



**American Water Works
Association**

The Authoritative Resource for Safe Drinking Water®

AWWA Standard

Nylon-11-Based Polyamide Coating System for the Interior and Exterior of Steel Water Pipe, Connections, Fittings, and Special Sections



Effective date: May 1, 2007.

First edition approved by AWWA Board of Directors: June 17, 2001.

This edition approved: Feb. 12, 2006.

Approved by American National Standards Institute: Feb. 15, 2007.

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA C224.

I. Introduction.

I.A. *Background.* Polyamide (Nylon-11-based) coatings are thermoplastic coatings. Typically, they are placed by applying dry polyamide powder (ordinarily in a controlled plant environment, by any of several techniques, e.g., electrostatic spray, immersion in a fluidized bed, spray onto preheated article, rotocoating) onto steel surfaces previously primed with a thin layer of epoxy primer (note that other primers may be used, as appropriate). When treated at the appropriate temperature, the dry polyamide powder melts to form a uniform, continuous polyamide coating on the steel surface. Simultaneously during this thermal treatment, chemical reactions occur between the steel surface and epoxy and between epoxy and polyamide. These chemical reactions provide for bonding between the polyamide coating and steel surface.

The first commercial use of polyamide coatings for the protection (from corrosion) of steel used in water-handling applications was in West Germany in 1970. Regarding the United States, it is believed that first use was in 1985. However, prior to this, polyamide coatings had been used in 1983 for the protection of the interior of steel piping used in the petroleum industry. Currently, the use of polyamide coatings to protect steel has grown to include many types of articles (both interiors and exteriors) in a variety of industries, such as oil and natural gas exploration and production, and water and wastewater handling. Polyamide coatings also can be used to protect accessory steel articles, such as pumps, valves, couplers, and flowmeters.

I.B. *History.* C224-01 was the first standard specifically concerning polyamide coating systems. However, it is noted that polyamide-based coatings have been used according to ANSI/AWWA Standard C550-01. This second edition of C224 was approved by the AWWA Board of Directors on February 12, 2006.

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 US, 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.
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.

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

[†]NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48105.

[‡]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.

ANSI/AWWA C224 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 Material Application.* This standard defines the use of polyamide coatings for the interiors and exteriors of steel articles used for water handling in the following environments: aboveground, belowground, or underwater—under normal conditions. Also, this standard describes the quality of polyamide coatings needed to produce long-term coating performance—in particular, long-term corrosion protection. Normal conditions are defined as those conditions, specified by the coating manufacturer (see Sec. 3), that are known beforehand not to adversely affect polyamide coatings.

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 C224, Nylon-11-Based Polyamide Coating System for the Interior and Exterior of Steel Water Pipe, Connections, Fittings, and Special Sections, of latest revision.
2. Any required exceptions to the standard.
3. Diameter, length, thickness, design, and location of coated steel articles.
4. 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.
5. Temperature, pH, and composition of water to be handled (Sec. 1.1.2).
6. Details of other federal, state, or local, and provincial requirements (Sec. 4.2).
7. Weld treatment (Sec. 4.5.2.1).
8. Visual standards (Sec. 4.5.2.4).
9. Coating holdback at pipe ends (Sec. 4.5.3.2).

10. Coating thickness (Sec. 4.5.3.3).
11. Field-welded joint coatings (Sec. 4.5.5).
12. Pipe bedding and trench backfill (Sec. 4.6.3).
13. Inspection (Sec. 5.1).
14. Number of adhesion tests (Sec. 5.3.2).
15. Delivery (Sec. 6).
16. Outdoor storage (Sec. 6.2.5).
17. 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 revisions made to the standard in this edition include the following:

1. Sec. 4.5.1 was rewritten.
2. Particle size distribution was modified in Table 1.
3. Consistent terminology for abrasive blast cleaning, abrasive mix, and visual comparative standards was added in (Sec. 4.5).
4. Thermal spray technology was added to Sec. 4.5.5.
5. A new adhesion test was adopted (Sec. 5.3.2)

V. Comments. If you have any comments or questions about this standard, please call the AWWA Volunteer and 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 standards@awwa.org.



ANSI/AWWA C224-06
(Revision of ANSI/AWWA C224-01)

AWWA Standard

Nylon-11-Based Polyamide Coating System for the Interior and Exterior of Steel Water Pipe, Connections, Fittings, and Special Sections

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes polyamide (Nylon-11-based) coating systems for interior and exterior of steel pipe, connections, fittings, and special sections that are used in water-handling equipment that is installed aboveground, belowground, or underwater. Polyamide coating systems are thermoplastic and are ordinarily applied in a shop or manufacturing facility.

1.1.1 *Minimum pipe diameter.* The minimum pipe diameter for application of the polyamide coating system to the interior of a pipe shall be the diameter that permits effective inspection and repair. For joints of pipe, this minimum diameter is ordinarily 24 in. (600 mm). For pipe diameters less than 24 in. (600 mm), the coating manufacturer shall be consulted regarding methods of inspection and repair.

1.1.2 *Maximum temperature.* AWWA pipe coating standards are written for and based on the service temperature of potable water. The maximum temperature at which a polyamide coating system can be used shall be specified by the manufacturer.

Sec. 1.2 Purpose

The purpose of this standard is to establish and describe the minimum requirements for the application and use of polyamide coatings for steel articles employed in water handling to maximize long-term performance—in particular, long-term corrosion protection.

Sec. 1.3 Application

This standard may be referenced in documents for the application, use, and testing of polyamide coating systems for steel articles employed in water handling. The requirements of this standard will apply when referenced and only regarding these coating systems.

SECTION 2: REFERENCES

This standard references the following documents. In their latest editions, these documents form a part of this standard to the extent specified within the standard. In 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 C210—Liquid-Epoxy Coating Systems for the Interior and 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.

ASTM^{*} D570—Standard Test Method for Water Absorption of Plastics.

ASTM D789—Standard Test Methods for Determination of Relative Viscosity and Moisture Content of Polyamide (PA).

ASTM D792—Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

ASTM D1921—Standard Test Methods for Particle Size (Sieve Analysis) of Plastic Materials.

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

ASTM D6677—Standard Test Methods for Evaluating Adhesion by Knife.

ASTM E324—Standard Test Method for Relative Initial and Final Melting Points and the Melting Range of Organic Chemicals.

NACE[†] RP-0188—Discontinuity (Holiday) Testing of Protective Coatings.

NACE RP-0490-95—Holiday Detection of Coatings of 250 µm to 760 µm (10 to 30 mils).

SSPC[‡] AB-1—Mineral and Slag Abrasives.

SSPC AB-3—Ferrous Metallic Abrasives.

SSPC PA-2—Measurement of Dry Coating Thickness with Magnetic Gauges.

SSPC SP-1—Solvent Cleaning.

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

SSPC VIS 1-89—Visual Standard for Abrasive Blast Cleaned Steel.

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. *Constructor:* The party that provides work and materials for placement or installation.
2. *Manufacturer:* The party that manufactures the coating material described in this standard.

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

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

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

3. *Purchaser:* The person, company, or organization that purchases any materials or work to be performed.

The terms *coating*, *polyamide coating*, or *polyamide coating system* shall refer to a uniform, continuous, usually two-layer (a primer layer and a polyamide top layer) Nylon-11-based polyamide coating system. This coating system is placed on a steel surface by applying a primer layer, followed by the application of the dry powder form of the polyamide with coating formation by subsequent melt processing. Some products are “self-primed” and do not require a discrete primer layer. The terms *article* or *steel article* shall refer to steel pipes, connections, fittings, or special sections.

Nylon-11 is the common name for poly (11-aminoundecanoic acid).

SECTION 4: REQUIREMENTS

Sec. 4.1 Equipment

The constructor’s equipment for abrasive blast cleaning, priming, and application of the polyamide coating shall be of a design, construction, and condition that complies with applicable requirements of this standard.

Sec. 4.2 Materials and Workmanship

Materials provided by the manufacturer and applied by the constructor shall meet applicable requirements of this standard. The constructor shall ensure that operations are performed by personnel qualified in primer application and powder coating application techniques.

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

Sec. 4.3 Primer

Only those primers approved by the coating manufacturer may be used in the production of a polyamide coating system. Specifics of shelf life and proper storage of a primer shall be provided by the manufacturer.

Sec. 4.4 Polyamide Powder

4.4.1 *Properties.* The polyamide powder employed in the production of polyamide coating shall be a single-component product, principally composed of

Nylon-11, fillers, colorants, antioxidants, and other materials, so that when employed according to the specifications of the manufacturer, produces a uniform, continuous coating that complies with requirements of this standard. This polyamide powder shall comply with the requirements of Table 1. A fluidized bed grade of powder and electrostatic spray grade of powder are described in Table 1. These two grades differ in particle size distribution only. Other properties remain the same. The selection of powder grade to use in manufacturing is dependent on the application techniques discussed in Sec. 4.5.1

4.4.2 *Shelf life and storage.* Specifics of shelf life and proper storage of the polyamide powder described in Sec. 4.4.1 shall be provided by the manufacturer.

4.4.3 *Application capability.* When applied by a method specified by the manufacturer, the polyamide powder described in Sec. 4.4.1 shall produce, after appropriate thermal treatment, a uniform coating having a thickness that complies with the requirements written in Table 2 and Sec. 4.5.3.3.

Table 1 Properties of polyamide powder employed in the production of polyamide coating system

	Minimum Value	Maximum Value	ASTM Method
Specific Gravity at 73°F (g/cm ³)	1.05	1.20	D792
Particle Size Distribution (median diameter, microns)			
fluidized bed grade	104	130	D1921
electrostatic spray grade	27	45	D1921
Melting Point (°C/°F)	182/360	191/376	E324
Water Absorption (weight percent)	1.0	2.7	D570
Amount of Poly (11-aminoundecanoic acid) (weight percent)	70	—	—
Inherent Viscosity (deciliters/g)	0.72	—	D789

Note: *Inherent viscosity* is measured at 20°C on a 0.5 percent (by weight) solution of polyamide powder dissolved in meta-cresol. Alternatively, this requirement shall be satisfied if the Nylon-11 resin from which polyamide powder is produced has a minimum value of inherent viscosity (measured under the exact same conditions as just cited) of 0.82 deciliters/g.

Table 2 Thicknesses of polyamide coating systems

	Minimum Value	Maximum Value		
	Thickness (mils) ^(*)		Standard Method	Reference (Section)
Exterior and Interior by <i>fluidized bed, electrostatic spray, or spray into preheated article</i> ^(*)				
—pipes, connections, fittings, special sections, other articles	9 [‡]	24	SSPC PA-2	4.5.3.3
Interior Only by <i>fluidized bed, electrostatic spray, or spray into preheated article</i>				
—pipes,	9 [‡]	24	SSPC PA-2	4.5.3.3
Interior Only by <i>rotocoating</i>	14	40	SSPC PA-2	4.5.3.3
—pipes, connections, fittings, special sections, other articles				
Exterior Only by <i>fluidized bed, electrostatic spray, or spray into preheated article</i> ^(†)	9 [‡]	40	SSPC PA-2	4.5.3.3
—pipes, connections, fittings, special sections, other articles				

Notes:

^(*)Thicknesses include both primer layer and polyamide layer.

^(†)In the case where the steel article is placed in a position where it may be subjected to a high level of mechanical abrasion/impact/etc. (e.g., a coated pipe placed underground and thus subject to a high level of abrasion/impact from dirt or rock backfilling), the purchaser shall consult the manufacturer to obtain a recommendation for coating thickness.

^(‡)In the case where a weld reinforcement is present, a minimum thickness of 12 mils shall apply.

Sec. 4.5 Coating Application

4.5.1 General. Polyamide coatings shall be applied by a method specified by the manufacturer. A fluidized bed grade of powder, having a coarser particle size distribution, is preferable when both the internal and external surfaces of a preheated article are to be coated by immersion in a fluidized bed of powder. An electrostatic spray grade of powder, having a finer particle size distribution, is preferable when the method of electrostatic spraying of powder onto an ambient temperature article, or onto a preheated article, is employed. Either the interior surface or exterior surface or both can be coated using the electrostatic spray method. The choice of powder shall be made by consultation with the manufacturer. When different coatings are used for internal surface and external surface, it may be preferable to employ the method of rotocoating (a method whereby the coating is applied to the interior surface of a pipe by rotating the pipe [heated] with polyamide powder inside). It should be noted, however, that because elevated temperatures are required to perform rotocoating, coatings that have been applied prior to rotocoating may be damaged.

4.5.2 *Steel surface preparation.*

4.5.2.1 Weld reinforcements. Weld reinforcements (i.e., the raised components of weld seams) in a steel article shall be deburred or may be removed when required by the purchaser, such that the area formerly under the weld reinforcement is flush to all adjacent surfaces. When performed, removal of weld reinforcements shall be performed prior to hydrostatic testing, surface cleaning, or abrasive blast cleaning.

4.5.2.2 Surface cleaning. Prior to the performance of abrasive blast cleaning, steel surfaces shall be inspected and cleaned according to SSPC SP-1 to remove oil, grease, or other adhering deposits. Care shall be taken to ensure that use of solvents complies with applicable local regulations. Heating to remove water and ice may be performed, provided that steel surfaces are heated in a manner that prevents distortion and other damage. If any contaminant remains after cleaning, more vigorous cleaning steps (e.g., chemical treatment) may be needed.

4.5.2.3 Abrasive blast cleaning. Pipe surfaces shall be abrasive blast cleaned with mineral abrasives, slag abrasives, steel shot, or steel grit (reference SSPC AB-1—Mineral and Slag Abrasives, and SSPC-AB3—Ferrous Metallic Abrasive) in accordance with SSPC SP-10/NACE No. 2. The blast anchor pattern shall be angular and the profile depth shall be 2 mils to 4 mils (50 microns to 100 microns), measured in accordance with ASTM D4417.

4.5.2.4 Visual comparative standards. If required by the purchaser, before abrasive blast cleaning is started, the constructor shall prepare a representative area of the abrasive-blast-cleaned surface on the actual work surface, as well as visual standards on panels that are a minimum of 6 in. × 6 in. × ¼ in. (150 mm × 150 mm × 6 mm). On agreement between the purchaser and constructor that the visual standards meets the requirements of Sec. 4.5.2.3, the panels shall be wrapped in 4 mils to 6 mils (102 microns to 152 microns) plastic, sealed with tape, or otherwise protected from surface contamination and corrosion, and maintained as visual reference standards throughout the coating operation. Alternatively, other industry-accepted visual standards, such as those provided by NACE or SSPC and agreed on by the purchaser and constructor, may be used.

4.5.2.5 Abrasive working mix. The abrasive working mix shall be maintained free of contaminants (oil, water, etc.).

4.5.2.6 Surface inspection. Blast-cleaned steel surfaces shall be inspected visually for adequate surface preparation. Surface imperfections that include but are not necessarily limited to sharp edges, slivers, scabs, burrs, weld spatter, etc., shall be removed by hand filing, grinding, or another appropriate method, in order to prevent

imperfections in subsequent polyamide coatings. After this, further surface cleaning according to the requirements of Sec. 4.5.2.2 or 4.5.2.3 may be required.

4.5.2.7 Protection of surfaces. Blast-cleaned steel surfaces shall be handled and stored so that no corrosion or surface deterioration or contamination is permitted to occur prior to coating. If surface deterioration or contamination should occur, surfaces shall be recleaned according to the requirements of Sec. 4.5.2.2 and 4.5.2.3.

4.5.2.8 Primer application. Primer (Sec. 4.3) shall be applied to steel surfaces according to the primer manufacturer's specifications. Only those primers that are approved for use by the coating manufacturer may be used. Primers may be in either liquid form or powder form. The thickness of the resultant primer layer shall be measured according to and be in accordance with the manufacturer's specifications. The constructor shall ensure that after performance of all steps involved in primer application, but prior to application of polyamide powder, no corrosion or surface deterioration or contamination of the primed steel surface is permitted to occur. If such corrosion or surface deterioration or contamination should occur, the steel surface shall be reprocessed according to the requirements of Sec. 4.5.2.2 and 4.5.2.3.

4.5.3 *Methods of coating.* Polyamide coatings may be applied to steel surfaces by any method specified by the manufacturer. Acceptable methods are electrostatic spray, immersion in a fluidized bed, spray onto a preheated article, thermal spray, and rotocoating.

4.5.3.1 Heating. For the purpose of coating as written in Sec. 4.5.3, steel surfaces that have been prepared in accordance with the requirements of Sec. 4.5.2 shall be heated in accordance with the specifications of the coating manufacturer. Temperature limits and exposure time limits at defined temperatures shall not be exceeded for the purpose of preventing coating degradation. If temperature limits or exposure time limits are exceeded, it may be necessary to reprocess or discard the steel article. To verify that temperature limits are not exceeded, surface temperatures of representative steel articles shall be examined every four hours. Temperatures may be examined with any established method.

4.5.3.2 Pipe ends. The polyamide coating may be held back approximately 2.5 in. (64 mm) $\pm$ 0.5 in. (13 mm) from either end, on both the exterior surface and interior surface. The presence of any coating material on the area held back, bevel or land, is not acceptable. In the case of coating of plain-end pipes where joints with rubber gaskets or mechanical couplings are to be used, coating to the edge of the pipe is acceptable, unless specified otherwise by the purchaser.

4.5.3.3 Thickness. The thickness of polyamide coating that is needed for a particular application shall be chosen pursuant to consultation between the purchaser and the manufacturer. The minimum thickness at which polyamide coatings shall be employed is 9 mils (225 microns), for both exterior and interior surfaces. More specific requirements are given in Table 2. When the surface to be coated contains a weld reinforcement, the minimum thickness shall be 12 mils (300 microns). When a rotocoating operation is used to apply a coating to an interior surface, the minimum thickness shall be 14 mils (350 microns). When the coated steel article is to be placed in a position where it may be subjected to a large amount of mechanical abrasion/impact/etc., the purchaser shall consult the manufacturer to choose the proper thickness. The dry film thickness of the coating shall be measured according to SSPC PA-2 (Sec. 2). The averages listed in SSPC PA-2 shall be deleted, and the minimum dry film thickness of measurements shall be as specified by the purchaser.

4.5.3.4 Cooling. Immediately after the melting phase of polyamide coating application, the coating shall be allowed to cool in ambient air to room temperature. Handling of the coated steel article and inspection and repair of the coating may be performed after the coating has cooled to below 140°F (60°C).

4.5.3.5 Defects. When the coating process is complete, the polyamide coating shall be visually inspected for defects and electrically inspected for holidays in accordance with Sec. 5.3.1. Inspection and repairs may be performed after the coating has cooled to below 140°F (60°C). Repairs shall be made according to the requirements of Sec. 4.5.4.1 and 4.5.4.2.

4.5.4 Coating repair.

4.5.4.1 Minor defects. Coating defects that include but are not necessarily limited to scars, slivers, imperfections, and discontinuities (see Sec. 5.3.1) shall be repaired using only materials and procedures specified by the coating manufacturer. Repairs should be made in a shop or manufacturing facility, if possible. Ordinarily, the repair material is a two-part liquid epoxy patching compound or a hot-melt patching compound compatible with the polyamide coating applied. Areas to be repaired shall be prepared according to the specifications of the manufacturer of the repair material. These same methods shall apply to the repair of small, uncoated areas of steel articles that served as holding points during application of the polyamide coating. Areas repaired shall be inspected electrically, using a holiday detector according to the requirements of Sec. 5.3.1.

4.5.4.2 Major defects. Polyamide coatings having major defects that include but are not necessarily limited to partial coverage, unbonded areas, and inadequate thickness shall be completely reprocessed, beginning with steel surface preparation, in accordance with Sec. 4.5.2. Instructions on removal of polyamide coatings shall be obtained from the coating manufacturer. Reprocessing shall be performed in a shop or manufacturing facility.

4.5.5 *Field-welded joints.* The exteriors of field-welded joints shall be coated with materials and procedures specified by the coating manufacturer. This may include thermal spray technology. Alternatively, field-welded joints may be treated in accordance with the requirements of ANSI/AWWA C203, C209, C210, C216, or C217. The interior of field-welded joints shall be coated in accordance with ANSI/AWWA C210.

Sec. 4.6 Field Procedures

During the construction/assembly of installations with steel articles coated with polyamide coatings, the constructor shall use every precaution to prevent damage to the coatings. Unnecessary contact between the coatings and metal tools or any heavy object shall be prevented. Workers shall not be permitted to walk on the coatings, unless absolutely necessary, and then only with suitable footwear that will not cause damage to the coating. If specified by the purchaser, holiday testing (according to the requirements of Sec. 5.3.1) of polyamide coatings may be performed immediately prior to installation. Damaged coatings shall be repaired.

4.6.1 *Protection during welding.* During welding operations, the constructor shall ensure that no damage to the polyamide coating occurs. This may be done by employing precautions such as covering the coating or cooling the coating during welding operations.

4.6.2 *Hoisting.* Coated pipes shall be hoisted using wide belt slings or other equipment that will not cause damage to the coatings. Metal chains, cables, or other equipment likely to cause damage shall not be used. Coated pipes shall not be moved by dragging, skidding, or other abrasive activity. The constructor shall permit inspection of polyamide coatings on pipe surfaces. Any damage to polyamide coatings shall be repaired according to the requirements of Sec. 4.5.4.

4.6.3 *Bedding and trench.* Backfilling shall be performed in a manner that avoids damage to polyamide coatings on the exterior of a pipe. Unless otherwise specified by the purchaser, the following requirements shall be met:

- a. Where the trench, into which pipe is to be placed, traverses rocky ground containing hard or sharp objects that could penetrate or damage the polyamide coating, a layer of screened backfill (earth, sand, or gravel with a maximum particle size of approximately $\frac{3}{4}$ in. [19 mm]), no less than 6 in. (150 mm) thick, shall be placed in the bottom of the trench prior to the installation of the pipe. Other suitable bedding materials may be used in place of screened backfill, if approved by the purchaser.
- b. Placement of screened backfill around the exterior of pipe coated with polyamide shall be done only in a manner approved by the purchaser, after final inspection and acceptance of the coating. Rocks, concrete chunks, or other hard or sharp objects shall not be placed within 6 in. (150 mm) of the exterior of the pipe. If excavated trench material contains oversized rocks, concrete chunks, or other hard or sharp objects along any section of the trench in which the pipe is to be placed, screened backfill material shall be placed around the pipe within that section, to a minimum depth of 6 in. (150 mm) above the exterior of the coated pipe, before the excavated backfill can be used to fill the remainder of the trench.
- c. Compaction of bedding and screened backfill in the trench in which coated or lined pipe lies shall be as specified by the purchaser. Compaction with metal rods or other metal tools that could come into contact with the coated pipe and cause damage to the coating shall not be permitted.

SECTION 5: VERIFICATION

Sec. 5.1 Inspection by Purchaser

5.1.1 *Inspection.* If specified, the entire procedure of applying polyamide coating, from steel surface preparation through completion of final coating, may be inspected by the purchaser. The inspection shall not relieve the manufacturer or the constructor of any responsibility for providing materials and performing work in accordance with this standard.

5.1.2 *Access for purchaser.* The purchaser shall have reasonable access to areas germane to the performance of work described in this standard, including but not necessarily limited to construction sites, coating facilities, and material-handling facilities.

5.1.3 *Facilities for inspection.* The purchaser shall be provided with facilities and space for inspection testing and acquisition of information regarding the material used, the application process, the progress and manner of the work, and results obtained as specified by the purchaser.

Sec. 5.2 Nonconformance

5.2.1 *Surface.* The constructor may reject steel articles if the surface is found to be unsuitable for cleaning or primer application, in accordance with the requirements of Sec. 4.5.2. Further, the purchaser may reject articles if, for any reason, the surface condition prevents compliance with the requirements of Sec. 4.5. In the event that articles are rejected by the purchaser because of inadequate cleaning or priming, the constructor shall have the option to try to use these articles by recleaning and repriming. The purchaser shall retain the right to reinspect and reject these reused articles.

5.2.2 *Coating work.* When inspection is performed by the purchaser, polyamide coatings not applied in the presence of the purchaser are subject to rejection (Sec. 4.5.4.1 and 4.5.4.2). If, at any time, it is determined that the procedures employed for preparation of steel surface or application of coatings do not meet the requirements of this standard, the purchaser shall have the option to reject all coated steel articles so produced.

Sec. 5.3 Testing of Production-Coated Articles

Inspection for determination of continuity and thickness of a polyamide coating may begin after the coated steel article has cooled to 140°F (60°C) or less.

5.3.1 *Continuity.* When coatings-related operations for a steel surface are completed, and prior to storage, polyamide coatings shall be inspected for continuity in accordance with NACE RP-0188. Holidays and discontinuities shall be repaired according to the requirements of Sec. 4.5.4.1. At the sole option of the purchaser, a steel surface shall be reprocessed per Sec. 4.5.4.2 if the number of detected holidays exceeds values of

- a. One per 3 ft (0.9 m) of pipe length for pipes smaller than 14 in. (350 mm) in outside diameter, or
- b. One per 25 ft² (2.3 m²) of surface area for pipes larger than 14 in. (350 mm) in outside diameter, or

c. One per 25 ft² (2.3 m²) of surface area for connections, fittings, special sections, or other articles.

If the option of reprocessing is not elected, holidays and discontinuities shall be repaired according to the requirements of Sec. 4.5.4.1.

5.3.2 Adhesion. The adhesion of the coating to the surface of a steel article shall be examined. When possible, the surface to be tested will be a surface not exposed to water. Adhesion shall be measured according to ASTM D6677. Adhesion is acceptable when a rating value greater than or equal to “8” is obtained.

The number of tests per coated article shall be specified by purchaser. Ordinarily one test per article is performed. The tested area shall be repaired in accordance with the requirements of Sec. 4.5.4.1. Adhesion measurements shall not be made preferably within 24 hours of application of coating.

5.3.3 Thickness. Polyamide coating thicknesses shall be in accordance with the requirements of Sec. 4.5.3.3 and Table 2. Coating thicknesses shall be measured in accordance with SSPC PA-2.

SECTION 6: DELIVERY

Sec. 6.1 Packaging and Marking

Containers holding polyamide coating powders shall be plainly marked with the name of the manufacturer, type of material, batch or lot number, storage conditions, and any other information required by federal, state or provincial, and local regulations.

Sec. 6.2 Handling, Storage, and Shipping

Polyamide-coated steel articles shall be stored and handled in a manner to prevent damage to the coating. Damaged coatings shall be repaired. Repairs shall be made in accordance with the requirements of Sec. 4.5.4.1.

6.2.1 Stacking. Stacking of polyamide-coated steel articles shall be performed according to good safety practices and the purchaser's instructions. Spacers, paddings, etc., shall be employed as required to prevent damage to the coatings.

6.2.2 Shipping. Coated steel articles shall be transported from the site of coating operations to the site of field use according to agreement between the

purchaser and the constructor. Transport of coated steel articles shall be performed to prevent damage to the coatings.

6.2.3 *Loading.* Coated steel articles shall be loaded for shipment in accordance with standard shipping practices. Loading shall be performed to prevent damage to the coatings.

6.2.4 *Trench-side placement.* Coated steel articles, especially pipes coated on the exterior, placed alongside trenches prior to placement in the trenches shall be supported off the ground to prevent damage to the coatings.

6.2.5 *Outdoor storage.* The purchaser should consult with the manufacturer and the constructor regarding the specific weather conditions (e.g., temperature, humidity, ultraviolet exposure) to which coated steel articles, especially pipes coated on the exterior, will be subjected during storage prior to installation. From this consultation, any decisions concerning any protective measures shall be made.

Sec. 6.3 Affidavit of Compliance

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

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1P-3.6M-43224-4/07-JP



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