3.5 Pipe ends. Coating cut back shall be a minimum of 3 in. (75 mm) from the position where field welds are made. The coating shall be terminated with a taper over a minimum length of three times the coating thickness.

When rubber gasketed joints are used, the coating shall extend around the ends of the pipe so that there is no exposed steel. Internal linings shall overlap the internal

FBPE coating by a minimum distance of 1 in. (25 mm). When FBPE is applied to the joint region of rubber-gasketed joints, direct measurement or the use of go/no-go gauges shall be used on the bell and the spigot to ensure the joints are within the requirements.

4.4.3.6 Pipe support. When coating the joint region of rubber-gasket-jointed pipe, the coated pipe may be supported during the cooling operation. These support regions shall be repaired by the two-stage process specified in Sec. 4.5, or as recommended by the manufacturer.

4.4.3.7 Imperfections. On completion of the coating operation, all coated surfaces shall be electrically inspected for holidays as specified in Table 3.

4.4.3.8 Adhesion. Tests for adhesion shall be undertaken as specified in Table 3.

4.4.3.9 Thickness. The coating shall be applied to produce the thicknesses specified in Table 3.

Sec. 4.5 Coating Steel Pipe Fittings and Specials

4.5.1 *General.* This section covers application of FBPE coatings to steel pipe fittings and specials.

4.5.2 *Application.* All coatings shall be applied in the factory and shall be carried out in accordance with Sec. 4.4, except that a two-stage coating application process may be used. In the two-stage process, modified polyethylene is used in the first stage to achieve the adhesion at a lower application temperature. The first stage is immediately followed by a second-stage application of polyethylene material (as

Table 3 Properties of production coating

Property	Minimum Requirement	Test Method
High-voltage electrical continuity	No holidays at 12kV	Sec. 5.4.2
Adhesion	17 lbf/in. width (3.0 N/mm)	Sec. 5.4.3
Pipe coating thickness, based on pipe nominal diameter		
Up to 10 in. (254 mm)	63 mil (1.6 mm)	Sec. 5.4.4
> 10–20 in. (> 254–508 mm)	70 mil (1.8 mm)	Sec. 5.4.4
> 20–30 in. (> 508–762 mm)	80 mil (2.0 mm)	Sec. 5.4.4
Above 30 in. (above 762 mm)	90 mil (2.3 mm)	Sec. 5.4.4
For rubber-gasketed joint pipe, within 6 in. (150 mm) of pipe ends	40 mil (1.0 mm)	Sec. 5.4.4

specified in Sec. 4.3). The second-stage polyethylene material shall have a minimum thickness of at least 50 percent of the total required thickness as specified in Table 3. It shall completely fuse with and be inseparable from the modified polyethylene material.

4.5.3 *Imperfections.* On completion of the coating operation, all coated surfaces shall be electrically inspected for holidays as specified in Table 3.

4.5.4 *Adhesion.* Tests for adhesion shall be undertaken as specified in Table 3.

4.5.5 *Thickness.* The coating shall be applied to give the thicknesses specified in Table 3.

Sec. 4.6 Coating Repair

4.6.1 *Major defects.* Pipe sections with coating defects, such as partial coating, insufficient adhesion, inadequate film thickness, where the repair area is in excess of 10 percent of the coated surface, or where there are holidays in excess of the limit specified in Sec. 5.4.2, shall be recoated starting with the surface preparation procedures specified in Sec. 4.4.2.

4.6.2 *Minor defects.* Coating that requires repair because of coating imperfections and damage, as identified by the procedure in Sec. 4.4.3.7 and Sec. 4.5.2, and not classified as major defects, shall be repaired using the two-stage process specified in Sec. 4.5, or by using heat-shrinkable coatings meeting the requirements of AWWA/ANSI C216, or as recommended by the manufacturer. The coating shall be tapered over a minimum length of three times the coating thickness prior to repair. Repaired areas shall be electrically inspected for holidays at the voltage specified in Table 3.

Sec. 4.7 Field Procedures

4.7.1 *General.* At all times during construction of the pipeline, the constructor shall use every precaution to prevent damage to the protective coatings on the pipe. During pipeline installation, before final acceptance, any damage to the pipe or to the protective coatings shall be repaired in accordance with Sec. 4.6.2.

4.7.2 *Handling.* Coated pipe shall be handled in a manner that will minimize damage to the coating. Pipe may be hoisted by the use of belt slings or vacuum lifters. Metal chains, cables, tongs, or other equipment likely to cause damage to the coating shall not be permitted. The constructor shall allow inspection of the coating on the underside of the pipe while the pipe is suspended.

4.7.3 *Protection during welding.* A heat-resistant material with a minimum width of 18 in. (450 mm) shall be draped over the top half of the pipe section on each side of the coating holdback during welding to avoid damage to the coating by

hot-weld spatter. The welder grounding clamp shall not be attached to the coated part of the pipe. If the weld area requires preheating, damage to the coating shall be avoided.

4.7.4 *Joint coatings.* The exterior of field-welded joints may be coated with a cold-applied tape, in accordance with the requirements of AWWA/ANSI C209, or a heat-shrinkable coating, in accordance with AWWA/ANSI C216, or as specified by the purchaser. After completion of the field joints, the constructor shall high-voltage electrically test for flaws in the coating repairs and field joints in accordance with NACE RP0274. Defects shall be repaired by a method specified by the purchaser.

4.7.5 *Pipe bedding and trench backfill.* Backfilling shall be conducted at all times in a manner that avoids damage to the coating on the pipe. Unless otherwise specified by the purchaser, the following requirements shall be met:

4.7.5.1 Rocky ground. Where the trench traverses rocky ground containing hard objects that could penetrate the protective coating, a layer of screened noncohesive earth, sand, or 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 the installation of pipe. Other suitable bedding materials may be used in place of earth, sand, or gravel if specified by the purchaser.

4.7.5.2 Backfill. Placement of backfill around the exterior of the coated pipe shall be performed in the manner specified by the purchaser. If the backfill material contains oversize rocks, concrete chunks, or other hard objects along any section of the pipeline, screened backfill material shall be placed around the pipe and above the pipe to a minimum width and depth of at least 6 in. (150 mm) around and above the pipe before backfilling the remainder of the trench.

4.7.5.3 Compaction. Compaction of bedding and backfill in the trench shall be as specified by the purchaser. Compaction with metal rods or other metal tools that will come into contact with and damage the pipe coating shall not be acceptable.

SECTION 5: VERIFICATION

Sec. 5.1 Coating-Materials Acceptance Testing

The basis for acceptance of proposed coating materials shall be as specified by the purchaser from the following options, and as detailed in Sec. 5.2 and Sec. 5.3:

(1) acceptance on the basis of manufacturer's certified test reports submitted by the constructor, (2) acceptance on the basis of testing of samples of proposed materials submitted by the constructor with testing conducted by the purchaser in the purchaser's laboratory or by a responsible commercial laboratory designated by the purchaser, or (3) acceptance on another basis defined and specified by the purchaser.

Sec. 5.2 Inspection and Testing by the Purchaser

5.2.1 *Inspection.* At the purchaser's option, the entire procedure of applying the protective coating material as described in this standard may be inspected from surface preparation to completion of coating. Such inspection shall not relieve the constructor of responsibility to provide materials and perform work in accordance with this standard.

5.2.2 *Coating application inspection.* When agreed on by the constructor and the purchaser, all coating work shall be done in the presence of the purchaser.

5.2.3 *Access of purchaser.* The purchaser shall have access to those parts of the plant that are involved in the performance of work under this standard.

5.2.4 *Facilities for purchaser.* The constructor shall provide the purchaser with facilities and space for inspecting, testing, and obtaining the desired information regarding the material used, the application, the progress and manner of the work, and the results obtained.

Sec. 5.3 Laboratory Qualification Tests

5.3.1 *Polyethylene material tests.* Tests shall be undertaken on fully compounded polyethylene granules, as used to produce the polyethylene material. If the test results do not meet the values specified in Sec. 4.3.2 for the following items, the polyethylene material is subject to rejection.

5.3.1.1 Density. The density of the polyethylene material shall be determined in accordance with ASTM D1505.

5.3.1.2 Carbon black content. The average carbon black content of the polyethylene material shall be determined in accordance with ASTM D1603.

5.3.1.3 Oxygen induction time (thermal aging resistance). The mean oxygen induction time of the polyethylene material shall be determined in accordance with ASTM D3895 at 392°F (200°C).

5.3.2 *Laboratory applied coating tests.* When requested prior to application of the polyethylene coating to pipe, acceptable test results shall be submitted to the

purchaser. Samples of coating 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. If the test results do not meet the values specified in Sec. 4.3.3, the material is subject to rejection.

5.3.2.1 Dielectric strength. The average dielectric strength shall be determined in accordance with ASTM D149. The test shall be undertaken on an 80–100-mil (2.0–2.5-mm) thick coating removed from a steel pipe or panel coated with the use of a release agent. The release agent shall be removed by light sanding prior to testing.

5.3.2.2 Water vapor transmission. The average water vapor transmission shall be determined in accordance with ASTM E96 Procedure B. The test shall be undertaken on an 80–100 mil (2.0–2.5 mm) thick coating removed from a steel pipe or panel coated with the use of a release agent. The release agent shall be removed by light sanding prior to testing. The smooth unsanded exterior side of the coating shall be exposed to the water vapor.

5.3.2.3 Environmental stress-cracking resistance. The environmental stress-cracking resistance F_{50} shall be determined in accordance with ASTM D1693, Condition B. The test shall be undertaken on coating removed from a steel pipe or panel coated with the use of a release agent. The steel side of the coating may be sanded, if required, to achieve the thickness requirements of ASTM D1693. The exterior surface of the coating shall be placed in tension during the test.

5.3.2.4 Impact resistance. The impact resistance shall be determined in accordance with ASTM G14, except that the test shall be carried out on 8-in. (200-mm) nominal diameter, $^3/_{16}$-in. (4.8-mm) wall thickness coated steel pipe with an average coating thickness of 90–100 mil (2.3–2.5 mm).

5.3.2.5 Penetration resistance. The average penetration resistance shall be determined in accordance with ASTM G17 on duplicate samples at both 72°F (22°C), and 158°F (70°C). The test shall be undertaken on an 80–100-mil (2.0–2.5-mm) thick coating applied to a 2-in. (50-mm) nominal diameter steel pipe.

5.3.2.6 Water absorption. The water absorption shall be determined in accordance with ASTM D570. The test shall be undertaken on an 80–100-mil (2.0–2.5-mm) thick coating removed from a steel pipe or flat steel panel coated with the use of a release agent. Any specimen size with an area of at least 4 in.^{2} (2,600 mm^2) may be used. The release agent shall be removed by light sanding prior to testing.

5.3.2.7 Tensile strength at yield. The average tensile strength at yield shall be determined in accordance with ASTM D638, using Specimen Type IV, and a test speed of 2 in./min (50 mm/min). Humidity control during conditioning and testing is not required. The test shall be undertaken on coating removed from a steel pipe or flat steel panel coated with the use of a release agent. The steel side of the coating shall be wet sanded, finishing with a grit size of P150 or finer to remove all other grinding marks and surface irregularities and to produce a final thickness of 80–100 mil (2.0–2.5 mm).

5.3.2.8 Cathodic disbondment. The average area of disbondment from three holidays on one pipe shall be determined in accordance with ASTM G8, in accordance with Method A for a period of 30 days. The test shall be undertaken on coating applied to a 4-in. (100-mm) nominal diameter pipe.

5.3.2.9 Adhesion. The coating adhesion shall be determined on coating applied to a 4-in. (100-mm) diameter pipe. A full circumference section shall be taken, approximately 4 in. (100 mm) long. Two parallel circumferential through thickness cuts shall be made into the coating 1½ in. (38 mm) apart and approximately 6 in. (150 mm) long, in the mid-length position of the pipe section. A cut shall be made to join the incisions at one end and the coating shall be peeled for a distance of approximately 1 in. (25 mm).

The adhesion shall be determined in accordance with ASTM D1000, but with the peeled coating at an angle of 90° to the pipe surface, maintained throughout the test, by utilizing equipment that permits rotation in order to maintain the 90° angle (as also described in EN 12068). After the first 1 in. (25 mm) of coating is removed, the force required for peeling over the next 4 in. (100 mm) shall be averaged and divided by the coating width to determine the adhesion.

Sec. 5.4 Coating Production Tests

5.4.1 *General.* The applied FBPE coating shall meet the requirements specified in Sec. 4.4.3.7 through 4.4.3.9. If the test results do not meet those values for the following items, the coating is subject to rejection.

5.4.2 *Electrical inspection for continuity.* All coated surfaces shall be high-voltage inspected for continuity in accordance with NACE RP0274, at a minimum voltage of 12 kV. Holidays detected shall be repaired at the coating plant in accordance with Sec. 4.6 of this standard. If the number of holidays exceeds an average of one per 50 ft^2 (4.65 m^2) per pipe, the pipe shall be recoated.

5.4.3 *Adhesion.* Prepare the pipe to be tested by allowing a minimum period of 1 hr after coating application prior to adhesion testing, and with the coating at a minimum temperature of 59°F (15°C) at the time of testing.

Two parallel circumferential through thickness cuts shall be made into the coating 1 1/2 in. (38 mm) apart and approximately 6 in. (150 mm) long. A cut shall be made to join the incisions at one end and the coating is peeled for a distance of approximately 1 in. (25 mm). A portable load-measuring device capable of continuous recording, with an accuracy of ± 4 percent, shall be used to continuously peel the coating, maintaining the peeled coating at an angle of 90° to the pipe surface at a rate of 12 in./min (300 mm/min) ± 20 percent. The peeling force shall be recorded after the first, second, third, fourth, and fifth inch (25 mm) of peeling. The adhesion shall be calculated by averaging these five results and dividing by the coating width. If the adhesion requirement is not met, and the test temperature is above 68°F (20°C), the test shall be deemed to be a no-test, and it shall be repeated at the referee maximum temperature, which is ≤ 68°F (≤ 20°C). The adhesion shall be checked at a frequency agreed on with the purchaser, but no less than twice per shift, at the beginning and middle of the shift.

5.4.4 *Coating thickness.* The thickness of the coating systems shall be measured in accordance with ASTM G12. The thickness shall be checked on every pipe, fitting, and special.

SECTION 6: DELIVERY

Sec. 6.1 Packaging and Marking of Polyethylene Material

The polyethylene material containers shall be plainly marked with the name of the manufacturer, type of material, batch or lot number, date of manufacture, and information as required by federal, state or provincial, and local laws.

Sec. 6.2 Pipe Handling, Transport, and Storage

Pipe shall be handled and stored so as to prevent damage to pipe, appurtenances, and the coating. Damaged pipe, appurtenances, and coating shall be repaired in accordance with Sec. 4.5.

6.2.1 *Stacking.* Spacers or padding shall be used to prevent damage to the pipe and coating.

6.2.2 *Transport.* Pipe shall be shipped using shoring or dunnage, padding, and banding to protect the pipe and its coating.

6.2.3 *Loading.* Pipe shall be loaded for transport in compliance with existing transport standards.

6.2.4 *Trench-side placement.* Pipe placed alongside the trench shall be supported off the ground to avoid damage to the coating.

6.2.5 *Storage.* The coating is suitable for aboveground exposure when supplied with carbon black, as specified in Sec. 4.3.1 and Sec. 4.3.2, or other suitable ultraviolet ray stabilizers.

Sec. 6.3 Affidavit of Compliance

The purchaser may require the constructor to provide an affidavit attesting that all materials and work provided comply with the applicable requirements of this standard.

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