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Standard Specification for High-Strength Zinc–5 % Aluminum-Mischmetal Alloy-Coated Steel Core Wire for Aluminum and Aluminum-Alloy Conductors, Steel Reinforced¹

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¹ This specification is under the jurisdiction of ASTM Committee B-01 on Electrical Conductors and is the direct responsibility of Subcommittee B01.05 on Conductors of Ferrous Metals.

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1. Scope

1.1 This specification covers round, high strength, zinc–5 % aluminum-mischmetal (Zn–5Al–MM) alloy-coated, steel core wire with Class A Zn–5Al–MM alloy coating used for mechanical reinforcement in the manufacture of special aluminum and aluminum-alloy conductors, steel reinforced.

1.2 This specification covers wire of diameter from 0.0500 to 0.1900 in. inclusive.

1.3 ~~The SI values for resistivity are regarded as standard. For all other properties the stated in inch-pound units or SI units are to be regarded separately as standard. The values in each system are not exact equivalents; therefore, each system shall be used independently of the SI units other. Combining values from the two systems may be approximate, result in nonconformance with this specification.~~

2. Referenced Documents

2.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein.

2.2 ASTM Standards:

A 90/A90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings²

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products³

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products³

B 193 Test Method for Resistivity of Electrical Conductor Materials⁴

B 750 Specification for Zinc–5 % Aluminum-Mischmetal Alloy (~~UNS Z38510~~) in Ingot Form for Hot-Dip Coatings⁵

E 47 Test Methods for Chemical Analysis of Zinc Die-Casting Alloys⁶

~~E 1277 Test Method 1277 Practice~~ for Chemical Analysis of Zinc-5 Aluminum-Mischmetal Alloys by ICP Emission Spectrometry⁶

2.3 Other Standard:

GF-1 Standard Practice for Determination of Cerium and Lanthanum Compositions in Galfan Alloy (5 % Al-0.04 % La-0.04 % Ce-Bal SHG Zn)⁷

3. Terminology

3.1 Abbreviations: Abbreviations:

3.1.1 MM—mischmetal

3.1.2 Zn–5Al–MM—zinc–5 % aluminum mischmetal

3.2 Definitions:

² Annual Book of ASTM Standards, Vol 01.06.

³ Annual Book of ASTM Standards, Vol 01.03.

⁴ Annual Book of ASTM Standards, Vol 02.03.

⁵ Annual Book of ASTM Standards, Vol 02.04.

⁶ Annual Book of ASTM Standards, Vol 03.05.

~~Annual Book of ASTM Standards, Vol 03.06.~~

⁷ Available from International Lead Zinc Research Organization, 2525 Meridian Parkway, P.O. Box 12036, Research Triangle Park, NC 27709-2036

3.2.1 *lot*—unless otherwise specified in the contract or order, a lot shall consist of all coils of wire of the same diameter and unit lengths submitted for inspection at the same time.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information:

- 4.1.1 Quantity of each size,
- 4.1.2 Wire diameter in inches (Section ~~7~~, 13),
- 4.1.3 Certification, if required (Section 18),
- 4.1.4 Test report, if required (Section 18), and
- 4.1.5 Package Size (Section 19).

5. Materials and Manufacture

- 5.1 The base metal shall be steel produced by the open-hearth, electric furnace, or basic oxygen process.
- 5.2 The wire shall be cold drawn and coated with Zn-5A1-MM alloy to produce the desired properties.

6. Chemical Composition

6.1 The steel shall conform to the requirements prescribed in Table 1.

6.2 Chemical analysis of the steel shall be conducted in accordance with Test Methods, Practices, and Terminology A 751.

6.3 The ingot form of zinc-5 % aluminum-mischmetal alloy shall conform to Specification B 750.

6.3.1 For a two-step coating operation where the first coating is zinc (hot-dip galvanized or electrogalvanized), the final bath may have an aluminum content of up to 7.2 %, to prevent depletion of the aluminum content of the bath.

6.3.2 *Method of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E 47 for Tin), ICP Argon Plasma Spectrometric (~~Test Method (Practice E 1277)~~), or other methods. In case of dispute, the results secured by ~~Test Method Practice E 1277~~ shall be the basis of acceptance.

6.3.3 A standard practice of X-ray fluorescence spectrometry for determination of cerium and lanthanum in a Zn-5A1-MM alloy has been established by the International Lead Zinc Research Organization (Standard Practice GF-1). In case of dispute, the results secured by ~~Test Method Practice E 1277~~ shall be the basis of acceptance.

7. Dimensions and Permissible Variations

~~7.1 The specified diameter of the Zn-5A1-MM alloy-coated wire shall be expressed in decimal fractions of an inch to four decimal places, or in millimetres to three decimal places.~~

~~7.2 For diameter measurements and diameter tolerance, specified diameters shall be rounded to the closest 0.0005 in. (0.013 mm).~~

~~7.3 The average of the largest and smallest diameter readings, each to the nearest 0.001 in. (0.025 mm) taken at the same cross section, shall not differ from the specified diameter by more than the tolerances shown in Table 2.~~

8. Workmanship, Finish, and Appearance

~~8.1 The Zn-5A1-MM alloy coating shall be reasonably smooth, continuous, of reasonably uniform thickness and free of imperfections not consistent with good commercial practice.~~

9. Tensile Test

~~97.1 The Zn-5A1-MM-coated steel core wire shall conform to the tensile and elongation requirements prescribed in Table ~~3~~ 2.~~

~~97.2 Tensile tests shall be conducted in accordance with Test Methods and Definitions A 370, using the initial settings for determining stress at 1 % extension given in Table ~~4~~ 3 of this specification.~~

~~97.3 Test Specimens~~—The test specimens shall be free of bends or kinks other than the curvature resulting from the usual coiling operations. Any hand straightening necessary to permit insertion of the specimen in the jaws of the testing machine shall be performed by drawing between wood blocks or by some other equally satisfactory means.

~~10.~~

8. Wrap Test

~~108.1~~ The material, as represented by the test specimens, shall not fracture when the Zn-5A1-MM alloy-coated wire is wrapped

TABLE 1 Chemical Requirements

Element	Composition, %
Carbon	0.50 to 0.88
Manganese	0.50 to 1.30
Phosphorus, max	0.035
Sulfur, max	0.045
Silicon	0.10 to 0.35

TABLE 2 6 Permissible Variations in Diameter of Zn-5A1-MM Alloy-Coated Steel Wire

NOTE 1— It is recognized that the surface of coatings, particularly those produced by the hot-dip method of coating, are not perfectly smooth and devoid of irregularities. If the tolerances shown in the table are rigidly applied to such irregularities that are inherent to the product, unjustified rejections of wire that would actually be satisfactory for use could occur. It is intended that these tolerances be used in gaging the wires where there is a minimum of such diameter irregularities due to hot dip coating.

Specified Diameter		Permissible Variation			
in.	mm	in.		mm	
		Plus	Minus	Plus	Minus
0.0500 to 0.0749, incl	1.270 to 1.902, incl	0.0015	0.001	0.038	0.025
0.0750 to 0.1199, incl	1.905 to 3.045, incl	0.002	0.002	0.051	0.051
0.1200 to 0.1399, incl	3.048 to 3.553, incl	0.003	0.002	0.076	0.051
0.1400 to 0.1900, incl	3.556 to 4.823, incl	0.004	0.003	0.102	0.076

TABLE 3 2 Tensile Requirements

Specified Diameter		Stress at 1 % Extension, min		Ultimate Tensile Strength, min		Elongation in 10 in. or 250 mm, min %
in.	mm	ksi	MPa	ksi	MPa	
0.0500 to 0.0899, incl	1.270 to 2.283, incl	210	1450	235	1620	3.0
0.0900 to 0.1199, incl	2.286 to 3.045, incl	205	1410	230	1590	3.0
0.1200 to 0.1399, incl	3.048 to 3.553, incl	200	1380	225	1550	3.5
0.1400 to 0.1900, incl	3.556 to 4.823, incl	195	1340	220	1520	3.5

TABLE 4 3 Initial Settings for Determining Stress at 1 % Extension

Specified Diameter		Initial Stress		Initial Setting of Extensometer, in./in. or mm/mm
in.	mm	ksi	MPa	
0.0500 to 0.0899, incl	1.270 to 2.283, incl	14	97	0.0005 (0.05 % Extension)
0.0900 to 0.1199, incl	2.286 to 3.045, incl	28	193	0.0010 (0.10 % Extension)
0.1200 to 0.1900, incl	3.048 to 4.823, incl	42	290	0.0015 (0.15 % Extension)

at a rate not exceeding 15 turns/min in a close helix of at least eight turns around a cylindrical mandrel with a diameter equal to three times the specified diameter of the wire under test, $\pm 5\%$.

11.

9. Coating Test

119.1 The Zn-5A1-MM alloy-coated wire shall conform to the coating requirements prescribed in Table-5 4.

119.2 The coating test shall be conducted in accordance with Test Method A 90/A 90M.

120. Adherence of Coating Test

120.1 The Zn-5A1-MM alloy-coated wire shall be capable of being wrapped in a close helix at a rate not exceeding 15 turns/min around a cylindrical mandrel having a diameter as prescribed in Table-6 5, without cracking or flaking the coating to such an extent that any Zn-5A1-MM alloy can be removed by rubbing with the bare fingers.

NOTE 1—Loosening or detachment during the adhesion test of superficial, small particles of Zn-5A1-MM alloy formed by mechanical polishing of the surface of the coated wire shall not be considered cause for rejection.

131. Joints

131.1 No joints shall be made in the finished wire.

TABLE 5 4 Zn-5A1-MM Alloy Coating

Specified Diameter of Coated Wire		Area Density of Zn-5A1-MM Alloy Coating min of Uncoated Wire Surface	
in.	mm	oz/ft ²	g/m ²
0.0500 to 0.0599, incl	1.270 to 1.521, incl	0.60	183
0.0600 to 0.0749, incl	1.524 to 1.902, incl	0.65	198
0.0750 to 0.0899, incl	1.905 to 2.283, incl	0.70	214
0.0900 to 0.1039, incl	2.286 to 2.639, incl	0.75	229
0.1040 to 0.1199, incl	2.642 to 3.045, incl	0.80	244
0.1200 to 0.1399, incl	3.048 to 3.553, incl	0.85	259
0.1400 to 0.1799, incl	3.556 to 4.569, incl	0.90	274
0.1800 to 0.1900, incl	4.572 to 4.823, incl	1.00	305

TABLE 6 5 Mandrel Size for Adherence Test

Specified Wire Diameter		Ratio of Mandrel Diameter to Wire Diameter
in.	mm	
0.0500 to 0.0899, incl	1.270 to 2.283, incl	3
0.0900 to 0.1399, incl	2.286 to 3.553, incl	4
0.1400 to 0.1900, incl	3.556 to 4.823, incl	5

131.2 Joints may be made at any stage of processing prior to final cold drawing by the electric butt-weld or flash or flash-welding process.

131.3 Welding equipment and procedure shall be such that it can be demonstrated that the ultimate tensile strength of a finished wire specimen containing the welded section shall be not less than 96 % of the specified minimum stress at 1 % extension.

131.4 A welded section shall not be required to meet the stress at 1 % extension, elongation, and wrap tests.

142. Density and Resistivity

142.1 For the purpose of calculating mass per unit length, cross sections, and so forth, the density of Zn-5A1-MM alloy-coated steel wire at 20°C shall be taken as 0.281 lb/in.³ (7780 kg/m³).

142.2 A maximum resistivity of Zn-5A1-MM alloy-coated steel wire is not guaranteed but a typical value of 0.19157 Ωmm²/m may be used for purpose of calculation. For conversion to other units of conductivity or resistivity, refer to Test Method B 193.

13. Dimensions and Permissible Variations

13.1 The specified diameter of the Zn-5A1-MM alloy-coated wire shall be expressed in decimal fractions of an inch to four decimal places, or in millimetres to three decimal places.

13.2 For diameter measurements and diameter tolerance, specified diameters shall be rounded to the closest 0.0005 in. (0.01 mm).

13.3 The average of the largest and smallest diameter readings, each to the nearest 0.001 in. (0.025 mm) taken at the same cross section, shall not differ from the specified diameter by more than the tolerances shown in Table 6.

14. Workmanship, Finish, and Appearance

14.1 The Zn-5A1-MM alloy coating shall be reasonably smooth, continuous, of reasonably uniform thickness and free of imperfections not consistent with good commercial practice.

15. Number of Tests and Retests

15.1 One test specimen shall be taken from each 5000 lb (23500 kg) or fraction thereof in the inspection lot.

15.2 Each specimen shall be tested for compliance with Sections ~~9, 7, 8, 10, 12, and 7~~ 13. At least half of the specimens shall be tested for compliance with Section ~~11, 9~~.

15.3 Should one or more of the test specimens fail any of the tests specified, the nonconforming coil or coils may be removed and the balance of the lot subjected to retests. For retest purposes, two additional coils for each 5000 lbs (2500 kg) in the lot shall be sampled and tested for the property in which the original sample failed to comply.

15.4 Should any of the retest specimens fail to meet the properties specified, the lot represented by the test specimens shall be rejected.

15.5 Instead of rejecting the entire lot as provided in 15.4, the producer may test specimens from every coil in the lot for the property in which failure occurred, and reject only the nonconforming coils.

16. Inspection

16.1 Unless otherwise specified in the contract or purchase order, the manufacturer shall be responsible for the performance of all inspection and test requirement specified.

16.2 All inspections and tests shall be made at the place of manufacture unless otherwise especially agreed to by the manufacturer and the purchaser at the time of the purchase.

16.3 The manufacturer shall afford the inspector representing the purchaser all reasonable manufacturer's facilities to satisfy him that the material is being furnished in accordance with this specification.

17. Rejection and Rehearing

17.1 Material that fails to conform to the requirements of this specification shall be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

18. Certification

18.1 When specified in the purchase order or contract, a producer's or supplier's certification shall be furnished to the purchaser

showing that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

19. Packaging and Package Marking

19.1 The unit lengths shall be as specified in the contract or order. Length tolerances shall be $\pm 2\%$ unless otherwise specified by the purchaser.

19.2 Package dimensions, kind of package (coils, reels, or reelless coils), and quantity of wire in each package shall be agreed upon by the manufacturer and the purchaser.

19.3 A durable tag shall be securely attached to each package showing the nominal diameter of wire, length, approximate weight, purchaser's order number, and manufacturer's name.

19.4 The starting end shall be identified.

19.5 In case there is more than one piece in a package, the length and position of each piece shall be shown on the tag.

20. Keywords

20.1 coated steel wire; high strength steel wire; steel core wire; steel wire; zinc-5 % aluminum-mischmetal alloy-coated steel wire

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