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**Designation: A 90/A 90M – 95a (Reapproved 1999)**



**Designation: A 90/A 90M – 01**

## Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings<sup>1</sup>

This standard is issued under the fixed designation A 90/A 90M; 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 Department of Defense.*

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.07 on Methods of Testing.

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### 1. Scope

1.1 This test method covers procedures for determining the weight [mass] of coating on iron or steel sheet, wire, and other articles in which the coating is zinc or a zinc alloy, such as zinc-5 % aluminum (including zinc-5 % aluminum-mischmetal and zinc-5 % aluminum-0.1 % magnesium) or 55 % aluminum-zinc. In the body of this test method, reference to zinc coating shall be interpreted to also include zinc alloy coating except where specifically stated otherwise.

1.2 The final results determined by this test method shall be expressed in inch-pound units or SI units, depending on the units used in the material specification to which the results are to be compared. Certain portions of the procedure involving determination of specimen weight [mass] have traditionally been performed in SI units, and corresponding inch-pound units are not included.

~~1.3 In this test method, the quantity of material is described in terms of weight [mass]. Weight is the force describing the gravitational attraction of the earth on a quantity of material. In general usage on the surface of the earth, mass of an unknown quantity is determined by comparing with a known quantity (either directly or indirectly and ignoring the buoyancy of the air) as indicated by the attraction of the earth's gravity, thus weight is actually determined. See Appendix X1 of Terminology E 12 for further discussion of weight and mass.~~

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~~1.3~~ *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. For specific hazards statements see 5.1.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

A 653/A 653M Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process<sup>2</sup>

A 792/A 792M Specification for Steel Sheet, 55 % Aluminum-Zinc Alloy-Coated by the Hot-Dip Process<sup>2</sup>

A 875/A 875M Specification for Steel Sheet, Zinc-5 % Aluminum Alloy-Coated by the Hot-Dip Process<sup>2</sup>

D 1193 Specification for Reagent Water<sup>3</sup>

~~E 12 Terminology Relating to Practice for Using Significant Digits in Test Data to Density and Specific Gravity of Solids, Liquids, and Gases Determine Conformance with Specifications<sup>4</sup>~~

~~E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>5</sup>~~

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method<sup>5</sup>

<sup>2</sup> Annual Book of ASTM Standards, Vol 01.06.

<sup>3</sup> Annual Book of ASTM Standards, Vols 10.01 and 11.01.

<sup>4</sup> Annual Book of ASTM Standards, Vols 15.052 and 14.02.

<sup>5</sup> Annual Book of ASTM Standards, Vols 14.02 and Standards, Vol 14.02.

### 3. Significance and Use

3.1 This test method provides a standard method for determining the weight [mass] of coating for comparison with specification requirements. A coating of zinc on iron or steel articles provides protection against corrosion. As the protection is provided by sacrificial loss of zinc, the degree of protection is proportional to the weight [mass] of zinc coating. Specifications for zinc-coated articles frequently provide for different classes of coating so that the purchaser can select the coating weight [mass] most suitable to his needs.

### 4. Reagents

4.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.<sup>6</sup> Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

4.2 *Purity of Water*—Water used to prepare chemical solutions shall be reagent water as defined by Type IV of Specification D 1193.

4.3 *Antimony Trichloride Solution*—Dissolve 20 g of  $\text{Sb}_2\text{O}_3$  or 32 g of  $\text{SbCl}_3$  in 1000 mL of HCl (sp gr 1.19).

4.4 *Hydrochloric Acid* (sp gr 1.19)—Concentrated hydrochloric acid (HCl).

4.5 *Hydrochloric Acid—Antimony Trichloride Solution*—Add 5 mL of antimony trichloride solution to 100 mL of HCl (sp gr 1.19).

4.6 *Hydrochloric Acid (1 + 1)*—Mix 500 mL of HCl (sp gr 1.19) with 500 mL of reagent water and cool to room temperature.

### 5. Hazards

5.1 **Warning**—Small amounts of the poisonous gas stibine ( $\text{SbH}_3$ ) may be evolved during the stripping process using the hydrochloric acid-antimony trichloride method. Hydrochloric acid fumes are present, and hydrogen gas is evolved in the stripping process. Therefore, the test should be performed under conditions of adequate ventilation. A fume hood is recommended for large numbers of samples or where the test is to be carried out frequently over extended periods of time.

### 6. Sampling

6.1 *Zinc-Coated Sheets*—Samples for weight [mass] of coating determination shall be secured in accordance with Specifications A 653/A 653M, A 792/A 792M, or A 875/A 875M depending on the type of coating.

NOTE 1—For convenience in calculating test results in inch-pound units, the specimen should have an area of 5.08 in.<sup>2</sup> of sheet ( $2.25 \pm 0.01$ -in. square or  $2.54 \pm 0.01$  in. in diameter). The weight [mass] of coating in grams on a specimen of that area is numerically equal to the weight [mass] of coating in ounces per square foot of sheet. For results to be reported in metric units, the specimen should have an area of 3330 mm<sup>2</sup> of sheet ( $57.7 \pm 0.1$ -mm square or  $65.1 \pm 0.1$  mm in diameter).

6.2 *Zinc-Coated Wire*—Samples shall be secured as designated in the appropriate specification. The specimen of wire may be of any length over 12 in. [305 mm], but preferably about 24 in. [609 mm]. Where a continuous length is not available, shorter lengths totaling over 12 in. [300 mm], but preferably about 24 in. [600 mm], shall be used. Since the density of the steel is known 0.283 lb/in.<sup>3</sup> [7830 kg/m<sup>3</sup>], it is not necessary to use a specific length of specimen.

6.3 *Zinc-Coated Articles Other Than Sheet or Wire*—Samples for weight [mass] of coating determination shall be secured as designated in the appropriate specification. Except as otherwise provided, the specimens should have a minimum area of 3 in.<sup>2</sup> (2000 mm<sup>2</sup>) of zinc-coated surface. For very small items, several pieces may have to be stripped to obtain the minimum area.

6.3.1 In the case of threaded articles, such as bolts and screws, the determination shall be made on a portion of the articles that does not include any thread.

### 7. Procedure

7.1 Stripping of zinc alloy coatings containing less than 90 % zinc shall be done using the dilute hydrochloric acid method. Stripping of coatings containing 90 % or more zinc may be done using either hydrochloric acid-antimony trichloride solution or dilute hydrochloric acid (1 + 1) (alternative standard method).

7.2 Clean the specimens by washing with solvent naphtha or other suitable solvent, then rinse with alcohol, and dry thoroughly.

7.3 Determine the weight [mass] of the specimens individually to the nearest 0.01 g, except that articles other than sheet or wire with a specimen weight [mass] over 125 g may have the weight [mass] determined to the nearest 0.1 g. After determining the weight [mass], immerse each specimen singly in the stripping solution and allow to remain until the violent evolution of hydrogen has ceased, and only a few bubbles are being evolved. This requires about 15 to 30 s, except in the case of sherardized coatings, which require a somewhat longer time. The same solution may be used repeatedly until the time required for stripping becomes

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<sup>6</sup> "Reagent Chemicals, American Chemical Society Specifications," Am. Chemical Soc., Washington, DC. For suggestions on the testing of ASTM reagents not listed by the American Chemical Society, see "Anal. Standards, Vol. 14.02, for Laboratory U.K. Chemicals," BDH Ltd., Poole, Dorset, and the "United States Pharmacopeia."

inconveniently long. The temperature of the stripping solution shall at no time exceed 100°F [38°C]. After stripping, wash the specimens by scrubbing them under running water, dip in hot water, and wipe or blow dry. Determine the weight [mass] of the specimens again, to the same precision as in the initial determination.

7.3.1 When determining the coating weight [mass] on one side of sheet material, use the procedure described in 7.3, except use a “stop-off” to protect one side from the stripping medium. Acid-resistant paints or lacquers, acid-resistant tape, or mechanical devices fastened to the test specimen are examples of commonly used “stop-off” materials. Apply the “stop-off” to the specimen after the initial determination of weight [mass] and removed before the second determination of weight [mass]. Because of the possibility of moisture absorption during the stripping process, the “stop-off” must not be on the specimen during either weight [mass] determinations. The coating weight [mass] on the second side may be determined subsequently without a “stop-off” on the first side.

7.4 *Sheet Specimens*—Determine the area of sheet (one surface) to the nearest 0.01 in.<sup>2</sup>[5 mm<sup>2</sup>]. If specimens were prepared to the dimensions as provided in Note 1, they shall be presumed to have an area of 5.08 in.<sup>2</sup>[3330 mm<sup>2</sup>]. When it is not possible to determine the area accurately, as in specimens from corrugated sheets, the thickness of the stripped sheet shall be determined to the nearest 0.001 in. [0.01 mm].

7.5 *Wire Specimens*—Determine the diameter of the stripped wire to the nearest 0.001 in. [0.01 mm] by taking the average of two measurements at right angles to each other.

7.6 *Specimens Other Than Sheet or Wire*— Determine the total coated area of the original specimen to the nearest 0.01 in.<sup>2</sup>[5 mm<sup>2</sup>]. Alternatively, for specimens of uniform thickness of base metal, such as a piece of plate or pipe, determine the average thickness of the stripped specimen to the nearest 0.001 in. [0.01 mm].

## 8. Calculation

### 8.1 Zinc-Coated Sheet:

#### 8.1.1 Results in Inch-Pound Units:

8.1.1.1 When the area of sheet is determined, calculate the weight [mass] of zinc coating as follows:

$$C = [(W_1 - W_2)/A] \times K \quad (1)$$

where: =

- $C$  = weight [mass] of coating, oz/ft<sup>2</sup> of sheet,
- $W_1$  = original weight [mass] of specimen, g,
- $W_2$  = weight [mass] of stripped specimen, g,
- $A$  = area of sheet, in.<sup>2</sup> or mm<sup>2</sup>, and,
- $K$  = a constant = 5.08 when  $A$  is in in.<sup>2</sup> =  $3.28 \times 10^3$  when  $A$  is in mm<sup>2</sup>.

NOTE 2—If the specimen was prepared to the dimensions as provided in Note 1, having an area of 5.08 in.<sup>2</sup>, the loss of weight [mass] in grams is numerically equal to the weight [mass] of coating in ounces per square foot of sheet.

8.1.1.2 When it is not possible to secure a specimen of measurable area, the following equation may be used to calculate the weight [mass] of coating:

$$C = [(W_1 - W_2)/W_2] \times T \times K \quad (2)$$

where: =

- $C$  = weight [mass] of coating, oz/ft<sup>2</sup> of sheet,
- $W_1$  = original weight [mass] of specimen, g,
- $W_2$  = weight [mass] of stripped specimen, g,
- $T$  = thickness of stripped sheet, in. or mm, and
- $K$  = a constant = 652 if  $T$  is in in. = 25.7 if  $T$  is in mm.

#### 8.1.2 Results in Metric Units:

8.1.2.1 When the area of sheet is determined, calculate the weight [mass] of zinc coating as follows:

$$C = [(W_1 - W_2)/A] \times K \quad (3)$$

where: =

- $C$  = weight [mass] of coating, g/m<sup>2</sup> of sheet,
- $W_1$  = original weight [mass] of specimen, g,
- $W_2$  = weight [mass] of stripped specimen, g,
- $A$  = area of sheet, in.<sup>2</sup> or mm<sup>2</sup>, and
- $K$  = a constant =  $1.55 \times 10^3$  if  $A$  is in in.<sup>2</sup> =  $1 \times 10^6$  if  $A$  is in mm<sup>2</sup>.

NOTE 3—If the specimen was prepared to the dimensions as provided in Note 1, having an area of 3330 mm<sup>2</sup> of sheet, the factor  $K/A$  is approximately 300, which may be used in the calculation.

8.1.2.2 When it is not possible to obtain a specimen of measurable area, the following equation may be used to calculate the weight [mass] of coating:

$$C = [(W_1 - W_2)/W_2] \times T \times K \quad (4)$$

where:

- $C$  = weight [mass] of coating, g/m<sup>2</sup> of sheet
- $W_1$  = original weight [mass] of the specimen, g,
- $W_2$  = weight [mass] of the stripped specimen, g,
- $T$  = thickness of stripped sheet, in. or mm, and
- $K$  = a constant =  $1.99 \times 10^5$  if  $T$  is in in., =  $7.83 \times 10^3$  if  $T$  is in mm.

### 8.2 Zinc-Coated Wire:

#### 8.2.1 Results in Inch-Pound Units:

8.2.1.1 Calculate the weight [mass] of zinc coating as follows:

$$C = [(W_1 - W_2)/W_2] \times D \times M \quad (5)$$

where: =

- $C$  = weight [mass] of coating, oz/ft<sup>2</sup> of stripped wire surface,
- $W_1$  = original weight [mass] of specimen, g,
- $W_2$  = weight [mass] of stripped specimen, g,
- $D$  = diameter of stripped wire, in. or mm, and
- $M$  = a constant = 163 if  $D$  is in in., = 6.42 if  $D$  is in mm.

#### 8.2.2 Results in Metric Units:

8.2.2.1 Calculate the weight [mass] of zinc coating as follows:

$$C = [(W_1 - W_2)/W_2] \times D \times M \quad (6)$$

where: =

- $C$  = weight [mass] of coating, g/m<sup>2</sup> of stripped wire surface,
- $W_1$  = original weight [mass] of specimen, g,
- $W_2$  = weight [mass] of stripped specimen, g,
- $D$  = diameter of stripped wire, in. or mm, and
- $M$  = a constant =  $4.97 \times 10^4$  if  $D$  is in in., =  $1.96 \times 10^3$  if  $D$  is in mm.

### 8.3 Zinc-Coated Articles Other Than Sheet or Wire:

#### 8.3.1 Results in Inch-Pound Units:

8.3.1.1 Calculate the weight [mass] of zinc coating as follows:

$$C = [(W_1 - W_2)/A] \times N \quad (7)$$

where: =

- $C$  = weight [mass] of coating, oz/ft<sup>2</sup> of surface,
- $W_1$  = original weight [mass] of specimen, g,
- $W_2$  = weight [mass] of stripped specimen, g,
- $A$  = coated area of original specimen, in.<sup>2</sup> or mm<sup>2</sup>, and
- $N$  = a constant = 5.08 if  $A$  is in in.<sup>2</sup> =  $3.28 \times 10^3$  if  $A$  is in mm<sup>2</sup>.

8.3.1.2 If the specimen has a uniform thickness of base metal, the weight [mass] of the zinc coating may be calculated as follows:

$$C = [(W_1 - W_2)/W_2] \times G \times Z \quad (8)$$

where: =

- $C$  = weight [mass] of coating, oz/ft<sup>2</sup> of surface,
- $W_1$  = original weight [mass] of specimen, g,
- $W_2$  = weight [mass] of stripped specimen, g,
- $G$  = thickness of stripped specimen, in. or mm, and

$Z$  = a constant = 326 if  $G$  is in in. or 12.8 if  $G$  is in mm.

### 8.3.2 Results in Metric Units:

8.3.2.1 Calculate the weight [mass] of zinc coating as follows:

$$C = [(W_1 - W_2)/A] \times N \quad (9)$$

where: =

$C$  = weight [mass] of coating,  $\text{g}/\text{m}^2$  of surface,

$W_1$  = original weight [mass] of specimen, g,

$W_2$  = weight [mass] of stripped specimen, g,

$A$  = coated area of original specimen,  $\text{in.}^2$  or  $\text{mm}^2$ , and

$N$  = a constant =  $1.55 \times 10^3$  if  $A$  is in  $\text{in.}^2$  =  $1 \times 10^6$  if  $A$  is in  $\text{mm}^2$ .

8.3.2.2 If the specimen has a uniform thickness of base metal, the weight [mass] of the zinc coating may be calculated as follows:

$$C = [(W_1 - W_2)/W_2] \times G \times Z \quad (10)$$

where: =

$C$  = weight [mass] of coating,  $\text{g}/\text{m}^2$  of surface,

$W_1$  = original weight [mass] of specimen, g,

$W_2$  = weight [mass] of stripped specimen, g,

$G$  = thickness of stripped specimen, in. or mm, and

$Z$  = a constant =  $9.95 \times 10^4$  if  $G$  is in in., =  $3.92 \times 10^3$  if  $G$  is in mm.

## 9. Report

9.1 Weight [mass] of coating on zinc-coated sheet is expressed in weight [mass] per unit area of sheet, which is the sum of the weights of coating on both surfaces of the sheet. Weights [masses] of coating on each surface of the sheet are not necessarily equal. Coating weights [masses] on all zinc-coated articles other than sheets are expressed in weight [mass] per unit area of surface.

9.2 Report the weight [mass] of zinc coating to the nearest 0.01  $\text{oz}/\text{ft}^2$  when reporting in inch-pound units.

9.3 Report the weight [mass] of zinc coating to the nearest 1  $\text{g}/\text{m}^2$  when reporting in metric units.

9.4 When the weight [mass] of coating of a number of specimens is to be averaged to determine conformance with a specification limit, the average value shall be reported to the precision described in 9.2 and 9.3 in accordance with the Rounding Method of Practice E 29.

## 10. Precision and Bias

10.1 *Precision*—The precision of this test method for sheet product with commercial zinc and zinc-alloy coatings has been determined in accordance with Practice E 691.

10.1.1 The repeatability was found to be 0.049  $\text{oz}/\text{ft}^2$ , and the reproducibility was found to be 0.060  $\text{oz}/\text{ft}^2$ .

10.2 The precision of the test method for other products or coating materials has not been determined.

NOTE 4—Repeatability and reproducibility, based on test error alone, are defined as the difference, in absolute value, of two test results obtained in the same laboratory or between laboratories on the same material. The differences will be expected to exceed the repeatability or reproducibility only about 5 % of the time.

10.3 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in this test method, bias has not been determined.

## 11. Keywords

11.1 55 % aluminum-zinc alloy coating; coating weight [mass]; steel sheet; steel wire; zinc alloy coatings; zinc coating; zinc-5 % aluminum alloy coating; zinc-5 % aluminum-0.1 % magnesium alloy coating; zinc-5 % aluminum-mischmetal alloy coating

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