



Standard Specification for Zinc-5 % Aluminum (Hot-Dip) Coatings on Iron and Steel Products¹

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1. Scope

1.1 This specification covers the requirements for zinc-5 % aluminum coated, by the hot-dip process on iron and steel products. The coating may also contain small amounts of elements other than zinc and aluminum that are intended to improve processing and the characteristics of the coated product. These metallic coatings include zinc- 5 %-aluminum (Zn-5Al), zinc-5 %-aluminum-mischmetal (Zn-5Al-MM) and zinc-5 %-aluminum-magnesium (Zn- %Al-Mg).

1.2 This specification covers both un-fabricated products and fabricated products, for example, assembled steel products, structural steel fabrications, large tubes already bent or welded before hot-dip coating, and wire work fabricated from un-coated steel wire. This specification, also, covers steel forgings and iron castings incorporated into pieces fabricated, before hot-dip coating or which are too large to be centrifuged (or otherwise handled to remove excess molten bath metal).

1.3 Fabricated reinforcing steel bar assemblies are covered by the present specification.

1.4 This specification is applicable to orders in either inch-pound units (as A1072) or SI units (as A1072M). Inch-pound units and SI units are not necessarily exact equivalents. Within the text of this specification and where appropriate, SI units are shown in parentheses. Each system shall be used independently of the other without combining values in any way. In the case of orders in SI units, all testing and inspection shall be done using the metric equivalent of the test or inspection method as appropriate. In the case of orders in SI units, such shall be stated to the hot-dip coater when the order is placed.

¹ This specification is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.13 on Structural Shapes and Hardware Specifications.

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2. Referenced Documents

2.1 ASTM Standards:²

- A47/A47M Specification for Ferritic Malleable Iron Castings
- A90/A90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
- A143/A143M Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
- A384/A384M Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
- A385 Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
- A780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
- A902 Terminology Relating to Metallic Coated Steel Products
- B487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section
- B602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings
- B750 Specification for GALFAN (Zinc-5 % Aluminum-Mischmetal) Alloy in Ingot Form for Hot-Dip Coatings
- E376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Testing Methods

3. Terminology

3.1 *Definitions*—The following terms and definitions are specific to this specification. Terminology A902 contains other terms and definitions relating to metallic-coated steel products.

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.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *average coating thickness, n*—the average of three specimen coating thicknesses.

3.2.2 *black, adj*—denotes the condition of not galvanized or otherwise coated. For purposes of this specification the word “black” does not refer to the color or condition of surface, or to a surface deposit or contamination.

3.2.3 *coating thickness grade, n*—the numerical value from **Table 1** at the intersection of a material category and a thickness range.

3.2.4 *gross cross inclusions, n*—the iron/aluminum intermetallics present in a galvanized coating in a form other than finely dispersed pimples.

3.2.4.1 *Discussion*—These inclusions would create an exposed steel spot if they were removed from the coating. These inclusions are raised surfaces and are easily knocked off through contact with lifting straps or chains, tools, fixtures, or other galvanized parts.

3.2.5 *material category, n*—the general class or type of material or process of manufacture, or both, that nominally describes a unit of product, or from which a unit of product is made. For example, bar grating belongs to the category “strip,” handrail belongs to the category “pipe,” etc.

3.2.6 *multi-specimen article, n*—a unit of product whose surface area is greater than 160 in.² [100 000 mm²]. For thickness testing purposes, articles whose surface area is greater than 160 in.² are subdivided into three continuous local sections, nominally equal in surface area, each of which constitutes a specimen. In the case of any such local section containing more than one material category or steel thickness range as delineated in **Table 1**, that section will contain more than one specimen (see **Fig. 1**).

3.2.7 *sample, n*—a collection of individual units of product from a single lot selected in accordance with Section 7, and intended to represent that lot for acceptance. If a sample is taken as representing the lot for acceptance, the sample shall be taken at random from the lot without regard to the perceived quality or appearance of any individual unit in the lot being sampled. The sample consists of one or more test articles.

3.2.8 *single-specimen article, n*—a unit of product whose surface area is equal to or less than 160 in.² [100 000 mm²] or that is centrifuged or otherwise similarly handled in the galvanizing process to remove excess galvanizing bath metal (free zinc). For thickness testing purposes, the entire surface area of each unit of product constitutes a specimen. In the case of any such article containing more than one material category

or steel thickness, that article will contain more than one specimen (see **Fig. 1**).

3.2.9 *specimen, n*—the surface of an individual test article or a portion of a test article, upon which thickness measurements are to be performed, which is a member of a lot, or a member of a sample representing that lot. For magnetic thickness measurements, specimen excludes any area of the surface which is subject to processes (such as flame cutting, machining, threading, etc.) that can be expected to result in surface conditions not representative of the general surface condition of the test article, or is disqualified by the measurement method. For a unit of product whose surface area is equal to or less than 160 in.² [100 000 mm²], the entire surface area of each test article constitutes a specimen. In the case of an article containing more than one material category or steel, that article will contain more than one specimen, as appropriate (see **Fig. 1**).

3.2.10 *specimen coating thickness, n*—the average thickness from no less than five test measurements on a specimen, when each measurement location is selected to provide the widest dispersion (in all applicable directions) of locations for the steel category of the test article within the confines of the specimen volume.

3.2.11 *test article, n*—an individual unit of product that is a member of the sample and that is examined for conformance to a part of this specification.

4. Ordering Information

4.1 Orders for coatings provided under this specification shall include the following:

4.1.1 Quantity (number of pieces to be galvanized) and total weight.

4.1.2 Description (type and size of products) and weight.

4.1.3 ASTM specification designation and year of issue.

4.1.4 Material identification (see 5.1) and surface condition or contamination.

4.1.5 Sampling plan, if different from 7.3.

4.1.6 Special test requirements (see 8.1).

4.1.7 Special requirements (special stacking, heavier coating weight, etc.).

4.1.8 Tagging or piece identification method.

5. Materials and Manufacture

5.1 *Steel or Iron*—The specification, grade, or designation and type and degree of surface contamination of the iron or steel in articles to be hot-dip coated shall be supplied by the purchaser to the hot-dip coater prior to coating.

5.2 *Fabrication*—The design and fabrication of the product to be hot-dip coated are the responsibilities of the designer and the fabricator. Practices **A143/A143M**, **A384/A384M**, and **A385** provide guidance for steel fabrication for optimum hot dip coating and shall be complied with in both design and fabrication. Consultation between the designer, fabricator, and coater at appropriate stages in the design and fabrication process will reduce future problems.

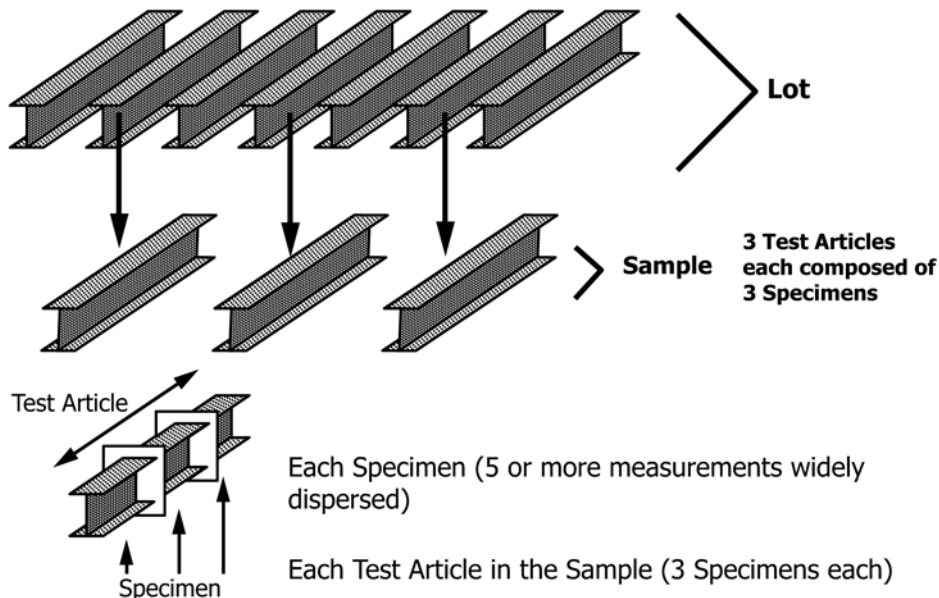
5.3 *Castings*—The composition and heat treatment of iron and steel castings shall conform to specifications designated by

TABLE 1 Guide to Conversion Between Coating Weight [Mass] and Thickness
A875/A875M Zinc-5 % Aluminum Alloy-Coated Sheet

| (Assume 1.00 oz/ft ² = 305 g/m ² = 1.75 mils) | | | |
|---|---------------------|-------------------|-------|
| Coating Weight [Mass] | | Coating Thickness | |
| oz/ft ² | [g/m ²] | mil | μm |
| 1.00 | 305 | 1.75 | 44.6 |
| 0.00328 | 1.00 | 0.00574 | 0.146 |
| 0.570 | 174 | 1.00 | 25.4 |
| 0.0224 | 6.83 | 0.0394 | 1.00 |

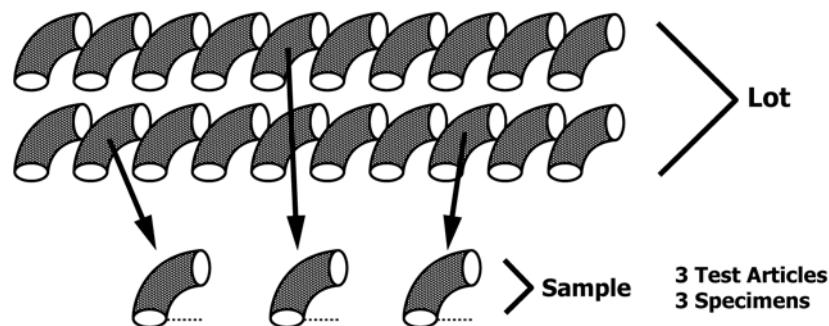
Multi-Specimen Articles

Articles whose Surface Area is greater than 160 sq. in. (100,000 sq. mm)



Single-specimen Articles

Articles whose Surface Area is equal to or less than 160 sq. in. (100,000 sq. mm)



Each Specimen (5 or more measurements widely dispersed)

Based on an alloy density of 427 lb/ft³ [6840 kg/m³]: To convert from coating wt. to thickness, use Zn-5% Al alloy-coated area, the relationship between coating weight [mass] and thickness is as follows:

$$1.0 \text{ oz/ft}^2 = 0.00175 \text{ in } 305 \text{ g/m}^2 / 6840 = 0.0446 \text{ mm}$$

FIG. 1 Single- and Multi-Specimen Articles

the purchaser. Some types of castings have been known to show potential problems with predisposition to being embrittled during the normal thermal cycle of hot-dip coating. It is the responsibility of the purchaser to heat treat or otherwise allow for the possibility of such embrittling phenomena. The requirements for malleable iron castings to be hot-dip coated shall be as stated in Specification A47/A47M.

5.4 *Zinc*—The zinc-aluminum alloy used in the hot-dip coating bath shall conform to Specification B750. If a zinc-

aluminum alloy is used as the primary feed to the molten bath, then the base material used to make that alloy shall conform to Specification B750.

5.5 *Coating Bath Analysis*—The molten metal in the working volume of the galvanizing bath shall contain not less than an average value of 93 % zinc by weight.

5.5.1 Bath Metal used in bath hot-dip Zn-5Al-MM alloy coating shall meet the chemical composition limits specified in Specification B750.

5.5.2 The determination of chemical composition shall be in accordance with suitable chemical, ICP spectrometric, or other methods.

6. Coating Properties

6.1 *Coating Thickness*—The minimum average thickness of coating for all specimens tested shall be a minimum of 0.39 mil [10 µm]. The minimum average thickness of coating for any individual specimen shall be 0.3 mil [8 µm].

6.2 *Finish*—The coating shall be continuous (except as provided below), and as reasonably smooth and uniform in thickness as the weight, size, shape of the item, and necessary handling of the item during the dipping and draining operations at the hot-dip coating kettle will permit. Except for local excess coating thickness which would interfere with the use of the product, or make it dangerous to handle (edge tears or spikes), rejection for nonuniform coating shall be made only for plainly visible excess coating not related to design factors such as holes, joints, or special drainage problems (see **Note 6**). Since surface smoothness is a relative term, minor roughness that does not interfere with the intended use of the product, or roughness that is related to the as-received (ungalvanized) surface condition, steel chemistry, or steel reactivity to zinc shall not be grounds for rejection (see **Note 7**). Surface conditions related to deficiencies related to design, detailing, or fabrication as addressed by Practice **A385** shall not be grounds for rejection. Surfaces that remain uncoated after galvanizing shall be renovated in accordance with the methods in Practice **A780** unless directed by the purchaser to leave the uncoated areas untreated for subsequent renovation by the purchaser.

6.2.1 Each area subject to renovation shall be 1 in. [25 mm] or less in its narrowest dimension.

6.2.2 The total area subject to renovation on each article shall be no more than ½ of 1 % of the accessible surface area to be coated on that article, or 36 in.² per short ton [256 cm² per metric ton] of piece weight, whichever is less.

NOTE 1—Inaccessible surface areas are those which cannot be reached for appropriate surface preparation and application of repair materials as described in Practice **A780**. Such inaccessible areas, for example, would be the internal surfaces of certain tanks, poles, pipes, tubes, and so forth.

6.2.3 The thickness of renovation shall be a minimum of 0.3 mil [8 µm], except that for renovation using zinc rich paints, the thickness of renovation shall be at least 1 mil [25 µm].

6.2.4 When areas requiring renovation exceed the criteria previously provided, or are inaccessible for repair, the coating shall be rejected.

NOTE 2—The requirements for the finish of a zinc aluminum coated product address themselves to a visual type of inspection. They do not address the matter of measured coating thickness variations that can be encountered because of different steels or different thicknesses of a given steel being used in an assembly.

NOTE 3—Items which are prepared for hot-dip coating by abrasive cleaning will generally develop a thicker coating with a moderately rougher surface.

6.3 *Threaded Components in Assemblies*—The zinc coating on external threads shall not be subjected to a cutting, rolling, or finishing tool operation, unless specifically authorized by the

purchaser. Internal threads are not prohibited from being tapped or re-tapped after hot-dip coating.

6.4 *Appearance*—Upon shipment from the galvanizing facility, galvanized articles shall be free from uncoated areas, blisters, flux deposits, and gross cross inclusions. Lumps, projections, globules, or heavy deposits of zinc which will interfere with the intended use of the material will not be permitted. Plain holes of ½-in. [12.5-mm] diameter or more shall be clean and reasonably free from excess zinc-aluminum metal. Marks in the coating caused by tongs or other items used in handling the article during the hot-dip coating operation shall not be cause for rejection unless such marks have exposed the base metal and the bare metal areas exceed allowable maximums from **6.2.1** and **6.2.2**. The pieces shall be handled so that after hot-dip coating they will not freeze together on cooling.

NOTE 4—Depending upon product design or material thickness, or both, filming or excess zinc-aluminum buildup in plain holes of less than ½-in. [12.5-mm] diameter may occur that requires additional work to make the holes usable as intended.

6.5 *Adherence*—The zinc coating shall withstand handling consistent with the nature and thickness of the coating and the normal use of the article, without peeling or flaking.

7. Sampling

7.1 Sampling of each lot shall be performed for conformance with the requirements of this specification.

7.2 A lot is a unit of production or shipment from which a sample is taken for testing. Unless otherwise agreed upon between the hot-dip coater and the purchaser, or established within this specification, the lot shall be as follows: For testing at a galvanizer's facility, a lot is one or more articles of the same type and size comprising a single order or a single delivery load, whichever is the smaller, or any number of articles identified as a lot by the hot-dip coater, when these have been coated within a single production shift and in the same bath. For test by the purchaser after delivery, the lot consists of the single order or the single delivery load, whichever is the smaller, unless the lot identity, established in accordance with the above, is maintained and clearly indicated in the shipment by the hot-dip coater.

7.3 The method of selection and number of test specimens shall be agreed upon between the hot-dip coater and the purchaser. Otherwise, the test specimens shall be selected at random from each lot. In this case, the minimum number of specimens from each lot shall be as follows:

| Number of Pieces in Lot | Number of Specimens |
|-------------------------|---------------------|
| 3 or less | all |
| 4 to 500 | 3 |
| 501 to 1200 | 5 |
| 1201 to 3200 | 8 |
| 3201 to 10 000 | 13 |
| 10 001 and over | 20 |

NOTE 5—Where a number of identical items are to be galvanized, a statistical sampling plan may be desired. Such a plan is contained in Test Method **B602** which addresses sampling procedures for the inspection of electrodeposited metallic coatings and related finishes. If Test Method **B602** is used, the level of sampling shall be agreed upon between the hot-dip coater and the purchaser at the time the coating order is placed.

7.4 A test specimen which fails to conform to a requirement of this specification shall not be used to determine the conformance to other requirements.

8. Tests

8.1 *Test Requirements*—The following tests shall be conducted to ensure that the zinc coating is being furnished in accordance with this specification. The specifying of tests for adhesion and embrittlement shall be subject to mutual agreement between the galvanizer and purchaser. Visual inspection of the coating shall be made for compliance with the requirements.

8.2 *Thickness of Coating Test*—The thickness of coating is determined by one or more of the four methods described as follows.

8.2.1 *Magnetic Thickness Measurements*—The thickness of the coating shall be determined by magnetic thickness gauge measurements in accordance with Practice E376 unless the methods described in 8.2.2, 8.2.3, or 8.2.4 are used. For each specimen (as described in 3.2.9) five or more measurements shall be made at points widely dispersed throughout the volume occupied by the specimen so as to represent as much as practical, the entire surface area of the test specimen. The average of the five or more measurements thus made for each specimen is the specimen coating thickness.

8.2.1.1 In the case of threaded components, the thickness of coating shall be made on a portion of the article that does not include any threads.

8.2.1.2 The use of magnetic measurement methods is appropriate for larger articles, and is appropriate for smaller articles when there is sufficient flat surface area for the probe tip to sit flat on the surface using Practice E376.

8.2.2 *Stripping Method*—The average weight of coating shall be determined by stripping a test article, a specimen removed from a test article, or group of test articles in the case of very small items such as nails, etc., in accordance with Test Method A90/A90M unless the methods described in 8.2.1, 8.2.2, or 8.2.4 are used. The weight of coating per unit area thus determined is converted to equivalent coating thickness values using the following see Table 1. The thickness of coating thus obtained is the test article coating thickness, or in the case of a specimen removed from a test article, is the specimen average coating thickness.

8.2.2.1 The stripping method is a destructive test and is appropriate for single specimen articles, but is not practical for multi-specimen articles.

8.2.3 *Weighing Before and After Hot-dip Coating*—The average weight of coating shall be determined by weighing articles before and after galvanizing, subtracting the first weight from the second and dividing the result by the surface area unless the methods described in 8.2.1 or 8.2.2 are used. The first weight shall be determined after pickling and drying and the second after cooling to ambient temperature. The weight of coating per unit area thus determined is converted to equivalent coating thickness values in accordance with 8.2.2. The thickness of coating thus obtained is the test article coating thickness.

8.2.3.1 The weighing before and after method is appropriate for single-specimen articles, but is not practical for multi-specimen articles.

NOTE 6—Both the stripping method and the weighing before and after method do not take into account the weight of iron reacted from the article that is incorporated into the coating. Thus, the methods may underestimate coating weight (and therefore the calculated thickness) by up to 10 %. The accuracy of both methods will be influenced by the accuracy to which the surface area of the articles tested can be determined.

NOTE 7—Items which are prepared for galvanizing by abrasive cleaning will generally develop a thicker coating with a moderately rougher surface.

8.2.4 *Microscopy*—The thickness of coating shall be determined by cross-sectional and optical measurement in accordance with Test Method B487 unless the methods described in 8.2.1 or 8.2.2 are used. The thickness thus determined is a point value. No less than five such measurements shall be made at locations on the test article which are as widely dispersed as practical, so as to be representative of the whole surface of the test article. The average of no less than five such measurements is the specimen coating thickness.

8.2.4.1 The microscopy method is a destructive test and is appropriate for single-specimen articles, but is not practical for multi-specimen articles.

8.2.4.2 For multi-specimen articles, a new sample shall be taken randomly from the lot of material, which has twice the number of test articles as the sample which failed to conform to this specification. If the lot size is such that the sample size cannot be doubled, then the sample size shall be as previous, but the number of widely dispersed sites at which measurements were made shall be doubled, and these sites will constitute the new sample. This new sample shall be measured using magnetic thickness gauges which have been calibrated for accuracy against reference material thickness standards. If the lot is found to be nonconforming by the new sample, the hot-dip coater has the right to sort the lot for conforming articles by individual test, to re-coat non-conforming articles, or to renovate the nonconforming articles in accordance with 6.2.

8.2.4.3 For single-specimen articles, a new sample shall be taken randomly from the lot of material, which has twice the number of test articles as the sample which failed to conform to this specification. The test method for the new sample shall be selected by mutual agreement between the purchaser and hot-dip coater. If the lot is found to be nonconforming by the new sample, the galvanizer has the right to sort the lot for conforming articles by individual test, to re-galvanize non-conforming articles, or to renovate the nonconforming articles in accordance with 6.2.

8.3 *Adhesion*—Determine adhesion of the zinc coating to the surface of the base metal by cutting or prying with the point of a stout knife, applied with considerable pressure in a manner tending to remove a portion of the coating. The adhesion shall be considered inadequate if the coating flakes off in the form of a layer of the coating so as to expose the base metal in advance of the knife point. Do not use testing carried out at edges or corners (points of lowest coating adhesion) to determine

adhesion of the coating. Likewise, do not use removal of small particles of the coating by paring or whittling to determine failure.

8.4 *Embrittlement*—Test for embrittlement shall be made in accordance with Practice **A143/A143M**. These tests shall not be required unless strong evidence of embrittlement is present.

9. Inspection, Rejection, and Retest

9.1 *Inspection by the Hot-dip Coater*—It is the responsibility of the hot-dip coater to ensure compliance with this specification. This shall be achieved by an in-plant inspection program designed to maintain the coating thickness, finish, and appearance within the requirements of this specification unless the inspection is performed in accordance with **9.2**.

9.2 *Inspection By the Purchaser*—The purchaser shall accept or reject material by inspection either through the galvanizer's inspector, the purchaser's inspector, or an independent inspector. The inspector representing the purchaser shall have access at all times to those areas of the hot-dip coater's facility which concern the application of the zinc-aluminum coating to the material ordered while work on the contract of the purchaser is being performed. The galvanizer shall afford the inspector all reasonable facilities to satisfy him that the zinc-aluminum coating is being furnished in accordance with this specification.

9.3 *Location*—The material shall be inspected at the hot-dip coater's plant prior to shipment. However, by agreement the purchaser is not prohibited from making tests which govern the acceptance or rejection of the materials in his own laboratory or elsewhere.

9.4 *Reinspection*—When inspection of materials to determine conformity with the visual requirements of **6.2** warrants rejection of a lot, the hot-dip coater is not prohibited from sorting the lot and submit it once again for acceptance after he has removed any nonconforming articles and replaced them with conforming articles.

9.5 The sampling plan that was used when the lot was first inspected shall be used for resampling of a sorted lot. By mutual agreement, the hot-dip coater is not prohibited from submitting the lot remaining after sorting and removing nonconforming articles without replacement of the nonconforming articles. In such case, the now-smaller lot shall be treated as a new lot for purposes of inspection and acceptance.

9.6 Materials that have been rejected for reasons other than embrittlement are not prohibited from being stripped and recoating and again submitted for inspection and test at which time they shall conform to the requirements of this specification.

10. Certification

10.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed by this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

11. Keywords

11.1 coatings—zinc 5 % aluminum; galvanized coatings; steel products—metallic coated; zinc 5 % aluminum coatings—steel products

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