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## Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement<sup>1</sup>

This standard is issued under the fixed designation A767/A767M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

### 1. Scope-~~Scope~~\*

1.1 This specification covers steel reinforcing bars with protective zinc coatings applied by ~~dipping~~immersing the properly prepared reinforcing bars into a molten bath of zinc.

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

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

1.3 Guidelines for use of zinc-coated (galvanized) reinforcing bars with non-galvanized steel forms are presented in Appendix X2.

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

1.5 This specification is applicable for orders in either inch-pound units (as Specification A767) or SI units (as Specification A767M).

1.6 The values stated in either ~~SI or~~ inch-pound units or SI units are to be regarded separately as standard. Within the text, the ~~inch-pound~~SI units are shown in brackets. The values stated in each system ~~are~~may not be exact equivalents. Therefore, each system ~~must~~shall be used independently of the other. Combining values from the two systems may result in ~~none~~nonconformance ~~non-~~conformance with this specification.

### 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

A90/A90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

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

A780/A780M Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

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

B6 Specification for Zinc

B487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section

E376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Testing Methods

2.2 ~~ACI Specification: Standard~~:<sup>3</sup>

ACI 301 Specifications for Structural Concrete

2.3 *AWS Standard*:<sup>4</sup>

AWS D1.4/D1.4M Structural Welding Code—Reinforcing Steel

<sup>1</sup> 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.

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<sup>2</sup> 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.

<sup>3</sup> Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, <http://www.concrete.org>.

<sup>4</sup> 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

### 3. Terminology

#### 3.1 Definition of Term Specific to This Specification:

3.1.1 *lot, n*—all bars of one size furnished to the same steel reinforcing bar specification that have been coated within a single production shift.

### 4. Ordering Information

4.1 It shall be the responsibility of the purchaser to specify all requirements that are necessary for material ordered to this specification. Such requirements shall include, but are not limited to, the following: ~~Orders for zinc-coated (galvanized) bars for concrete reinforcement under this specification shall include the following information:~~

3.1.1 Quantity of bars,

3.1.2 Size of bars,

4.1.1 Reinforcing bar specification ~~Specification for reinforcing bars to be coated (ASTM designation and year of issue) and (5.1 grade),~~

4.1.2 Quantity of bars,

4.1.3 Size and grade of bars,

4.1.4 Class of coating, ~~coating (Class 1 or Class 2) (6.5),~~

4.1.5 Galvanization ~~Galvanizing before or after fabrication, and fabrication for Class 1 coating (7.3),~~

NOTE 1—A typical ordering description is as follows: Deformed Grade 420 bars to ASTM A615M—; 1600 m, No. 19, 8 m long in secured lifts; zinc-coated (galvanized) to ASTM A767M—; including Class 1 coating, and galvanization after fabrication:

[Deformed Grade 60 bars to ASTM A615—; 4000 linear ft, No. 6, 20 ft, 0 in. long in secured lifts; zinc-coated (galvanized) to ASTM A767—, including Class 1 coating, and galvanization after fabrication.]

4.1.6 ASTM designation A767 [A767M] 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 inspection (8.1),

4.2.2 Manufacturer certification (10.1), and

4.2.3 Other special requirements, if any.

### 5. Materials

5.1 Steel reinforcing bars to be zinc-coated (galvanized) shall conform to one of the following Specifications: A615, A706, or A996 [A615M, A706M, or A996M], as specified by the purchaser.

5.2 The zinc used for coating shall be any grade that conforms to Specification B6.

### 6. Galvanizing—Zinc Coating Process

6.1 Reinforcing bars shall be prepared for galvanizing using any surface cleaning process that allows the zinc to bond with the steel, such that the galvanized bar coating appearance and continuity requirements in Section 7 of this specification are satisfied.

6.2 The reinforcing bars shall be coated by immersing the reinforcing bars into a molten bath of zinc until the zinc reacts with the steel surface to form zinc-iron inter-metallic alloys.

6.3 ~~Handling:~~ After solidification of the zinc coating, the coated reinforcing bars shall meet the minimum coating thickness or equivalent weight [mass] requirements in Table 1.

4.1.1 The galvanizer shall be permitted to subject the newly coated steel reinforcing bars to air or steam wiping to remove excess zinc from the bars. After the wiping, the coated steel reinforcing bars shall meet the minimum coating mass [weight].

NOTE 2—During the wiping process, care should be taken to maintain a uniformly thick coating around the perimeter of the bar.

NOTE 2—Excess liquid zinc can be removed from freshly coated bars either by allowing liquid zinc to drain off the surface by gravity, or by subjecting the bars to an air or wiping process, where in the case of the latter method, care should be taken to maintain a uniformly thick coating around the perimeter of the bar.

4.1.2 It shall be the responsibility of the galvanizer to maintain identity of the reinforcing bars throughout the galvanizing process and to the point of shipment.

6.4 It shall be the responsibility of the galvanizer to maintain identity of the reinforcing bars throughout the galvanizing process and to the point of shipment.

6.5 Class of Coating Thickness and Equivalent Weight [Mass]:

6.5.1 This specification includes two classes of zinc coating thickness and corresponding equivalent weight [mass]. The equivalent weight [mass] of zinc coating on the bar shall conform to the requirements in Table 1.

6.6 Mass [Weight] of Coating and Test: Coating Thickness Tests:

4.2.1 This specification includes two classes of coating mass [weight]. The mass [weight] of zinc coating based on actual area of the bar shall conform to the requirements shown in Table 1.



TABLE 1 Mass [Weight] of Zinc Coating

Coating Class	Mass [Weight] of Zinc Coating; min., g/m <sup>2</sup> [oz/ft <sup>2</sup> ] of Surface
Class I	
— Bar Designation Size No. 10 [3]	915 [3.00]
— Bar Designation Size No. 13 [4] and Larger	1070 [3.50]
Class II	
— Bar Designation Size No. 10 [3] and Larger	610 [2.00]

TABLE 1 Zinc Coating Thickness and Equivalent Weight [Mass]

NOTE 1—The key value in this table is micrometres ( $\mu\text{m}$ ) and is based on a zinc density of  $7140 \text{ kg/m}^3$ . The other values are based on conventions using the following formulae:  $\text{mils} = \mu\text{m} \times 0.03937$ ;  $\text{oz/ft}^2 = \mu\text{m} \times 0.0232$ ;  $\text{g/m}^2 = \mu\text{m} \times 7.14$ ; and  $\text{mg/cm}^2 = \mu\text{m} \times 0.714$ .

Classification	Zinc Thickness		Weight [Mass]/Unit Area	
	mils	$\mu\text{m}$	oz/ft <sup>2</sup>	mg/cm <sup>2</sup>
Class 1				
— Bar Designation No. 3 [10]	5.1	129	3.0	92
— Bar Designation No. 4 [13] and Larger	5.9	150	3.5	107
Class 2				
— Bar Designation No. 3 [10] and Larger	3.4	86	2.0	62

NOTE 3—The nominal diameter of a deformed bar is equivalent to that of a plain round bar having the same mass per metre [weight per foot] as the deformed bar. Coating mass [weight] shown in is based on an assumed area ratio of 1.2:1 (actual to nominal surface area of the steel reinforcing bar).

6.6.1 *Magnetic Thickness Measurements*—The mass [weight] of the coating shall be determined by magnetic thickness gage measurements. Coating thickness tests shall be performed in accordance with Practice E376. The thickness measurement is used to calculate the mass [weight] by multiplying it by the surface area of coated bar and by the zinc density. One or more of the following methods shall be permitted to be used to referee the results obtained by magnetic thickness measurements of the following test methods:

6.6.1.1 *Magnetic Thickness Gauge Measurements*—The thickness of the coating shall be determined by magnetic thickness gauge measurements in accordance with Practice E376. Use Table 1 to determine the equivalent weight [mass] of the coating. One or more of the following methods shall be permitted to be used to referee the results obtained by magnetic thickness gauge measurements.

6.6.1.2 *Stripping Method*—The mass [weight] shall be determined by stripping the coating from the steel reinforcing bar section in accordance with Test Method A90/A90M. This test method shall not be used for deformed reinforcing bars.

NOTE 4—This is a destructive test appropriate for small samples of a minimum of  $2000 \text{ mm}^2$  [ $3 \text{ in.}^2$ ] of surface area. It does not include the mass [weight] of iron reacted with the zinc coating and may overestimate coating mass [weight] by up to 10 %.

6.6.1.3 *Weighing Before and After Galvanizing*—The mass [weight] shall be determined by weighing steel reinforcing bars before and after galvanizing. The difference between the two measurements divided by the surface area of the bars provides the mass [weight]/unit area. The original weighing shall occur after pickling and drying. The second weighing shall occur after cooling to ambient temperature. This test method shall not be used for deformed reinforcing bars.

NOTE 3—Due to variations in the surface areas of deformed bars as a function of deformation pattern and bar size, the methods in 6.6.1.2 and 6.6.1.3 to measure coating thickness are not appropriate for deformed bars. These are destructive tests appropriate for small samples of a minimum of  $3 \text{ in.}^2$  [ $2000 \text{ mm}^2$ ] of surface area. These tests do not include the weight [mass] of iron reacted with the zinc coating and may overestimate coating weight [mass] by up to 10 %.

6.6.1.4 *Microscopy*—The mass [weight]-equivalent weight [mass] shall be determined by cross-sectional and optical measurement in accordance with Test Method B487. A cross-section sample of the steel shall be polished and examined with an optical microscope to determine the coating thickness. The coating mass [weight] shall be determined by multiplying coating thickness by Measurements of thickness shall not be taken on points located on longitudinal ribs or transverse deformations. Use Table 1 the surface area of the coated sample and by the density of zinc, to determine the equivalent weight [mass] of the coating.

6.6.2 *Number of Tests*—For determination of the coating mass [weight], three random samples shall be tested from each lot. For each magnetic thickness measurement sample, five or more. The following number of coated steel samples and measurements shall be made at various points throughout the sample so as to represent the entire surface of the sample. A total of at least fifteen measurements shall be averaged to obtain the coating thickness. For the microscopy method, five samples shall be tested per lot. Each sample shall be measured on four sides and the total of twenty measurements shall be averaged to obtain the coating thickness. For the stripping method and the weighing method, three samples per lot shall be measured, to determine coating thickness:

NOTE 5—A lot shall be as follows: All bars of one size furnished to the same steel reinforcing bar specification that have been galvanized within a single production shift.



6.6.2.1 For determination of the coating weight [mass] using magnetic thickness gauge measurements, three random samples shall be tested from each lot. For each magnetic thickness gauge measurement sample, five or more measurements shall be made at various points throughout the sample so as to represent the entire surface of the sample. A total of at least fifteen measurements shall be averaged to obtain the coating thickness.

6.6.2.2 For determination of the coating thickness or equivalent weight [mass] using the stripping method and the weighing method, three random coated steel samples shall be tested from each lot.

6.6.2.3 For determination of the coating thickness or equivalent weight [mass] using the microscopy method, five random coated steel samples shall be tested per lot. Each sample shall be measured on four sides and the total of twenty measurements shall be averaged to obtain the coating thickness.

4.2.4 *Retests*—If the average zinc coating mass [weight] fails to meet the requirements of **Table 1**, six additional random samples from the lot shall be permitted to be tested. If the average zinc coating mass [weight] of the six samples conforms to the requirements of **Table 1**, the lot shall be accepted.

6.7 *Retests*—If the average zinc coating thickness or equivalent weight [mass] fails to meet the requirements of **Table 1**, six additional random samples from the lot shall be permitted to be tested. If the average zinc coating thickness or equivalent weight [mass] of the six samples conforms to the requirements of **Table 1**, the lot shall be accepted.

6.8 *Chromating*—The galvanized zinc coating shall be chromate treated. This is to preclude a reaction between the bars and fresh portland cement paste. Proprietary chromating solutions of equivalent strength are permitted in place of the generic chemical treatment specified, treated unless waived by the purchaser.

NOTE 4—The purpose of chromate treatment is to preclude a reaction between the bars and fresh portland cement paste.

6.8.1 If the chromate treatment is performed immediately after galvanizing, it may zinc or zinc-alloy coating, it shall be accomplished either by quenching the coated steel reinforcing bars in a solution containing at least 0.2 mass [weight]-% of weight [mass]-% of pure sodium dichromate in water (such as 2 kg/m<sup>3</sup> [3-oz of each 10 gal] gal [2 kg/m<sup>3</sup>] of quench water) or by quench chromating in a minimum of 0.2%-0.2% chromic acid solution. The solution shall be at least 32°C [90°F]-90°F [32°C]. The galvanized zinc or zinc-alloy coated reinforcing bars shall be immersed in the solution for at least 20 s.

6.8.2 Proprietary chromating solutions of equivalent strength shall be permitted in place of the generic chemical treatment specified in **6.8.1**.

6.8.3 If the galvanized zinc or zinc-alloy coated reinforcing bars are at ambient temperature, the chromate treatment shall be the same as specified in **6.8.1** except that 0.5 to 1.0%-1.0% concentration of sulfuric acid shall be added as an activator of the chromate solution. In this case, there is no temperature requirement for the activated chromate solution.

## 5. General Requirements

5.1 The steel reinforcing bars shall conform to one of the following specifications: A615M, A706M, or A996M [A615, A706, or A996].

5.2 The zinc used for coating shall be any grade that conforms to Specification **B6**.

## 7. Finish and Adherence of Coating

7.1 The zinc coating zinc-coated bars shall have no bare spots, uncoated areas. The coating shall be free of blisters, flux spots or inclusions, dross, and acid or black spots. Bars that stick adhere together after galvanizing shall be rejected. In addition, the presence of tears or sharp spikes which make the bar hazardous to handle shall be cause for rejection. A matte gray finish appearance shall not be itself a cause for rejection.

NOTE 5—Specific concentrations of elements such as silicon, carbon, and phosphorus in steel tend to accelerate the growth of the zinc-iron alloy layer so that the galvanized coating may have a matte finish with little or no free zinc outer layer. The mass, shape, and amount of cold working of the bar being galvanized may also affect this condition.

7.2 The coating shall be adherent so it cannot be removed by any reasonable process of handling or erection. handling.

### 7.3 Class 1 Coatings—Fabrication:

#### 7.3.1 Fabrication Before Galvanizing:

7.3.1.1 Minimum finished bend diameters for reinforcing bars that are fabricated before galvanizing shall be equal to or greater than those specified in **Table 2**.

7.3.1.2 When reinforcing bars are fabricated to smaller finished bend diameters than those specified in **Table 2**, the bars shall be stress relieved at a temperature from 900 to 1050°F [480 to 560°C] for 1 h per in. [25 mm] of bar diameter.

#### 7.3.2 Fabrication After Galvanizing:

7.3.2.1 When fabrication is performed after galvanizing, some cracking and flaking of the galvanized coating in the bend areas shall not be cause for rejection (**Note 6**).

7.3.2.2 Damaged coating due to fabrication shall be repaired and cut ends shall be coated in accordance with **Section 9**.

NOTE 6—The tendency for cracking of the zinc coating increases with bar diameter and with severity and rate of bending.