Designation: A 849 – 00

Standard Specification for Post-Applied Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe[1]

This standard is issued under the fixed designation A 849; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers post-applied coatings, pavings, and linings for corrugated steel pipe and corrugated steel structural plate pipe, pipe-arches, and arches coated, paved, or lined with specified materials over either metallic coatings or metallic coatings with polymer coatings. This specification includes asphalt, polymerized asphalt, polymer, mastic, and emulsion coatings and asphalt and concrete pavements and linings applied to the pipe in the producing plant, as well as, asphalt and mastic coatings applied in the field. Field-applied concrete pavements and linings are covered by Specification A 979/A 979 M. The pipe to which the coatings are applied is described in Specifications A 760/A 760M, A 761/A 761M, and A 762/A 762M.

1.2 There is no cleaning operation currently included in pipe coating practice. However, experience has shown that a clean substrate provides good adherence for both cold- and hot-applied post coatings. The performance of post coating or lining, or both, will depend on the surface cleanliness over which it is applied.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in brackets are for information only.

1.4 The following safety hazards caveat pertains only to the test methods portions, Sections 11 and 12, of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

A 185 Specification for Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement[2]

A 615/A 615M Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement[2]

A 742/A 742M Specification for Steel Sheet, Metallic-Coated and Polymer Precoated for Corrugated Steel Pipe[3]

A 760/A 760M Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains[3]

A 761/A 761M Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches[3]

A 762/A 762M Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains[3]

A 862 Practice for Application of Bituminous (Asphalt) Coatings to Corrugated Steel Sewer and Drainage Pipe[3]

A 885/A 885M Specification for Steel Sheet, Zinc and Aramid Fiber Composite Coated for Corrugated Steel Sewer, Culvert, and Underdrain Pipe[3]

A 926 Test Method for Comparing the Abrasion Resistance of Coating Materials for Corrugated Metal Pipe[3]

A 979/A 979M Specification for Concrete Pavements and Linings Installed in Corrugated Steel Structures in the Field[3]

C 31/C 31M Practice for Making and Curing Concrete Test Specimens in the Field[4]

C 33 Specification for Concrete Aggregates[4]

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[4]

C 150 Specification for Portland Cement[5]

C 309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete[4]

C 595 Specifications for Blended Hydraulic Cements[5]

C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete[4]

C 670 Practice for Preparing Precision and Bias Statements for Test Methods of Construction Materials[4]

D 5 Test Method for Penetration of Bituminous Materials[6]

D 6 Test Method for Loss on Heating of Oil and Asphaltic Compounds[7]

D 20 Test Method for Distillation of Road Tars[6]

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[1] This specification is under the jurisdiction of ASTM Committee A05 on Metallic Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.17 on Corrugated Steel Pipe Specifications.

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[2] *Annual Book of ASTM Standards*, Vol 01.04.

[3] *Annual Book of ASTM Standards*, Vol 01.06.

[4] *Annual Book of ASTM Standards*, Vol 04.02.

[5] *Annual Book of ASTM Standards*, Vol 04.01.

[6] *Annual Book of ASTM Standards*, Vol 04.03.

[7] *Annual Book of ASTM Standards*, Vol 04.04.

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1.2 There is no cleaning operation currently included in pipe coating practice. However, experience has shown that a clean substrate provides good adherence for both cold- and hot-applied post coatings. The performance of post coating or lining, or both, will depend on the surface cleanliness over which it is applied.

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[6] *Annual Book of ASTM Standards*, Vol 04.03.

[7] *Annual Book of ASTM Standards*, Vol 04.04.

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D 36 Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)[7]
D 70 Test Method for Density of Semi-Solid Bituminous Materials (ometer Method)[6]
D 92 Test Methods for Flash and Fire Points by Cleveland Open Cup[8]
D 1005 Test Methods for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers[9]
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D 2042 Test Method for Solubility of Asphalt Materials in Trichloroethylene[6]
D 4402 Test Method for Viscosity Determinations of Unfilled Asphalts Using the Brookfield Thermosel Apparatus[7]

3. Terminology

3.1 *Definitions:*

3.1.1 *fabricator*, *n*—refers to the producer of the pipe who generally applies the post coatings, pavings, and linings, except for those pipes that are coated in the field.

3.1.2 *lining*, *n—for corrugated metal pipe*, a layer of nonmetallic material applied to the interior of a fabricated pipe, of sufficient thickness to fill and cover the corrugations.

3.1.3 *manufacturer*, *n*—refers to the producer of the sheet.

3.1.4 *paving*, *n—for corrugated metal pipe*, a lining applied only to a portion of the interior circumference, usually the lower portion as installed.

3.1.5 *post coating*, *n—for corrugated metal pipe*, a layer of nonmetallic material applied to the interior or exterior surface of the pipe, or both, after fabrication of the pipe.

3.1.6 *Discussion—Coating* is generally used to refer to a layer or layers of material applied to the base metal in sheet form prior to fabrication into pipe. *Post coating* applies to a layer of nonmetallic material applied after fabrication into pipe. Where the context is clear, *coating* may be used in place of *post coating*.

3.1.7 *purchaser*, *n*—refers to the purchaser of the finished product.

4. Significance and Use

4.1 Post-applied coatings, linings, and pavements are used to improve hydraulic characteristics, corrosion resistance, or abrasion resistance, or a combination thereof. Generally, coatings improve corrosion resistance and are especially effective on the outside (soil side) of the pipe. While coatings improve abrasion resistance to varying degrees, pavements generally are used where abrasion is a significant consideration. Pave- ments improve abrasion resistance, protect the metallic and other coatings, and increase corrosion resistance. Smooth pavements, even though they typically cover only the invert of the pipe, improve hydraulic flow characteristics. Full linings and pavements, generally, provide all three benefits.

4.2 *Applications*:

4.2.1 Asphalt, polymer-modified asphalt, and polymer provide excellent corrosion resistance to the outside (soil side) of the pipe. These materials provide varying degrees of internal (water side) corrosion protection depending on the severity of abrasive flow conditions. Polymer-modified asphalt and polymer coatings provide longer-term protection than asphalt in more abrasive conditions.

4.2.2 Asphalt pavements are used for abrasive conditions. Where conditions involve repeated high flow velocities moving a heavy bed load of gravel or rocks, or both, concrete pavements are appropriate (see Specification A 979/A 979M).

4.2.3 Full asphalt linings enhance hydraulics while providing a completely "paved" interior. Full concrete linings are high-strength concrete that provides a lining similar in thickness to asphalt linings. They enhance hydraulic performance and offer abrasion protection, which is not as effective as the abrasion protection offered by a thicker concrete pavement.

5. Classification

5.1 The post-applied coatings, pavings, and linings are described in this section as a two-step classification procedure. The first classification is the type of coating, paving, or lining material to be used, for example, hot-applied asphalt, concrete, cold-applied mastic, cold-applied emulsion, polymer, or combination thereof. The second is a coating, paving, and lining type giving the physical location of the coating or lining on the pipe (see Table 1).

5.2 *Material Classes*:

5.2.1 *Class A*—Asphalt,

5.2.2 *Class PA*—Polymer modified asphalt, hot applied,

5.2.3 *Class C*—Concrete,

5.2.4 *Class M*—Mastic, either asphalt base or tar base, cold applied,

5.2.5 *Class P*—Polymer, and

5.2.6 *Class E*—Asphaltic emulsion.

5.3 *Coating, Paving, and Lining Types*:

5.3.1 *Fully Coated*—A uniform coating applied to the interior and exterior of the pipe.

5.3.2 *Half Coated*—A uniform coating applied to the interior and exterior of the pipe covering at least 50 % of the circumference on the lower portion of the pipe as installed.

5.3.3 *Exterior Coated*—A uniform coating applied to the exterior of the pipe.

5.3.4 *Interior Coated*—A uniform coating applied to the interior of the pipe .

5.3.5 *Invert Coating*—A uniform coating on the lower portion of the interior of the pipe as installed (the invert) to provide abrasion and corrosion resistance without filling the corrugations.

TABLE 1 Location and Material Class

Physical Location	A Asphalt, Hot-Applied	PA Polymerized Asphalt, Hot-Applied	C Concrete	M/E Cold-Applied[A]	P Polymer
Interior-coated	—	—	—	M/E	P
Exterior-coated	—	—	—	M/E	P
Fully-coated	A	PA	—	M/E	P
Half-coated	A	PA	—	M/E	P
Fully-lined	A	—	C	—	—
Invert-paved	A	PA	C	—	P
Invert-coated	—	PA	—	—	P

[A] May be plant or field applied.

[8] *Annual Book of ASTM Standards*, Vol 05.01.
[9] *Annual Book of ASTM Standards*, Vol 06.01.

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5.2.2 *Class PA*—Polymer modified asphalt, hot applied,

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5.3.4 *Interior Coated*—A uniform coating applied to the interior of the pipe .

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Exterior-coated	—	—	—	M/E	P
Fully-coated	A	PA	—	M/E	P
Half-coated	A	PA	—	M/E	P
Fully-lined	A	—	C	—	—
Invert-paved	A	PA	C	—	P
Invert-coated	—	PA	—	—	P

[A] May be plant or field applied.

[8] *Annual Book of ASTM Standards*, Vol 05.01.
[9] *Annual Book of ASTM Standards*, Vol 06.01.

5.3.6 *Invert Paved*—A paving on the lower portion of the interior of the pipe as installed (the invert) to provide an abrasion-resistant smooth flow line.

5.3.7 *Fully Lined*—A lining filling the corrugations on the full interior of the pipe to provide a smooth interior.

6. Ordering Information

6.1 The pipe to be coated shall be described as to the applicable standard (Specification A 760/A 760M, A 761/A 761M, or A 762/A 762M), including all detailed ordering provisions of that specification.

6.2 Orders for pipe coatings to this specification shall include the following information as necessary to adequately describe the desired product,

6.2.1 Class of material,

6.2.2 Type of coating, paving, or lining,

6.2.3 If post coating is to be applied in the plant or in the field (Note 1).

NOTE 1—Class M (mastic) and Class E (emulsions) coatings are suitable for either plant application or field application.

6.2.4 For Class M, whether asphalt base or tar base material,

6.2.5 For concrete *invert paved* material Class C, amount of reinforcement (see 7.2.2.5),

6.2.6 ASTM designation and year of issue,

6.2.7 Certification, if required, on the post coating, and,

6.2.8 Any special requirements.

7. Material Requirements

7.1 *Material Class A (Asphalt Material)*—The asphalt material shall be applied in accordance with Practice A 862 and shall meet the following requirements as applied to a pipe:

7.1.1 *Softening Point*—200°F [93°C] min.

7.1.2 *Penetration (Original Material)*—35 to 65 dmm.

7.1.3 *Penetration (Residue from Loss on Heating)*—85 % of original penetration, min.

7.1.4 *Flash Point*—450°F [232°C] min.

7.1.5 *Solubility*—99 % min.

7.1.6 *Specific Gravity*—0.98 min at 77°F [25°C].

7.1.7 *Loss on Heating*—1 % max.

7.1.8 *Shock*—The asphalt shall be considered acceptable if not more than one of the four test specimens shows a crack. Test as described in 11.2.

7.1.9 *Flow*—The asphalt shall be considered acceptable if the flow does not exceed ⅜ in. [9.5 mm] for either of the two test specimens. Test as described in 11.3.

7.1.10 *Imperviousness*—There shall not be any loosening or separation of the asphalt coating from the substrate at the end of 48 h when tested as described in 11.4.

7.2 *Material Class C (Concrete Material)*—Full concrete linings shall meet the requirements of 7.2.1. Concrete paved inverts shall meet the requirements of 7.2.2.

7.2.1 *Concrete Linings*—Full concrete linings shall cover 100 % of the pipe circumference. Linings shall be placed by a machine that, in one or more passes, completely fills the corrugation and provides a minimum ⅛ in. [3.2 mm] concrete thickness over the corrugation crests. Hand placement methods are acceptable for lining fittings and elbows when machine placement is not practical and the above results are achieved. The lining shall conform to the shape of the pipe and have a troweled surface finish meeting the requirements of 9.1.2.1.

7.2.1.1 The concrete shall be composed of cement, fly ash (when used), fine aggregates, and water that are well mixed and of such consistency as to produce a dense, homogeneous, nonsegregated lining. In no case shall the proportions of portland cement, blended cement, or portland cement plus pozzolanic material in the mixture be less than 470 lb/yd^3 [279 kg/m^3] of concrete. The concrete mix shall provide a minimum seven day compressive strength of 5000 psi [34.5 MPa] when tested in accordance with Practice C 31 and Test Method C 39. Concrete linings shall be cured to meet the requirements of 7.2.3. All concrete shall have a water-cement ratio not exceeding 0.50 by weight.

7.2.1.2 *Cement*—Cement shall conform to the requirements of Specification C 150, Type I or II or Specification C 595, Type IP. When Type IP cement is used, no fly ash shall be used in the mix.

7.2.1.3 *Fly Ash*—Fly ash shall conform to the requirements of Specification C 618, Class F or Class C. When fly ash is used, it shall not exceed 20 % by weight of the total cementitious materials in the mix.

7.2.1.4 *Aggregates*—Aggregates shall conform to the requirements of Specification C 33 except that the requirement for gradation and uniformity of gradation shall not apply. The aggregate shall be well graded with 100 % passing the No. 16 [1.18 mm] sieve with no more than 5 % passing the No. 100 [150 µm] sieve.

7.2.1.5 Only potable water shall be used.

7.2.2 *Concrete Pavements*—Special pavement designs that meet or exceed the requirements of this specification shall be fully detailed in the purchase documents. In lieu of a special design, pavements shall cover the bottom 25 % of a round pipe's circumference and the 40 % of the circumference of a pipe arch that constitutes the invert. Pavements shall conform to the shape of the pipe and have either a screeded or troweled surface finish as specified in the purchase documents. The troweled finish shall meet the requirements of 9.1.2.1.

7.2.2.1 The pavement shall provide a minimum 3 in. [76.2 mm] thickness over the corrugation crests, when concrete with a minimum 28-day compressive strength of 3250 psi [22.4 MPa] is used. Alternatively, the pavement shall provide a minimum 1 ½ in. [38.1 mm] thickness over the corrugation crests, when concrete with a minimum 28-day compressive strength of 9600 psi [66.2 MPa] is used. Concrete compressive strength shall be determined in accordance with Practice C 31 and Test Method C 39. All concrete pavements shall be cured to meet the requirements of 7.2.3.

7.2.2.2 *Cement*—The cement to be used shall be Type II portland cement conforming to Specification C 150 with alkali content not more than 0.60 % expressed as Na_2O, or Type IP (MS) portland pozzolan cement conforming to Specification C 595. When Type IP cement is used, no fly ash shall be used in the mix.

7.2.2.3 *Fly Ash*—Fly ash shall conform to the requirements of Specification C 618, Class F or Class C. When fly ash is used, it shall not exceed 20 % by weight of the total cementatious materials in the mix.

5.3.6 *Invert Paved*—A paving on the lower portion of the interior of the pipe as installed (the invert) to provide an abrasion-resistant smooth flow line.

5.3.7 *Fully Lined*—A lining filling the corrugations on the full interior of the pipe to provide a smooth interior.

6. Ordering Information

6.1 The pipe to be coated shall be described as to the applicable standard (Specification A 760/A 760M, A 761/A 761M, or A 762/A 762M), including all detailed ordering provisions of that specification.

6.2 Orders for pipe coatings to this specification shall include the following information as necessary to adequately describe the desired product,

6.2.1 Class of material,

6.2.2 Type of coating, paving, or lining,

6.2.3 If post coating is to be applied in the plant or in the field (Note 1).

NOTE 1—Class M (mastic) and Class E (emulsions) coatings are suitable for either plant application or field application.

6.2.4 For Class M, whether asphalt base or tar base material,

6.2.5 For concrete *invert paved* material Class C, amount of reinforcement (see 7.2.2.5),

6.2.6 ASTM designation and year of issue,

6.2.7 Certification, if required, on the post coating, and,

6.2.8 Any special requirements.

7. Material Requirements

7.1 *Material Class A (Asphalt Material)*—The asphalt material shall be applied in accordance with Practice A 862 and shall meet the following requirements as applied to a pipe:

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7.1.2 *Penetration (Original Material)*—35 to 65 dmm.

7.1.3 *Penetration (Residue from Loss on Heating)*—85 % of original penetration, min.

7.1.4 *Flash Point*—450°F [232°C] min.

7.1.5 *Solubility*—99 % min.

7.1.6 *Specific Gravity*—0.98 min at 77°F [25°C].

7.1.7 *Loss on Heating*—1 % max.

7.1.8 *Shock*—The asphalt shall be considered acceptable if not more than one of the four test specimens shows a crack. Test as described in 11.2.

7.1.9 *Flow*—The asphalt shall be considered acceptable if the flow does not exceed ⅜ in. [9.5 mm] for either of the two test specimens. Test as described in 11.3.

7.1.10 *Imperviousness*—There shall not be any loosening or separation of the asphalt coating from the substrate at the end of 48 h when tested as described in 11.4.

7.2 *Material Class C (Concrete Material)*—Full concrete linings shall meet the requirements of 7.2.1. Concrete paved inverts shall meet the requirements of 7.2.2.

7.2.1 *Concrete Linings*—Full concrete linings shall cover 100 % of the pipe circumference. Linings shall be placed by a machine that, in one or more passes, completely fills the corrugation and provides a minimum ⅛ in. [3.2 mm] concrete thickness over the corrugation crests. Hand placement methods are acceptable for lining fittings and elbows when machine placement is not practical and the above results are achieved. The lining shall conform to the shape of the pipe and have a troweled surface finish meeting the requirements of 9.1.2.1.

7.2.1.1 The concrete shall be composed of cement, fly ash (when used), fine aggregates, and water that are well mixed and of such consistency as to produce a dense, homogeneous, nonsegregated lining. In no case shall the proportions of portland cement, blended cement, or portland cement plus pozzolanic material in the mixture be less than 470 lb/yd^3 [279 kg/m^3] of concrete. The concrete mix shall provide a minimum seven day compressive strength of 5000 psi [34.5 MPa] when tested in accordance with Practice C 31 and Test Method C 39. Concrete linings shall be cured to meet the requirements of 7.2.3. All concrete shall have a water-cement ratio not exceeding 0.50 by weight.

7.2.1.2 *Cement*—Cement shall conform to the requirements of Specification C 150, Type I or II or Specification C 595, Type IP. When Type IP cement is used, no fly ash shall be used in the mix.

7.2.1.3 *Fly Ash*—Fly ash shall conform to the requirements of Specification C 618, Class F or Class C. When fly ash is used, it shall not exceed 20 % by weight of the total cementitious materials in the mix.

7.2.1.4 *Aggregates*—Aggregates shall conform to the requirements of Specification C 33 except that the requirement for gradation and uniformity of gradation shall not apply. The aggregate shall be well graded with 100 % passing the No. 16 [1.18 mm] sieve with no more than 5 % passing the No. 100 [150 µm] sieve.

7.2.1.5 Only potable water shall be used.

7.2.2 *Concrete Pavements*—Special pavement designs that meet or exceed the requirements of this specification shall be fully detailed in the purchase documents. In lieu of a special design, pavements shall cover the bottom 25 % of a round pipe's circumference and the 40 % of the circumference of a pipe arch that constitutes the invert. Pavements shall conform to the shape of the pipe and have either a screeded or troweled surface finish as specified in the purchase documents. The troweled finish shall meet the requirements of 9.1.2.1.

7.2.2.1 The pavement shall provide a minimum 3 in. [76.2 mm] thickness over the corrugation crests, when concrete with a minimum 28-day compressive strength of 3250 psi [22.4 MPa] is used. Alternatively, the pavement shall provide a minimum 1 ½ in. [38.1 mm] thickness over the corrugation crests, when concrete with a minimum 28-day compressive strength of 9600 psi [66.2 MPa] is used. Concrete compressive strength shall be determined in accordance with Practice C 31 and Test Method C 39. All concrete pavements shall be cured to meet the requirements of 7.2.3.

7.2.2.2 *Cement*—The cement to be used shall be Type II portland cement conforming to Specification C 150 with alkali content not more than 0.60 % expressed as Na_2O, or Type IP (MS) portland pozzolan cement conforming to Specification C 595. When Type IP cement is used, no fly ash shall be used in the mix.

7.2.2.3 *Fly Ash*—Fly ash shall conform to the requirements of Specification C 618, Class F or Class C. When fly ash is used, it shall not exceed 20 % by weight of the total cementatious materials in the mix.

7.2.2.4 *Aggregates*—The aggregates shall conform to the requirements prescribed in Specification C 33.

7.2.2.5 *Steel Reinforcement*—When steel reinforcement is required (special pavement designs), it shall be billet-steel bars conforming to Specification A 615, Grade 40 or Grade 60, or welded wire fabric reinforcement conforming to Specification A 185. Special pavement designs using reinforcement shall consider adequate concrete cover over the reinforcing steel for the intended application.

7.2.2.6 Only potable water shall be used.

7.2.3 Curing operations shall begin immediately after placing the lining or pavement and continue for a minimum of 72 h. The pipe shall be closed with airtight end covers and the concrete kept wet via an intermediate water source or a liquid membrane-forming compound conforming to Specification C 309 applied to the concrete surface. The manufacturer is responsible for adequate cure time, conditions, and shipment precautions to meet the applicable requirements of 7.2.1.1 or 7.2.2.1 and 9.1.2.

7.3 *Material Class M (Asphalt Mastic or Tar Base Mastic)*—The tar base mastic material shall conform to the requirements in Table 2. The asphalt mastic material shall have the following physical characteristics:

7.3.1 *Asphalt Base*—Oxidized petroleum asphalts.

7.3.2 *Solvent*—Rapid drying petroleum solvents.

7.3.3 *Fillers*—Mineral stabilizers and fillers.

7.3.4 *Consistency*—Material shall be furnished in consistency for application by trowel, brush, or spray, as specified.

7.3.5 *Physical Properties*—As described in Table 3.

7.4 *Material Class PA (Polymer Modified Asphalt)*—The polymer modified asphalt shall meet the following requirements as applied to the pipe:

7.4.1 *Softening Point*—200°F [93°C] minimum when tested in accordance with 11.1.1.

7.4.2 *Penetration*—25 to 50 dmm when tested in accordance with 11.1.1.

7.4.3 *Flash Point*—500°F [260°C] minimum when tested in accordance with 11.1.1.

7.4.4 *Loss on Heating*—1 % maximum when tested in accordance with 11.1.1.

7.4.5 *Shock*—No more than one specimen shall crack when tested in accordance with 11.2.

TABLE 2 Tar Base Material, Cold-Applied Requirements

Physical Properties	Requirement	Method
Sag test	no sag[A]	applied at the rate of 60 ft^2 per gal [1.47 m^2/L] to a smooth metal surface
Ash, mass, %	15–25	loss of ignition
Distillation, mass, %		
32–302°F [0–150°C]	0	
302–455°F [150–235°C]	20–30	
Distillation residue		
Softening point, °F [°C]	205–240 [96–115]	Test Method D 36
Penetration, (77°F [25°C], 100 g, 5 s) dmm	5–25	Test Method D 5
Drying time, h	24–48	surface dry under normal atmospheric conditions

[A] No statement is made about either the precision or the bias of the sag test because the result merely states whether there is conformance to the criteria for success specified in the procedure.

TABLE 3 Asphalt Mastic, Cold-Applied Physical Properties

	Trowel Grade		Spraying Grade		Brushing Grade	
	min	max	min	max	min	max
Solids, weight %	63	68	61	66	60	65
Weight [mass], lb/gal [kg/L]	8.7 [1.04]	8.9 [1.07]	8.3 [0.99]	9.3 [1.11]	8.2 [0.98]	8.5 [1.02]
Dry to touch, h	. . .	4	. . .	4	. . .	4
Dry hard, 1/16 in., h	. . .	48	. . .	48	. . .	48
Flow test[A]	. . .	. . .	. . .	. . .	. . .	. . .
Acid and alkali resistance[B]	. . .	. . .	. . .	. . .	. . .	. . .

[A] Shifting or sagging of lines is cause for rejection.
[B] Panel surface shall remain free of any pitting or rusting.

7.4.6 *Flow*—The polymer modified asphalt shall be acceptable if the flow of either of the two samples does not exceed ¼ in. [6.4 mm] when tested in accordance with 11.3.

7.4.7 *Imperviousness*—There shall be no disbonding of the polymer modified asphalt from the substrate in 48 h when tested in accordance with 11.4.

7.4.8 *Abrasion Resistance*—No more than 10 grid squares shall have exposed metal that is visible to the naked eye prior to 3 000 000 revolutions when tested in accordance with 11.5.

7.4.9 *Brookfield Viscosity Measured at 380°F [193°C]*—800 to 2000 cps when determined in accordance with 11.6.

7.5 *Material Class P (Polymer)*—The polymer material shall conform to the requirements of Specification A 742/ A 742M.

7.6 *Material Class E (Asphaltic Emulsion)*—Cold-applied asphaltic emulsions shall conform to the requirements of Specification D 1187.

8. Materials and Manufacture

8.1 *Pipe Fabrication*—All pipe post-coated under this specification shall be fabricated in accordance with the requirements of Specification A 760/A 760M, A 761/A 761M, or A 762/A 762M. Steel sheet composite-coated for corrugated steel sewer pipe (Specification A 885) shall be fabricated in accordance with the requirements for riveted or lock-seam pipe of Specification A 760/A 760M and only post-coated with Class A coating material *fully coated*, with or without being *invert paved* or *fully lined* (see 8.3, 8.4, and 8.6).

8.2 *Pipe Preparation*—The coatings of the types described in this specification shall be applied to pipe which is essentially free from all moisture, dirt, oil, grease, or other foreign matter.

8.3 *Fully Coated, Half-Coated, Exterior-Coated, Interior-Coated Types with Asphalt, Polymerized Asphalt, Mastic, and Asphaltic Emulsions (Classes A, PA, M, and E)*—The coating shall be applied to a minimum thickness of 0.05 in. [1.3 mm] measured on the crest of corrugations, on the top of ribs (for exterior coating on Type IR pipe), or on the smooth inside surface (for interior coating on Type IA Pipe, or interior or exterior of Type IR pipe). Material Classes A and PA are used only for *fully coated* and *half-coated* types. Material Class M is permitted for use for all four coating types.

8.4 *Invert Paved Type with Asphalt and Polymerized Asphalt (Classes A and PA)*—The material shall be applied to fill the corrugations and provide a minimum thickness of ⅛ in. [3.2 mm] above the crest of corrugations for at least 25 % of

7.2.2.4 *Aggregates*—The aggregates shall conform to the requirements prescribed in Specification C 33.

7.2.2.5 *Steel Reinforcement*—When steel reinforcement is required (special pavement designs), it shall be billet-steel bars conforming to Specification A 615, Grade 40 or Grade 60, or welded wire fabric reinforcement conforming to Specification A 185. Special pavement designs using reinforcement shall consider adequate concrete cover over the reinforcing steel for the intended application.

7.2.2.6 Only potable water shall be used.

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7.3 *Material Class M (Asphalt Mastic or Tar Base Mastic)*—The tar base mastic material shall conform to the requirements in Table 2. The asphalt mastic material shall have the following physical characteristics:

7.3.1 *Asphalt Base*—Oxidized petroleum asphalts.

7.3.2 *Solvent*—Rapid drying petroleum solvents.

7.3.3 *Fillers*—Mineral stabilizers and fillers.

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7.3.5 *Physical Properties*—As described in Table 3.

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Dry to touch, h	. . .	4	. . .	4	. . .	4
Dry hard, 1/16 in., h	. . .	48	. . .	48	. . .	48
Flow test[A]	. . .	. . .	. . .	. . .	. . .	. . .
Acid and alkali resistance[B]	. . .	. . .	. . .	. . .	. . .	. . .

[A]Shifting or sagging of lines is cause for rejection.
[B]Panel surface shall remain free of any pitting or rusting.

7.4.6 *Flow*—The polymer modified asphalt shall be acceptable if the flow of either of the two samples does not exceed ¼ in. [6.4 mm] when tested in accordance with 11.3.

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8.2 *Pipe Preparation*—The coatings of the types described in this specification shall be applied to pipe which is essentially free from all moisture, dirt, oil, grease, or other foreign matter.

8.3 *Fully Coated, Half-Coated, Exterior-Coated, Interior-Coated Types with Asphalt, Polymerized Asphalt, Mastic, and Asphaltic Emulsions (Classes A, PA, M, and E)*—The coating shall be applied to a minimum thickness of 0.05 in. [1.3 mm] measured on the crest of corrugations, on the top of ribs (for exterior coating on Type IR pipe), or on the smooth inside surface (for interior coating on Type IA Pipe, or interior or exterior of Type IR pipe). Material Classes A and PA are used only for *fully coated* and *half-coated* types. Material Class M is permitted for use for all four coating types.

8.4 *Invert Paved Type with Asphalt and Polymerized Asphalt (Classes A and PA)*—The material shall be applied to fill the corrugations and provide a minimum thickness of ⅛ in. [3.2 mm] above the crest of corrugations for at least 25 % of

the circumference of round pipe and 40 % of the circumference of pipe arch (the invert as installed) (Note 2).

NOTE 2—For pipe fabricated in accordance with the requirements of Specification A 760/A 760M, pipe should first be coated with Class A or PA material to a minimum thickness of 0.05 in. [1.3 mm] before placing *fully lined* or *invert paved* material to ensure good adhesion.

8.5 *Invert Paved Type with Concrete Material (Class C)*—The concrete material shall meet the requirements of 7.2.2. The concrete shall be placed after the pipe has been installed and backfilled. The coating shall have a minimum thickness of 3 in. [75 mm], and shall cover at least 25 % of the circumference of round pipe and 40 % of the circumference of pipe arch (the invert as installed). When concrete with a compressive strength of 9600 psi [65 MPa] is used the minimum coating thickness may be reduced to 1½ in. [38 mm].

8.6 *Fully Lined Type with Asphalt Material (Class A)*—The material shall be applied to fill the corrugations and provide a minimum thickness of ⅛ in. [3.2 mm] above the crests of corrugations on the pipe interior. The lining shall provide a smooth surface over the entire interior of the pipe (see Note 2).

8.7 *Fully Lined Type with Concrete Material (Class C)*—The concrete material shall meet the requirements of 7.2.1. The concrete lining shall be plant applied by a machine which places and mechanically trowels the concrete in the pipe while one moves relative to the other. The rate of concrete placement and relative rate of travel of pipe and machine shall be mechanically regulated so as to produce a homogenous, nonsegregated lining throughout. The lining shall have a minimum thickness of ⅛ in. [3.2 mm] above the crests of the corrugations.

8.8 *Fully Coated, Half-Coated, Exterior-Coated, and Interior-Coated Types with Polymer Material (Class P)*—The material shall be uniformly applied to the surfaces to be coated to a minimum thickness of 0.010 in. [0.25 mm] measured on the crest of corrugations, on the top of ribs (for exterior coating on Type IR pipe), or on the smooth surface (for interior coating on Type IA pipe, or interior or exterior on Type IR pipe).

8.9 *Invert Coated Type with Polymer Material (Class P)*—The material shall be applied to provide a minimum thickness of 0.05 in. [1.3 mm] for at least 25 % of the circumference of round pipe and 40 % of the circumference of pipe arch (the invert as installed).

8.10 *Invert Paved Type with Polymer Material (Class P)*—The material shall be applied to provide a minimum thickness of 0.05 in. [1.3 mm] above the crests of the corrugations for at least 25 % of the circumference of round pipe and 40 % of the circumference of pipe arch (the invert as installed).

9. Workmanship, Finish, and Appearance

9.1 The completed pipe shall show careful, finished workmanship in all particulars.

9.1.1 The following defects shall be considered as constituting poor workmanship for post coatings, pavings, and linings using asphalt, emulsion, mastic, polymerized asphalt, or polymer materials: coatings or linings that are bruised, broken, disbonded, or otherwise damaged.

9.1.2 The following defects shall be considered as constituting poor workmanship for concrete linings and pavements: concrete containing sandpockets, voids or chipped or spalled areas; cracks that produce spalled areas or cause loosening of the lining or pavement; troweled surface finishes that do not have an acceptable level of smoothness.

NOTE 3—Cracks are inherent in concrete linings because of the rigid lining in a flexible shell. They typically will heal autogenously when kept wet. Cracks are not a reason for concern unless they produce spalls or cause loosening of the lining material.

9.1.2.1 To determine the level of smoothness of troweled concrete surface finishes, measure the gaps between the concrete surface and a 12 in. [305 mm] straight edge laid on the surface, parallel to the axis of the pipe, using a predetermined random sampling plan agreed upon between the purchaser and the fabricator. The finish is acceptable for smoothness if 90 % of the gaps are ¼ in. [6.35 mm] or less.

9.2 Pipes containing damaged coatings, pavements, or linings shall be repaired by the fabricator to the satisfaction of the purchaser.

10. Repairs to Post-Coating, Paving, and Lining

10.1 Materials used to repair damaged areas on previously coated pipe shall be compatible with and capable of being applied to the previous coating as recommended by the manufacturer of the original material (see Note 4). Repair coatings shall be of equal thickness to the previous coating as a minimum and shall have equal adherence.

NOTE 4—Asphalt should be repaired with asphalt and coal tar with coal tar.

10.1.1 Damage to polymer precoating or metallic coatings shall be repaired in accordance with Specification A 760/ A 760M, A 761/A 761M, or A 762/A 762M as appropriate.

10.1.2 Repair to damaged concrete linings and pavements shall be made with a grout consisting of one part (by weight) cement to two parts washed, dry concrete sand. The grout shall be mixed with a minimum amount of water that will give a workable mix. The damaged area shall be cleaned of any dirt or loose material. After rinsing the area to be repaired with water, the grout shall be hand troweled to the same thickness and shall conform to the contour of the existing lining.

11. Test Methods for Sampling and Testing Asphalt and Polymerized Asphalt Materials

11.1 Obtain samples of the asphalt or polymerized asphalt coating by gathering strippings, sufficient to make a minimum 10-oz [0.3-kg] sample, from the inside of one or more lengths of pipe, preferably near the top as installed, or from the dip tank during the dipping process. Care shall be taken in sampling to avoid contamination.

11.1.1 Test the asphalt samples in accordance with the following ASTM test methods:

	Test Method
Softening point	D 36
Penetration	D 5, using conditions of 77°F [25°C], 100 g, and 5 s
Flash point	D 92
Solubility	D 2042
Specific gravity	D 70
Loss on heating	D 6

11.2 *Shock Test*:

11.2.1 *Apparatus*:

the circumference of round pipe and 40 % of the circumference of pipe arch (the invert as installed) (Note 2).

NOTE 2—For pipe fabricated in accordance with the requirements of Specification A 760/A 760M, pipe should first be coated with Class A or PA material to a minimum thickness of 0.05 in. [1.3 mm] before placing *fully lined* or *invert paved* material to ensure good adhesion.

8.5 *Invert Paved Type with Concrete Material (Class C)*—The concrete material shall meet the requirements of 7.2.2. The concrete shall be placed after the pipe has been installed and backfilled. The coating shall have a minimum thickness of 3 in. [75 mm], and shall cover at least 25 % of the circumference of round pipe and 40 % of the circumference of pipe arch (the invert as installed). When concrete with a compressive strength of 9600 psi [65 MPa] is used the minimum coating thickness may be reduced to 1½ in. [38 mm].

8.6 *Fully Lined Type with Asphalt Material (Class A)*—The material shall be applied to fill the corrugations and provide a minimum thickness of ⅛ in. [3.2 mm] above the crests of corrugations on the pipe interior. The lining shall provide a smooth surface over the entire interior of the pipe (see Note 2).

8.7 *Fully Lined Type with Concrete Material (Class C)*—The concrete material shall meet the requirements of 7.2.1. The concrete lining shall be plant applied by a machine which places and mechanically trowels the concrete in the pipe while one moves relative to the other. The rate of concrete placement and relative rate of travel of pipe and machine shall be mechanically regulated so as to produce a homogenous, nonsegregated lining throughout. The lining shall have a minimum thickness of ⅛ in. [3.2 mm] above the crests of the corrugations.

8.8 *Fully Coated, Half-Coated, Exterior-Coated, and Interior-Coated Types with Polymer Material (Class P)*—The material shall be uniformly applied to the surfaces to be coated to a minimum thickness of 0.010 in. [0.25 mm] measured on the crest of corrugations, on the top of ribs (for exterior coating on Type IR pipe), or on the smooth surface (for interior coating on Type IA pipe, or interior or exterior on Type IR pipe).

8.9 *Invert Coated Type with Polymer Material (Class P)*—The material shall be applied to provide a minimum thickness of 0.05 in. [1.3 mm] for at least 25 % of the circumference of round pipe and 40 % of the circumference of pipe arch (the invert as installed).

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9.1.2 The following defects shall be considered as constituting poor workmanship for concrete linings and pavements: concrete containing sandpockets, voids or chipped or spalled areas; cracks that produce spalled areas or cause loosening of the lining or pavement; troweled surface finishes that do not have an acceptable level of smoothness.

NOTE 3—Cracks are inherent in concrete linings because of the rigid lining in a flexible shell. They typically will heal autogenously when kept wet. Cracks are not a reason for concern unless they produce spalls or cause loosening of the lining material.

9.1.2.1 To determine the level of smoothness of troweled concrete surface finishes, measure the gaps between the concrete surface and a 12 in. [305 mm] straight edge laid on the surface, parallel to the axis of the pipe, using a predetermined random sampling plan agreed upon between the purchaser and the fabricator. The finish is acceptable for smoothness if 90 % of the gaps are ¼ in. [6.35 mm] or less.

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11.1.1 Test the asphalt samples in accordance with the following ASTM test methods:

	Test Method
Softening point	D 36
Penetration	D 5, using conditions of 77°F [25°C], 100 g, and 5 s
Flash point	D 92
Solubility	D 2042
Specific gravity	D 70
Loss on heating	D 6

11.2 *Shock Test*:

11.2.1 *Apparatus*:

11.2.1.1 *Rigid Metal Anvil or Base Plate*, not less than ½ in. [12.7 mm] thick resting on a solid foundation.

11.2.1.2 *Hammer*, weighing 2000 g arranged to fall freely in suitable guides upon a plunger.

11.2.1.3 *Plunger*, weighing 1000 g sliding freely in a vertical sleeve, the lower end of the plunger being spherical in shape with a radius of ½ in. [12.7 mm].

11.2.1.4 Means for raising the hammer and dropping it through a distance of 5⅛ in. [130 mm] upon the head of the plunger.

11.2.2 *Test Specimens*—Prepare four test specimens in the form of disks 1¾ in. [44.5 mm] in diameter and ⅜ in. [9.5 mm] thick. Heat on a hot plate the container with approxi- mately 4 oz [110 g] of the bituminous sample until the sample becomes fluid. Pour the fluid sample into a brass mold or molds treated with a release agent. Exercise care to melt the sample at the lowest possible temperature and to stir it thoroughly until it is homogeneous and free from air bubbles. Mold the test specimens separately or pour the material into one cylinder 1¾ in. in diameter and of appropriate length to cut four specimens from it with a wire cutter. Split brass molds, coated with a release agent having an inside diameter of 1¾ in. and slightly tapered outside surfaces, and held together by slip rings, are suitable for molding the test specimens.

11.2.3 *Procedure*—Remove the molds after the asphalt has cooled to room temperature. Cut the four specimens to thickness (if necessary) and cool for a period of at least 1 h in a bath of ice and salt brine at a temperature of 30°F [−1.0°C]. Remove the specimens from the bath one at a time and quickly place them on the anvil of the test apparatus. Center them under the plunger with the hammer tripped to fall through a height of 5⅛ in. [130 mm] upon the head of the plunger. Not more than 8 s shall elapse from the time each specimen is removed from the bath until the hammer strikes the plunger. Examine specimens for evidence of a crack. If it is difficult to determine visually whether a specimen has cracked, remove the specimen from the test apparatus and subject it to a slight bending. Also, samples should be cut and checked for air entrapment.

11.2.4 *Precision*—The shock test described in this test method is defined as a determination that at least three of four separate specimens comprising a single test sample will exhibit no cracking to yield an acceptable result. Analysis of an interlaboratory study (a blind study carried out by 9 laboratories in 4 different materials with 3 replicates of each material) reveals a pass/fail ratio for tests on the same material ranging from 0.22 to 1.45, with an overall pass/fail ratio for all 108 samples (27 samples of each of 4 materials) of 0.54. Further in each of 11, out of the total of 36 cases, where 3 replicate samples of the same material were tested in the same laboratory, the same laboratory obtained passing results on one of the 3 replicate samples and failing results on the other 2 replicate samples, or vice versa.

11.2.5 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in the test method for measuring shock, no statement on bias is being made.

11.3 *Flow Test*:

11.3.1 *Apparatus*—The apparatus for making the test shall consist of corrugated brass plate approximately 0.03 in. [0.8 mm] thick, 8 in. [200 mm] long, and 4 in. [100 mm] wide, with corrugations running lengthwise of the plate, and a metal support to hold the plate on a 45° angle with the horizontal. The corrugations shall have a crest to crest dimension of ⅝ in. [15.9 mm] and a depth of 3⁄16 in. [4.8 mm]. A line shall be scribed 6 in. [150 mm] from the lower edge.

11.3.2 *Test Specimens*—Test specimens shall be in the form of cylinders ⅜ in. [9.5 mm] in diameter and ¾ in. [19.0 mm] in length. Two specimens shall be used for each test. Make the specimens by pouring the asphalt from the specimens for the shock test into split, treated brass molds.

11.3.3 With the corrugated plate held at an angle of 45° to the horizontal, lay each test specimen in a corrugation so that its lower end will rest exactly along the line scribed 6 in. [150 mm] from the bottom edge of the plate. Place the test apparatus in an oven maintained at a temperature 150 6 2°F [65.6 6 1°C]. After 4 h in the oven, remove the apparatus and specimens and allow them to cool to room temperature. Measure the distance from the bottom of the corrugated plate to the lower edge of the test specimens. This distance subtracted from 6 in. [150 mm] is reported as the amount of flow.

11.3.4 *Precision*:

11.3.4.1 *Single-Operator Precision (Flow Test)*—The single-operator coefficient of variation for a single test result (a test result in this method has been defined as the measurements on two separate specimens) has been found to be 65 % (Note 5). Therefore, two properly conducted tests by the same operator (each consisting of measurements on two specimens from the same sample) shall not differ by more than 184 % (Note 5) of their average. The range (difference between the highest and lowest) of the two individual measurements comprising a test result should not exceed 260 % (Note 6) of the average of the two.

11.3.4.2 *Multilaboratory Precision (Flow Test)*—The multilaboratory coefficient of a variation of a single test result (a test result in this method has been defined as the measurements on two separate specimens) has been found to be 97 % (Note 5). Therefore, results of two properly conducted tests in different laboratories on the same bituminous coating should not differ by more than 275 % (Note 5) of their average.

NOTE 5—These numbers represent respectively the (1s %) and (d2s %) limits described in Practice C 670.

NOTE 6—Calculate as described in the paragraph on precision of individual measurements averaged to obtain a test result in Practice C 670.

NOTE 7—These precision statements are based on results of an interlaboratory test program using three replicates of each of four materials. Nine laboratories participated in the tests.

11.3.5 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in the test method for measuring flow, no statement on bias is being made.

11.4 *Imperviousness Test*—Hold in separate valleys of the coated corrugated steel pipe for a period of 48 h, a 25 % by volume solution of sulfuric acid, a 25 % by weight solution of sodium hydroxide, and a saturated solution of sodium chloride. This test may be made on an uncut section of pipe provided provision is made to prevent excessive evaporation of the three test solutions.

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