Designation: A90/A90M – 13

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

This standard is issued under the fixed designation A90/A90M; 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 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), zinc-aluminum-magnesium (including zinc-5 to 9 % aluminum-magnesium and zinc-9 to 13 % aluminum-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 For sheet products, the final results are expressed as either coating weight [mass] total both sides, or coating weight [mass] separately on each side, depending on the specified requirements.

1.4 *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:*[2]

A653/A653M Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

A792/A792M Specification for Steel Sheet, 55 % Aluminum-Zinc Alloy-Coated by the Hot-Dip Process

A875/A875M Specification for Steel Sheet, Zinc-5 % Aluminum Alloy-Coated by the Hot-Dip Process

A1046/A1046M Specification for Steel Sheet, Zinc-Aluminum-Magnesium Alloy-Coated by the Hot-Dip Process

A1057/A1057M Specification for Steel, Structural Tubing, Cold Formed, Welded, Carbon, Zinc-Coated (Galvanized) by the Hot-Dip Process

A1063/A1063M Specification for Steel Sheet, Twin-Roll Cast, Zinc-Coated (Galvanized) by the Hot-Dip Process

A1079 Specification for Steel Sheet, Complex Phase (CP), Dual Phase (DP) and Transformation Induced Plasticity (TRIP), Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

D1193 Specification for Reagent Water

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

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.

[1] 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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[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.

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

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.[3] 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 D1193.

4.3 *Antimony Trichloride Solution*—Dissolve 20 g of Sb_2O_3 or 32 g of $SbCl_3$ in 1000 mL of HCl (sp gr 1.18 to 1.19).

4.4 *Hydrochloric Acid (sp gr 1.18 to 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 1.18 to 1.19).

4.6 *Hydrochloric Acid (1 + 1)*—Mix 500 mL of HCl (sp gr 1.18 to 1.19) with 500 mL of reagent water and cool to room temperature.

4.7 *Sulfuric Acid (25 + 75)*—Mix 250 mL of H_2SO_4 (sp gr 1.84) with 750 mL of reagent water and cool to room temperature.

NOTE 1—It is advisable to use an inhibitor with acid solution (for example, Hexamethylamine Tetramine or similar) at the concentration level according to the manufacturer's recommendations to prevent attack of the substrate.

5. Hazards

5.1 **Warning—**Small amounts of the poisonous gas stibine (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.

5.2 **Warning—**Mixing of sulfuric acid with water could result in severe injuries if not properly done. Mixing must be done by slowly adding sulfuric acid to water due to the heat generated and possible splashing. Under no circumstances should the water be added to the acid. The mixing should be performed under an acid fume hood.

6. Sampling

6.1 *Zinc-Coated Sheets*—Samples for weight [mass] of coating determination shall be secured in accordance with Specifications A653/A653M, A792/A792M, A875/A875M, A1046/A1046M, A1057/A1057M, A1063/A1063M, or A1079 depending on the type of coating.

NOTE 2—For convenience in calculating test results in inch-pound units, the specimen should have an area of 5.08 in.^{2} of sheet (2.25 ± 0.01-in. square or 2.54 ± 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^2 of sheet (57.7 ± 0.1-mm square or 65.1 ± 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.^{3} [7830 kg/m^3], 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.^{2} (2000 mm^2) 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 Strip the zinc coating from the specimens by using one of the following methods: hydrochloric acid (1 + 1), hydrochloric acid-antimony trichloride solution, or sulfuric acid (25 + 75). For zinc alloy coatings containing less than 90 % zinc, the stripping shall be done using hydrochloric acid (1 + 1) or sulfuric acid (25 + 75).

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 for articles other than sheet or wire with a specimen weight [mass] greater than 125 g, determine the weight [mass] to at least 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 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.

7.4 *Sheet Specimens*—When measuring the total coating weight [mass] on both sides, or the single side coating weight [mass] on each side, determine the area of sheet (one surface)

[3] "Reagent Chemicals, American Chemical Society Specifications," Am. Chemical Soc., Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Analar Standards for Laboratory U.K. Chemicals," BDH Ltd., Poole, Dorset, and the "United States Pharmacopeia."

to the nearest 0.01 in.^{2} [5 mm^2]. If specimens were prepared to the dimensions as provided in Note 2, they shall be presumed to have an area of 5.08 in.^{2} [3330 mm^2]. 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].

7.4.1 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 remove 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. Determine the coating weight [mass] on the second side subsequently without a "stop-off" on the first side.

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.^{2} [5 mm^2]. 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 one surface of the sheet is determined, calculate the weight [mass] of coating as follows:

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

where:

C = weight [mass] of coating, oz/ft^2 of sheet,
W_1 = original weight [mass] of specimen, g,
W_2 = weight [mass] of stripped specimen, g,
A = area of one surface of the sheet, in.^{2} or mm^2, and,
K = a constant = 5.08 when A is in in.^{2}, or = 3.28 × 10^3 when A is in mm^2.

NOTE 3—If the specimen was prepared to the dimensions as provided in Note 2, having an area of 5.08 in.^{2}, 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, calculate the weight [mass] of coating as follows:

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

where:

C = weight [mass] of coating, oz/ft^2 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 when T is in in., or = 25.7 when 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 coating as follows:

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

where:

C = weight [mass] of coating, g/m^2 of sheet,
W_1 = original weight [mass] of specimen, g,
W_2 = weight [mass] of stripped specimen, g,
A = area of one surface of the sheet, in.^{2} or mm^2, and
K = a constant = 1.55 × 10^3 when A is in in.^{2}, or = 1 × 10^6 when A is in mm^2.

NOTE 4—If the specimen was prepared to the dimensions as provided in Note 2, having an area of 3330 mm^2 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, calculate the weight [mass] of coating as follows:

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

where:

C = weight [mass] of coating, g/m^2 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 × 10^5 when T is in in., or = 7.83 × 10^3 when 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^2 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 when D is in in., or = 6.42 when 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^2 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 × 10^4 when D is in in., or = 1.96 × 10^3 when 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 coating as follows:

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

where:

C = weight [mass] of coating, oz/ft^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, in.^{2} or mm^2, and
N = a constant = 5.08 when A is in in.^{2}, or = 3.28 × 10^3 when A is in mm^2.

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

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

where:

C = weight [mass] of coating, oz/ft^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 = 326 when G is in in., or 12.8 when 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, g/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, in.^{2} or mm^2, and
N = a constant = 1.55 × 10^3 when A is in in.^{2}, or = 1 × 10^6 when A is in mm^2.

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

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

where:

C = weight [mass] of coating, g/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 × 10^4 when G is in in., or = 3.92 × 10^3 when 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, and is either the sum of the weights [masses] of coating on both sides of the sheet, or single side weight [mass] on each of the two sides. Weights [masses] of coating on each side of the sheet are not necessarily equal, even when both sides are exposed to the molten metal or plating solution simultaneously. 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 oz/ft^2 when reporting in inch-pound units.

9.3 Report the weight [mass] of zinc coating to the nearest 1 g/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 E29.

10. Precision and Bias

10.1 The precision of this test method is based on an interlaboratory study conducted in 2006. Each of ten laboratories tested three replicates of two different materials.[4] Data was recorded in inch-pound units only and should not be considered metric equivalents. See Table 1 for a statistical summary of the test results.

10.1.1 *Repeatability*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material; "*r*" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

10.1.2 *Reproducibility*—Two test results shall be judged not equivalent if they differ by more than the "*R*" value for that material; "*R*" is the interval representing the difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

10.1.3 Any judgment in accordance with these two statements would have an approximate 95 % probability of being correct.

10.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

10.3 The precision statement was determined through statistical examination of three results, from ten laboratories, on two materials.

11. Keywords

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

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:A05-1003.

TABLE 1 Weight Mass Coating (in oz.ft^2)

NOTE 1—S_r means the standard deviation of *r* (repeatability). S_R means the standard deviation for *R* (reproducibility).

Material	$\bar{x}$	$S_{\bar{x}}$	S_r	S_R	*r*	*R*
Hot Dipped Zinc-Coated Samples	1.100780	0.021895	0.015333	0.025222	0.042933	0.070621
Electrolytic Zinc-Coated Samples	0.403221	0.008790	0.008378	0.011138	0.023457	0.031187

zinc-5 % aluminum alloy coating; zinc-5 % aluminum-0.1 % magnesium alloy coating; zinc-5 % aluminum-mischmetal alloy coating; zinc-5 to 9 % aluminum-magnesium alloy coating; zinc-9 to 13 % aluminum-magnesium alloy coating

SUMMARY OF CHANGES

Committee A05 has identified the location of selected changes to this standard since the last issue (A90/A90M - 11) that may impact the use of this standard. (April 1, 2013)

(1) Added references to A1057/A1057M and A1079 in 2.1 and 6.1.