Designation: A1055/A1055M – 16

Standard Specification for Zinc and Epoxy Dual-Coated Steel Reinforcing Bars[1]

This standard is issued under the fixed designation A1055/A1055M; 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.

1. Scope*

1.1 This specification covers deformed and plain steel reinforcing bars with a dual coating of zinc-alloy followed by an epoxy coating applied by the electrostatic spray method.

1.2 The zinc-alloy coating is produced as one of two types: zinc-alloy applied by the thermal spray method (Type I) or zinc-alloy applied in accordance with Specification A1094/A1094M (Type II).

NOTE 1—The coating applicator is identified throughout this specification as the manufacturer.

1.3 Requirements for the zinc coating are contained in Table 1.

1.4 Requirements for epoxy powder coatings are contained in Annex A1.

1.5 Guidelines for construction practices at the job-site are presented in Appendix X1.

1.6 The text of this specification references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the specification.

1.7 This specification is applicable for orders in either inch-pound units [as Specification A1055] or SI units [as Specification A1055M].

1.8 The values stated in either inch-pound units or SI units are to be regarded as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system must be used independently of the other, except as specifically noted in Table 2. Combining values from the two systems may result in nonconformance with this specification.

1.9 *This specification 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 specification to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

A706/A706M Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement

A775/A775M Specification for Epoxy-Coated Steel Reinforcing Bars

A944 Test Method for Comparing Bond Strength of Steel Reinforcing Bars to Concrete Using Beam-End Specimens

A996/A996M Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

A1094/A1094M Specification for Continuous Hot-Dip Galvanized Steel Bars for Concrete Reinforcement

B117 Practice for Operating Salt Spray (Fog) Apparatus

B833 Specification for Zinc and Zinc Alloy Wire for Thermal Spraying (Metallizing) for the Corrosion Protection of Steel

D4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser

D4417 Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

G14 Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)

G20 Test Method for Chemical Resistance of Pipeline Coatings

G62 Test Methods for Holiday Detection in Pipeline Coatings

2.2 *American Welding Society:*[3]

ANSI/AWS A5.33 Specification for Solid and Ceramic Wires and Ceramic Rods for Thermal Spraying

AWS C2.23M/C2.23 Specification for the Application of

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.05 on Steel Reinforcement.

Current edition approved Dec. 1, 2016. Published March 2017. Originally approved in 2008. Last previous edition approved in 2010 as A1055 – 10ε1. DOI: 10.1520/A1055_A1055M-16.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Welding Society (AWS), 8669 NW 36 St., #130, Miami, FL 33166-6672, http://www.aws.org.

*A Summary of Changes section appears at the end of this standard

TABLE 1 Chemical Composition Requirements for Zinc and Zinc-Alloy Wires

Common Name (UNS)[A]	Al, max unless noted	Cd, max	Cu, max	Fe, max	Pb, max	Sn, max	Sb, max	Ag, max	Bi, max	As, max	Ni, max	Mg, max	Mo, max	Ti, max	Zn, min	Other, Total max
99.99 Zinc[B] (Z13005)	0.002[C]	0.003	0.005	0.003	0.003	0.001	...[D]	...	...	...	...	...	...	...	99.99	...
99.99 Zinc[B] (Z15005)	0.01	0.02	0.02	0.02	0.03	...	...	...	...	...	...	...	...	...	99.9	0.10 total non-Zn
99.995 Zinc (...)[E]	0.001	0.003	0.001	0.002	0.003	0.003	...	...	...	...	...	...	...	...	99.995	0.005
99.95 Zinc (...)	0.01	0.02	0.001	0.02	0.03	0.001	...	...	...	...	...	...	...	...	99.95	0.050
99.95 Zinc (...)	0.01	0.005	0.7	0.01	0.005	0.001	...	...	...	...	...	0.01	0.01	0.18	99	1.0
98Zn/2Al (Z30402)	1.5-2.5	0.005	0.005	0.02	0.005	0.003	0.10	0.015	0.02	0.002	0.005	0.02	...	...	remainder	...

[A] UNS designations were established in accordance with Practice E527.
[B] In accordance with ANSI/AWS A5.33.
[C] The following applies to all specified limits in this table. For the purposes of determining conformance with this specification, an observed value obtained from analysis shall be rounded off to the nearest unit in the last right-hand place of figures used in expressing the limiting value, in accordance with the rounding method of Practice E29.
[D] ... indicates that the element is not applicable.
[E] (...) indicates no Unified Numbering System (UNS) designation for this option.

TABLE 2 Bend Test Requirements

A615, A706, or A996		A615M, A706M, or A996M		Bend Angle (After Rebound, degrees)	Time to Completion max, s
Bar No.	Pin Diameter in.[A]	Bar No.	Pin Diameter mm[A]		
3	3	10	75	180	15
4	4	13	100	180	15
5	5	16	125	180	15
6	6	19	150	180	15
7	7	22	175	180	45
8	8	25	200	180	45
9[B]	9	29[B]	230	180	45
10[B]	10	32[B]	250	180	45
11[B]	11	36[B]	280	180	45
14[B]	17	43[B]	430	90	45
18[B]	23	57[B]	580	90	45

[A] Pin diameters specified for similar size (shown on the same line) inch-pound bars and metric may be interchanged.
[B] Bar designation Nos. 9, 10, 11, 14, and 18 [29, 32, 36, 43, and 57] are not covered by Specification A996/A996M.

Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection for Steel
AWS C2.25/C2.25M Specification for Thermal Spray Feedstock—Solid and Composite Wire and Ceramic Rods

2.3 *Society for Protective Coatings Specifications:*[4]
SSPC-PA 2 Measurement of Dry Coating Thickness with Magnetic Gages
SSPC-SP 10 Near-White Blast Cleaning
SSPC-VIS 1 Pictorial Surface Preparation standards for Painting Steel Surfaces

2.4 *Concrete Reinforcing Steel Institute:*[5]
Voluntary Certification Program for Fusion Bonded Epoxy Coating Applicator Plants

2.5 *American Concrete Institute Standard:*[6]
ACI 301 Specifications for Structural Concrete

3. Terminology

3.1 *Definitions of Terms Specific to This Specification:*

3.1.1 *batch, n*—epoxy powder or patching material contained in an individual shipping release or shipping order.

3.1.2 *damaged coating, n*—area surrounded by coating where steel surface is visible to a person with normal or corrected vision.

3.1.3 *disbonding, n*—loss of adhesion between the fusion-bonded epoxy coating and the zinc-coated steel reinforcing bar.

3.1.4 *fusion-bonded epoxy coating, n*—a product containing pigments, thermosetting resins, cross-linking agents, and other additives, which is applied in the form of a powder onto a clean, heated metallic substrate and fused to form a continuous barrier coating.

3.1.5 *holiday, n*—a discontinuity in a coating that is not visible to a person with normal or corrected vision.

3.1.6 *lot, n*—bars of one size and pattern of deformations contained in an individual shipping release or shipping order.

3.1.7 *patching material, n*—a liquid two-part, epoxy coating used to repair damaged coating and to coat or uncoated areas on the surface of a coated bar, or to coat cut ends of a coated bar.

3.1.8 *thermal spray coating (metallizing), n*—a zinc and zinc alloy, or both, wire used in depositing a metallized layer of zinc by thermal spraying (metallizing) using oxy-fuel or electric-arc thermal spraying which is applied onto a clean, heated metallic substrate to form a continuous coating.

3.1.9 *wetting agent, n*—a material that decreases the surface tension of water allowing it to penetrate more effectively into small discontinuities in the coating giving a more accurate indication of the holiday count.

[4] Available from Society for Protective Coatings (SSPC), 800 Trumbull Dr., Pittsburgh, PA 15205, http://www.sspc.org.
[5] Available from Concrete Reinforcing Steel Institute (CRSI), 933 North Plum Grove Rd., Schaumburg, IL 60173-4758, http://www.crsi.org.
[6] Available from American Concrete Institute (ACI), 38800 Country Club Dr., Farmington Hills, MI 48331-3439, http://www.concrete.org.

4. Ordering Information

4.1 Orders for zinc-alloy and epoxy dual-coated steel reinforcing bars under this specification shall contain the following information:

4.1.1 Specification for reinforcing bars to be coated (ASTM designation and year of issue) (5.1),

4.1.2 Quantity of bars,

4.1.3 Size designation and grade of bars,

4.1.4 Requirements for the zinc-alloy coating, Type I or Type II (5.2 and 5.3), and that Type II product be chemically treated by the galvanizer,

4.1.5 Requirements for the epoxy powder coating (5.4),

4.1.6 Quantity of patching material, and

4.1.7 ASTM designation A1055 [A1055M] and year of issue.

4.2 The purchaser shall have the option to specify additional requirements, including, but not limited to the following:

4.2.1 Requirements for providing powder coating samples from each batch (5.4),

4.2.2 Approval from the coating manufacturer that the patching material supplied is compatible (5.5),

4.2.3 Specific requirements for sampling and test frequency for thickness, continuity, flexibility, and adhesion (9.1),

4.2.4 Whether a report on tests performed on the coated steel reinforcing bars being furnished is required (8.4.1 and Section 14),

4.2.5 Requirements for inspection (12.1),

4.2.6 Manufacturer qualification and certification requirements (if any), and

4.2.7 Other special requirements, if any.

NOTE 2—It is recommended that the coating application procedures and processes be audited by an independent certification program for coating applicator plants such as that provided by the Voluntary Certification Program or equivalent.

5. Materials

5.1 *Steel Reinforcing Bars for Type I Zinc-Alloy Coated Bars:*

5.1.1 Steel reinforcing bars to be coated shall meet the requirements of one of the following specifications: A615, A706, or A996 [A615M, A706M, or A996M] as specified by the purchaser and shall be free of contaminants such as oil, grease, or paint when received at the manufacturer's plant and prior to cleaning and coating.

NOTE 3—Bars with sharp edges on the deformations, rolled-in slivers, or other surface imperfections are difficult to coat properly and should not be coated. The coating will flow away from the sharp edges and may result in inadequate coating thickness at those points.

5.2 *Zinc-Alloy Wire for Type I Zinc-Alloy Coated Bars:*

5.2.1 The thermal spray coating feedstock material shall be specified according to Specification B833 or to AWS C2.25/C2.25M.

5.2.2 The wire shall conform to one of the chemical composition requirements prescribed in Table 1.

5.2.3 The wire shall be clean and free of corrosion, adhering foreign material, scale, seams, nicks, burrs, and other defects which would interfere with the operation of thermal spraying equipment. The wire shall uncoil readily and be free of bends or kinks that would prevent its passage through the thermal spray gun.

5.2.4 The wire shall be a continuous length per spool, coil, or drum. Splices or welds are permitted, provided that they do not interfere with the thermal spray equipment or coating process.

5.2.5 The starting end of each coil shall be tagged to indicate winding direction and to be readily identifiable with ASTM designation.

5.3 *Type II Zinc-Alloy Coated Bars:*

5.3.1 The product to be epoxy coated shall conform to the requirements of Specification A1094/A1094M.

5.4 *Epoxy Powder Coating:*

5.4.1 The epoxy powder coating shall conform to the requirements of Annex A1. Upon request, the purchaser shall be provided with data confirming the epoxy powder coating conforms to the requirements of Annex A1.

5.4.2 A written certification shall be furnished to the purchaser that properly identifies the number of each batch of epoxy powder coating used in the purchase order, material quantity represented, date of manufacture, name and address of the epoxy powder coating manufacturer, and a statement that the supplied epoxy powder coating is the same composition as that qualified in accordance with Annex A1 of this specification.

5.4.3 The epoxy powder coating shall be transported and stored in a temperature-controlled environment in accordance with the documented recommendations of the manufacturer of the epoxy powder coating until ready for use. At that point, if the storage temperature is below the plant ambient temperature, the epoxy powder coating shall be given sufficient time to reach a temperature that is within ±5°F [±2°C] of the plant ambient temperature.

5.4.4 The epoxy powder coating shall be used within the epoxy powder coating manufacturer's written recommended shelf life.

5.5 If specified in the purchase order or contract, a representative 8-oz [0.2-kg] sample of the epoxy powder coating shall be supplied to the purchaser from each lot. The sample shall be packaged in an airtight container and identified by lot number.

5.6 Patching material for repairing damaged epoxy coating shall conform to the requirements of Annex A2 in Specification A775/A775M.

5.6.1 The manufacturer of the patching material shall specify the metal surface preparation, the coating thickness, and the procedures for application of the patching material.

5.6.2 If specified in the purchase order or contract, patching material shall be supplied to the purchaser.

6. Surface Preparation

6.1 *Type I:*

6.1.1 Blast media found to be contaminated with soluble salts shall be rejected.

NOTE 4—It is recommended that incoming steel reinforcing bars and blast media be checked for soluble salt contamination prior to use. Steel

reinforcing bars found to be soluble salt contaminated from exposure to deicing salts or salt spray should be cleaned by acid washing or other suitable methods to remove soluble salt contaminants from the surface prior to abrasive blast cleaning.

6.1.2 The surface of the steel reinforcing bars to be coated shall be cleaned by abrasive blast cleaning to near-white metal in accordance with SSPC-SP 10. The final surface condition shall be defined according to SSPC-VIS 1.

6.1.3 Average blast profile roughness depth readings shall be 1.5 to 4.0 mils [40 to 100 μm]. Measurements shall be determined by either:

6.1.3.1 A "Profilometer" type surface instrument that measures the peak count as well as the maximum profile depth, used in accordance with the written instructions of the manufacturer of the instrument and Test Methods D4417, Method B, or

6.1.3.2 Replica tape measurements using Test Methods D4417, Method C.

NOTE 5—Abrasive blast cleaning of steel reinforcing bars with a high degree (>90 %) of grit in the cleaning media provides the most suitable anchor profile for coating adhesion. After grit has been recycled, a small portion of it will take on the appearance of shot.

6.1.4 Multidirectional, high-pressure dry air knives shall be used after blasting abrasive blast cleaning to remove dust, grit, and other foreign matter from the abrasive blast-cleaned steel surface. The air knives shall not deposit oil on the steel reinforcing bars.

6.2 *Type II:*

6.2.1 Prior to epoxy coating, the surface of Type II zinc-alloy coated bars produced to Specification A1094/A1094M shall be visually inspected to ensure freedom from surface contaminants such as dirt, dust, and oils. Any such contaminants shall be removed prior to epoxy coating.

7. Zinc-Alloy Coating Application

7.1 *Type I:*

7.1.1 A thin zinc-alloy layer shall be applied by a thermal arc spray (metallization) system directly after the abrasive blast cleaning and before application of the epoxy powder coating in accordance with AWS C2.23M/C2.23 and the written specification of the zinc alloy supplier.

7.1.1.1 Thermal spray equipment shall be set up, calibrated, and operated in accordance with the manufacturer's instructions and technical manuals, or the Thermal Coating Spray applicator's recommendation.

7.1.2 The zinc-alloy coating shall be applied to the cleaned steel reinforcing bar surface as soon as possible after the bar has been cleaned and before visible oxidation of the surface occurs as visible to a person with normal or corrected vision. In no case shall application of the coating be delayed more than 30 minutes after cleaning.

7.1.3 The epoxy powder coating shall be applied by electrostatic spray or other suitable method.

7.1.4 The fusion-bonded epoxy powder coating shall be applied in accordance with the written recommendations of the manufacturer of the epoxy powder coating for initial steel surface temperature range and post-application curing requirements. During continuous operations, the temperature of the metal surface immediately prior to coating shall be measured using infrared guns or temperature-indicating crayons, or both, at least once every 30 minutes. At no time shall the temperature of the metal surface exceed 700°F [334°C].

NOTE 6—The use of both infrared and temperature-indicating crayon measurement of the surface temperature of steel reinforcing bars is recommended.

7.2 *Type II:*

7.2.1 The zinc-alloy coating shall be applied in conformance to the requirements of Specification A1094/A1094M. Except in the case of continuous galvanizing followed by immediate in-line application of epoxy coating, the product shall be chemically treated by the galvanizer to provide a surface suitable for application of epoxy coating at another location.

8. Requirements for Coated Steel Reinforcing Bars

8.1 *Coating Thickness:*

8.1.1 The coating thickness of the zinc-alloy layer shall be a minimum of 1.4 mils [35 μm] for Type I and a minimum of 2.0 mils [50 μm] for Type II.

8.1.2 The total coating thickness measurements of the combined zinc-alloy layer and the epoxy coating layer after curing shall be 7 to 12 mils [175 to 300 μm] for bars sizes Nos. 3 to 5 [10 to 16] and 7 to 16 mils [175 to 400 μm] for bar sizes Nos. 6 to 18 [19 to 57]. The upper thickness limit shall not apply to repaired areas of damaged coating.

8.1.3 Coating thicknesses shall be measured and recorded for both zinc-alloy and epoxy thickness. A single-recorded steel reinforcing bar coating thickness measurement is the average of three individual gage readings obtained between four consecutive deformations. A minimum of five recorded measurements shall be taken approximately evenly spaced along each side of the test specimens (a minimum of ten recorded measurements per bar).

NOTE 7—The zinc-alloy thickness will be measured by either using a bar that has only the zinc-alloy coating applied or by use of a duplex measuring device capable of reading the zinc-alloy and epoxy coatings simultaneously.

8.1.4 For acceptance purposes, the average of all recorded coating thickness measurements shall not be less than the specified minimum thickness or more than the specified maximum thickness. No single-recorded coating thickness measurement shall be less than 80 % of the specified minimum thickness or more than 120 % of the specified maximum thickness.

8.1.5 Thickness measurements shall be made in accordance with SSPC-PA 2 and in accordance with the manufacturer's instructions for the measuring device, following the instructions for calibration and use recommended by the thickness gauge manufacturer. "Pencil-type" pull-off gauges that require the operator to observe the reading at the instant the magnet is pulled from the surface shall not be used.

8.1.6 The coating thickness shall be measured on the body of a straight length of steel reinforcing bar between the deformations.

8.2 *Coating Continuity:*

8.2.1 The zinc-alloy coating shall be uniform without blisters, cracks, loose particles, or exposed steel as examined with 10× magnification.

8.2.2 The manufacturer's plant shall have an operational in-line 67.5 V, 80 000 Ω wet-sponge type direct-current in-line holiday detector or equivalent holiday-detection system with an automated holiday counting system to determine the epoxy coating acceptability of the coated steel reinforcing bars prior to shipment. A wetting agent is not required during the inspection for holidays.

8.2.3 Hand-held holiday detector checks shall be performed during each production day to verify the accuracy of the in-line holiday detection system.

8.2.4 On average, there shall not be more than one holiday per foot [three holidays per metre] on a coated steel reinforcing bar. The average applies to the full production length of a bar.

8.3 *Epoxy Coating Flexibility:*

8.3.1 The epoxy coating flexibility for Type I and Type II shall be evaluated by bending production-coated steel reinforcing bars (with both the zinc-alloy and the powder coating applied) at a uniform rate around a pin of specified size within a maximum specified time period as prescribed in Table 2. The two longitudinal ribs of the coated bar shall be placed in a plane perpendicular to the radius of the pin. The temperature of the test specimens for Type I shall be between 158 and 176°F [70 and 80°C]. The temperature of the test specimens for Type II shall be between 68 and 86°F [20 and 30°C].

8.3.2 Cracking or disbonding of the coating on the outside radius of the bent bar visible to a person with normal or corrected vision shall be considered cause for rejection of the coated steel reinforcing bars represented by the bend test specimen.

NOTE 8—The qualification requirements for coating flexibility (see A1.3.4.1) prescribe bending a No. 6 [19] deformed bar around a 6-in. [150-mm] diameter pin. The bend test requirements in Table 2 for evaluating the coating flexibility of production-coated steel reinforcing bars, for bar sizes Nos. 3 to 8 [10 to 25], are not compatible with fabrication bending practices. Finished bend diameters for bar sizes Nos. 3 to 8 [10 to 25] used in actual construction are smaller than the pin diameters in Table 2. Thus, the finished bends of production-coated bars, particularly the smaller bar sizes used for stirrups and ties, should be examined closely for hairline cracking on the outside radius of the bent bar. If hairline cracking is present, it should be repaired with patching material. To minimize the potential for damaging the coating, bending should be performed within the prescribed temperature range of 158 and 176°F [70 and 80°C] for Type I product and 68 and 86°F [20 and 30°C] for Type II product.

8.3.3 A bend test in which fracture or partial failure of the steel reinforcing bar, or cracking or disbonding of the coating caused by imperfections in the bar surface visible after performing the bend test occurs, shall be considered an invalid test and the test shall be repeated on a new specimen.

8.4 *Coating Adhesion:*

8.4.1 The requirements for coated steel reinforcing bars shall be satisfied at the manufacturer's plant prior to shipment.

9. Number of Tests

9.1 The purchaser shall have the option to specify the sampling and test schedule for the number and frequency of tests for coating thickness, continuity, flexibility, and adhesion.

9.2 If the number and frequency of tests are not specified by the purchaser the following shall apply:

9.2.1 Tests for the zinc-alloy and epoxy coating thickness shall be performed on a minimum of two bars of each size every two production hours.

9.2.2 Bend tests for coating flexibility shall be performed on at least one bar of each size every four production hours.

9.2.3 Random tests shall be performed for coating continuity.

10. Retests

10.1 If the specimen for coating thickness or flexibility fails to meet the specified requirements, two retests on random specimens shall be performed for each failed test. Both retests shall meet the requirements of this specification.

11. Permissible Amount of Damaged Epoxy Coating and Repair of Damaged Epoxy Coating

11.1 The maximum amount of repaired damaged epoxy coating shall not exceed 1 % of the total surface area in each 1-ft [0.3-m] length of the bar. This limit on repaired damaged epoxy coating shall not include sheared or cut ends that are coated with patching material (see 11.6).

11.2 All damaged epoxy coating due to fabrication or handling (to the point of shipment) shall be repaired with patching material conforming to Annex A2 in Specification A775/A775M.

NOTE 9—If the amount of repaired damaged epoxy coating in any 1-ft [0.3-m] length of a coated bar exceeds 1 %, that section should be cut from the coated steel reinforcing bar and discarded. In repairing damaged epoxy coating, care should be taken not to apply the patching material over an excessive area of the intact coating during the repair process.

11.3 Repaired areas shall have a minimum coating thickness of 7 mils [175 μm].

11.4 Multiple applications of patching material shall be permitted.

11.5 The coating thickness of the repaired coating shall be measured in accordance with SSPC-PA 2 at a single location. Coated bars not meeting this requirement shall be subject to rejection. This measurement shall not be taken over areas with both coating and patching material.

11.6 When coated bars are saw-cut or cut by other means during the fabrication process, the cut ends shall be coated with patching material unless otherwise specified by the purchaser. The coating thickness after curing on cut ends shall be a minimum of 7 mils (175 μm). The patching material used to coat the cut ends shall not extend beyond 3 in. (75 mm) from the cut end. The average coating thickness shall be determined from averaging individual measurements performed at the center of the ends of a minimum of five coated bars. No individual bar coating thickness measurement shall be less than 80 % of the required coating thickness. Bars not meeting this requirement shall be subject to rejection.

11.7 Repair of damaged epoxy coating shall be done in accordance with the patching material manufacturer's written recommendations.

12. Inspection

12.1 Inspection of the zinc and epoxy dual-coated reinforcing bars shall be agreed upon between the purchaser and the manufacturer as part of the purchase order or contract.

13. Rejection

13.1 Coated steel reinforcing bars represented by test specimens that do not meet the requirements of this specification shall be rejected and marked with contrasting color paint or other suitable identification. At the manufacturer's option, the affected lot shall be replaced or, alternatively, stripped of coating, recleaned, recoated, and resubmitted for acceptance testing in accordance with the requirements of this specification.

14. Certification

14.1 At the time of shipment, the purchaser shall be furnished with a written certification that specimens representing each lot of coated steel reinforcing bars have been either tested or inspected as required in this specification and the requirements have been satisfied. When specified in the purchase order or contract, a report of the test results shall be furnished.

14.2 A Material Test Report, Certificate of Inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document shall meet the requirements of the invoked ASTM standard(s) and conform to any EDI agreement between the purchaser and the manufacturer. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

NOTE 10—The industry definition invoked here is: EDI is the computer-to-computer exchange of business information in a standard format such as ANSI ASC X12.

15. Handling and Identification

15.1 All systems for handling coated steel reinforcing bars shall have padded contact areas. All bundling bands shall be padded or suitable banding shall be used to avoid damage to the coating. All bundles of coated steel reinforcing bars shall be lifted with a strong back, spreader bar, multiple supports, or a platform bridge to prevent bar-to-bar abrasion from sages in the bundles of coated steel reinforcing bars. The bars or bundles shall not be dropped or dragged.

15.2 If circumstances require storing coated steel reinforcing bars outdoors for more than two months, protective storage measure shall be implemented to protect the material from sunlight, salt spray and weather exposure. If the manufacturer stores coated steel reinforcing bars outdoors without protective covering, the date on which the coated bars are placed outdoors shall be recorded on the identification tag on the bundles of coated reinforcing bars. Coated steel reinforcing bars, whether individual bars or bundles of bars, or both, shall be covered with opaque polyethylene sheeting or other suitable opaque protective material. For stacked bundles, the protective covering shall be draped around the perimeter of the stack. The covering shall be secured adequately, and allow for air circulation around the bars to minimize condensation under the covering.

15.3 Coated steel reinforcing bars, whether individual bars or bundles of bars, or both, shall be stored off the ground on protective cribbing.

15.4 The identification of all steel reinforcing bars shall be maintained throughout the coating and fabrication processes to the point of shipment. This identification shall include the heat and lot number of the steel reinforcing bars that were coated and the lot number of the epoxy powder coating.

16. Keywords

16.1 coating requirements; concrete reinforcement; continuous hot-dip galvanized; corrosion resistance; dual coated; epoxy coating; galvanizing; steel bars; thermal spray coating (metallization); zinc-alloy coating

ANNEX

(Mandatory Information)

A1. REQUIREMENTS FOR FUSION-BONDED EPOXY POWDER COATINGS FOR DUAL-COATED STEEL REINFORCING BARS

A1.1 Epoxy Powder Coatings

A1.1.1 This annex covers qualification requirements for fusion-bonded epoxy coatings for protecting steel reinforcing bars from corrosion.

A1.1.2 The powder coating shall be of epoxy composition except for the pigment, which may be inorganic if used.

A1.2 Test Materials

A1.2.1 A 1-lb [0.50-kg] sample of the epoxy powder coating with its generic description and fingerprint (including the method such as infrared spectroscopy or thermal analysis) shall be submitted to the testing laboratory. The fingerprint and

generic description shall become an integral part of the qualification test report.

A1.2.2 A sample of patching material conforming to Annex A2 in Specification A775/A775M shall be submitted to the testing laboratory. The product name and a description of the patching material shall be given in the test report.

A1.2.3 *Test Specimens:*

A1.2.3.1 The following specimens shall be submitted as a minimum for testing:

(1) Fourteen coated 4-ft [1.2-m] long No. 6 [19], Grade 60 [420] deformed steel reinforcing bars with a coating thickness of 7 to 12 mils [175 to 300 µm].

(2) Six 4-ft [1.2-m] long, uncoated and uncleaned No. 6 [19], Grade 60 [420] deformed steel reinforcing bars, from the same lot of steel as the coated bars.

(3) Four 4 in. by 4 in. by 0.05 in. [100 mm by 100 mm by 1.3 mm] steel panels with center holes for Taber abrasers coated to a thickness of 10 ± 2 mils [250 ± 50 µm].

(4) Four free films of coating material with a thickness of 7 to 9 mils [175 to 225 µm]. The films shall be at least 4 in. by 4 in. [100 mm by 100 mm].

(5) Fourteen coated 10-in. [250-mm] long No. 6 [19], Grade 60 [420] steel deformed reinforcing bars with a coating thickness of 7 to 12 mils [175 to 300 µm]. The coated steel reinforcing bars shall have their ends sealed with patching material.

A1.2.3.2 Steel reinforcing bars with a nominal diameter within ±0.04 in. [1 mm] of No. 6 [19] bars shall be acceptable for qualification testing.

A1.2.3.3 The coating on the bars and films shall be free of holes, voids, contamination, cracks, and damaged areas. The coated bar specimens shall be checked for holidays using a 67.5-V, 80 000-Ω wet–sponge type dc holiday detector in accordance with Test Methods G62. The total number of holidays found on the bar specimens tested shall be reported.

A1.2.3.4 Coating thickness measurements shall be performed in accordance with 8.1.

A1.2.3.5 The manufacturer of the epoxy powder coating shall specify the method and grade of metal surface preparation and the coating application procedures for the test specimens and for production of coated steel reinforcing bars. These procedures shall be listed in the test report.

A1.2.3.6 The bars used for the qualification tests shall be prepared using the same methods proposed for production of coated bars.

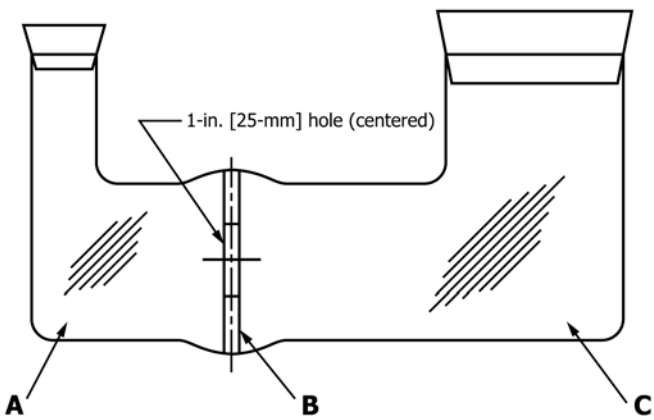
A1.2.3.6.1 Variations in the critical preparation, thermal treatment, and coating procedures known to be allowable without a compromise in quality shall be detailed in the qualification report.

A1.3 Coating Requirements

A1.3.1 *Chemical Resistance*—The chemical resistance of the coating shall be evaluated in accordance with Test Method G20 by immersing coated steel reinforcing bars in each of the following: distilled water, a 3*M* aqueous solution of calcium chloride ($CaCl_2$), a 3*M* aqueous solution of sodium hydroxide (NaOH), and a solution saturated with calcium hydroxide ($Ca(OH)_2$). Specimens without holidays and specimens with intentional holes drilled through the coating 0.25 in. [6 mm] in diameter shall be tested. The temperature of the test solutions shall be 75 ± 3.6°F [24 ± 2°C]. Minimum test time shall be 45 days. The coating shall not blister, soften, lose bond, nor develop holidays during this period. The coating surrounding the intentionally made holes shall exhibit no undercutting during the 45-day period.

A1.3.2 *Salt Spray Resistance*—The resistance of the coating to a hot, wet corrosive environment shall be evaluated in accordance with Practice B117 by exposing 10-in. [250-mm] long coated steel reinforcing bars containing intentional defects to 95 ± 3.6°F [35 ± 2°C] salt spray comprised of 5 % NaCl by mass dissolved in distilled water for 800 ± 20 h. Three intentional 0.12-in. [3-mm] diameter defects shall be drilled through the coating of each test specimen approximately evenly spaced along one side of the bar with the holes centered between transverse deformations. The coated steel reinforcing bars shall be placed horizontally in the cabinet with the damage sites facing the side (90°). The test specimens shall be allowed to cool for approximately 1 ± 0.25 h prior to evaluation. Make four radial cuts through the coating to the steel substrate, intersecting at the center of the intentional defects with a sharp, thin-bladed knife. Attempt to lift the coating at the intentional hole with the point of the sharp, thin-bladed knife. For each of the defects, four length measurements shall be taken of the amount of debonded coating, at 0°, 90°, 180°, and 270° and the values averaged. The average coating disbondment radius of nine test sites on three coated steel reinforcing bars shall not exceed 0.12 in. [3 mm] when measured from the edge of the intentional coating defect.

A1.3.3 *Chloride Permeability*—The chloride permeability characteristics of the cured coating having a film thickness of 7 to 9 mils [175 to 225 µm] shall be measured on two test films and a control film at 75 ± 3.6°F [24 ± 2°C] for 45 days. The permeability cells shall be of the type shown in Fig. A1.1. Films selected for testing shall be free of holes, voids, contaminants, cracks, and damaged areas prior to installation in



Permeability Cell Components:
A. Component containing distilled water
B. Epoxy film sandwich between two glass plates each having a centered 1-in. [25-mm] diameter hole
C. Component containing 3M NaCl

FIG. A1.1 Chloride Permeability Test Equipment Configuration

the cell. The cell shall consist of two glass compartments separated by a defect-free coating film sandwiched between two glass plates, each having a centered 1-in. [25-mm] diameter hole. One compartment shall contain 6 oz [175 mL] of 3*M* NaCl and the other 4 oz [115 mL] of distilled water. The activity of chloride ions passing through the film shall be measured using a specific ion meter equipped with a chloride electrode and a double junction reference electrode. Activity measurements shall be converted into concentration values of mole per *M* [L] with a conversion diagram, constructed by plotting measured chloride ion activities versus known chloride ion concentrations. The accumulative concentration of chloride ions permeating through the film shall be less than $1 \times 10^{-4}M$.

A1.3.4 *Coating Flexibility:*

A1.3.4.1 The coating flexibility for Type I shall be evaluated by bending three coated steel reinforcing bars 180° (after rebound) around a 6-in. [150-mm] diameter pin. The bend shall be performed at a uniform rate and completed within a 15-s time period. The two longitudinal ribs shall be placed in a plane perpendicular to the pin radius and the specimen shall be between 158 and 176°F [70 and 80°C].

A1.3.4.2 The coating flexibility for Type II shall be evaluated by bending three coated steel reinforcing bars 180° (after rebound) around a 6-in. [150-mm] diameter mandrel pin. The bend shall be made performed at a uniform rate and completed within a 15-s time period. The two longitudinal ribs shall be placed in a plane perpendicular to the mandrel pin radius and the specimen shall be between 68 and 86°F [20 and 30°C].

A1.3.4.3 No cracking of the coating shall be visible to a person with normal or corrected vision on the outside radius of any of the three bent-bars.

A1.3.4.4 A test in which fracture or partial failure of the steel reinforcing bar, or cracking or disbonding of the coating caused by imperfections in the bar surface visible after performing the bend test occurs, shall be considered an invalid test and the test shall be repeated on a new specimen.

A1.3.5 *Relative Bond Strength in Concrete*—The relative bond strength of the steel reinforcing bars to concrete shall be determined with beam-end specimens by the method described in Test Method A944 using No. 6 [19] steel reinforcing bars with a relative rib area (ratio of projected rib area normal to the bar axis to the product of the nominal bar perimeter and the center-to-center rib spacing) between 0.075 and 0.085. The bars shall be bottom-cast and shall have a cover of 1.5 ± 0.06 in. [40 ± 2 mm], a lead length of 0.5 ± 0.12 in. [13 ± 3 mm], and a bonded length of 10 ± 0.25 in. [250 ± 5 mm]. Test bars shall be oriented so that the longitudinal ribs and direction of rolling, relative to the direction of the applied tension, are the same for coated and uncoated bars. The test bars shall be pulled in the same direction with respect to the direction of rolling. Three to six coated bar specimens and three to six uncoated bar specimens shall be tested. All steel reinforcing bars in a test group shall be from the same steel heat. The uncoated bars shall be cleaned only by lightly wiping with acetone or other suitable solvent. The mean bond strength of the coated bars shall not be less than 85 % of the mean bond strength of the uncoated bars.

A1.3.6 *Abrasion Resistance*—The resistance of the coating on the three steel panels to abrasion by a Taber abraser (Test Method D4060) or its equivalent, using CS-10 wheels and a 2.2-lb [1-kg] load per wheel, shall be such that the weight [mass] loss shall not exceed 0.0035 oz [100 mg]/1000 cycles.

A1.3.7 *Impact Test*—The resistance of the steel reinforcing bar coating to mechanical damage shall be determined by the falling weight [mass] test. A test apparatus similar to that described in Test Method G14 shall be used along with a 4-lb [1.8-kg] tup having a nose diameter of 0.63 in. [16 mm]. Impact shall occur on the low-lying areas on the coated steel reinforcing bars, that is, between transverse deformations or longitudinal ribs. The test shall be performed at 75 ± 3.6°F [24 ± 2°C]. With an impact of 80 in.-lbf [9 Nm], no shattering, cracking, or bond loss of the coating shall occur except at the impact area, that is, the area permanently deformed by the tup.

A1.4 Qualification Testing

A1.4.1 *Testing Laboratory*—Qualification tests shall be performed by a testing laboratory acceptable to the purchaser.

A1.5 Certification

A1.5.1 A report summarizing the results of all tests and bearing the signature of the responsible person in charge of the testing laboratory shall be furnished to the manufacturer.

APPENDIX

(Nonmandatory Information)

X1. GUIDELINES FOR CONSTRUCTION PRACTICES AT THE JOB-SITE

X1.1 This specification (ASTM A1055/A1055M) is a product specification. Requirements for zinc and epoxy dual-coated steel reinforcing bars from the point of shipment to the job-site and subsequent construction practices at the job-site are not delineated in this product specification.

X1.2 The American Concrete Institute has published "Specifications for Structural Concrete (ACI 301)." Standard Specification ACI 301 is intended to be used in its entirety in the project specifications. An architect-engineer may cite Standard Specification ACI 301 in the project specifications for any cast-in-place concrete construction project. Standard Specification ACI 301 includes provisions for zinc and epoxy dual-coated steel reinforcing bars.

X1.3 The project specifications should prescribe requirements for the coated steel reinforcing bars from the point of shipment to the job-site and subsequent practices at the

job-site. If ACI 301 is not cited in the project specifications, the following guidelines are intended to serve as a resource for preparing requirements in project specifications:

X1.3.1 Coating damage incurred during shipment, storage, handling, and placing of coated reinforcing bars should be repaired with patching material conforming to X1.3.18.

X1.3.2 Equipment for handling coated reinforcing bars should have protected contact areas to avoid damaging the coating.

X1.3.3 Bundles of coated bars should be lifted at multiple pick-up points to prevent bar-to-bar abrasion from sags in the bundles. Coated bars should not be dropped or dragged.

X1.3.4 Coated reinforcing bars should be off-loaded as close as possible to their points of placement or under the crane so that the bars can be hoisted to the area of placement to minimize re-handling.

X1.3.5 Coated reinforcing bars should be stored off the ground on protective cribbing, and timbers placed between bundles when stacking is necessary. Space the cribbing sufficiently close to prevent sags in the bundles.

X1.3.6 Coated and uncoated reinforcing bars should be stored separately.

X1.3.7 Long-term storage should be minimized and work stoppages phased to suit construction progress.

X1.3.8 If circumstances require storing coated reinforcing bars outdoors for more than two months, protective storage measures should be implemented to protect the material from sunlight, salt spray, and weather exposure. If the coated reinforcing bars are stored outdoors without cover, it is recommended that the date on which the coated bars are placed outdoors be recorded on the identification tag on the bundles. Coated reinforcing bars stored in corrosive environments may require protection sooner. Coated reinforcing bars or bundles should be covered with opaque polyethylene sheeting or other suitable opaque protective material. For stacked bundles, the protective covering should be draped around the perimeter of the stack. The covering should be secured adequately and allow for air circulation around the bars to minimize condensation under the covering.

X1.3.9 If the extent of damaged coating exceeds 2 % of the surface area of the coated steel reinforcing bar in any 1-ft [0.3-m] length, the coated bar should be rejected.

X1.3.10 If the extent of the damage does not exceed 2 % of the surface area in any 1-ft [0.3-m] length, all damaged coating visible to a person with normal or corrected vision should be repaired with patching material.

X1.3.11 Coated reinforcing bars should not be flame cut. When coated reinforcing bars are cut in the field, the bar ends should be coated with the same material that is used for the repair of damaged coating.

X1.3.12 Coated reinforcing bars should be supported on coated wire bar supports or on bar supports made of plastic. Coatings on wire bar supports should be compatible with concrete. When precast concrete bar supports with embedded tie wires or dowels are used with coated bars, the wires or dowels should be coated with epoxy or another polymer. Reinforcing bars used as supports for coated bars should be epoxy coated.

X1.3.13 Coated reinforcing bars should be fastened (tied) with tie wires coated with epoxy or other polymer.

X1.3.14 After installing mechanical splices on coated reinforcing bars, damaged coating and areas of removed coating should be repaired with patching material conforming to X1.3.18. Exposed parts of mechanical splices should be coated with the same patching material that is used for the repair of damaged coating.

X1.3.15 After completing welds on coated reinforcing bars, damaged coating should be repaired with patching material conforming to X1.3.18. Welds should be coated with the same patching material that is used for the repair of damaged coating.

X1.3.16 After field bending or straightening coated reinforcing bars, damaged coating should be repaired with patching material conforming to X1.3.18.

X1.3.17 After placing coated reinforcing bars, the coated bars should be inspected for damaged coating prior to placing concrete. Where damage exists, it should be repaired with patching material conforming to X1.3.18.

X1.3.18 Patching material should conform to Annex A2 of Specification A775/A775M.

X1.3.19 Patching material should be applied in strict accordance with the written instructions furnished by the patching material manufacturer. Prior to application of the patching material, rust should be removed from the damaged areas by suitable means. The patching material should be allowed to cure before placing concrete over the coated reinforcing bars.

X1.3.20 Fading of coating color should not be cause for rejection of coated reinforcing bars.

X1.3.21 After placing coated reinforcing bars, walking on the coated bars should be minimized. The placement of construction equipment at the job-site should be planned to avoid damage to the coated bars.

X1.3.22 When immersion-type vibrators are used to consolidate concrete around coated reinforcing bars, the vibrators should be equipped with rubber or non-metallic vibrator heads.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A1055 – $10^{\varepsilon 1}$) that may impact the use of this standard. (Approved Dec. 1, 2016.)

(1) Revised throughout to standardize language so as to be in common with other A01.05 documents.
(2) Added Specification A1094/A1094M as an alternate method of applying the zinc coating.
(3) Deleted cathodic disbondment testing from Annex A1.