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Standard Specification for Zinc–5 % Aluminum-Mischmetal Alloy-Coated Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR)¹

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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, zinc–5 % aluminum-mischmetal (Zn–5Al–MM) alloy-coated, steel core wire with three classes of Zn–5Al–MM coating used for mechanical reinforcement in the manufacture of aluminum conductors, steel reinforced (ACSR).

1.2 This specification covers wire of diameter from 0.0500 to 0.1900 in. or 1.60 to 4.80 mm, inclusive.

1.3 The values 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 other. Combining values from the two systems may 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/A 90M 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 Alloy 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 Definition:

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.

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.

4. Classification

4.1 The wire is furnished in three classes of coating, Class A, Class B, or Class C, as specified, in conformance with the requirements of Section ~~12~~ 10 and Table 1 or Table 2.

5. Ordering Information

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

- 5.1.1 Quantity of each size,
- 5.1.2 Wire diameter in inches or millimetres (Section ~~8~~ 14),
- 5.1.3 Class of coating (see 4.1),
- 5.1.4 Certification, if required (Section 19),
- 5.1.5 Test report, if required (Section 19), and
- 5.1.6 Package Size (Section 20).

6. Materials and Manufacture

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

7. Chemical Composition

- 7.1 The steel shall conform to the requirements prescribed in Table 3.
- 7.2 Chemical analysis of the steel shall be conducted in accordance with Test Methods, Practices and Terminology A 751.
- 7.3 The ingot form of zinc-5% aluminum-mischmetal alloy shall conform to Specification B 750.
 - 7.3.1 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.
 - 7.3.2 *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.
 - 7.3.3 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.

8. Dimensions, Mass, and Permissible Variations

- ~~8.1 The specified diameter shall be expressed in decimal fractions of an inch to four decimal places or in millimetres and decimal fractions of a millimetre to two decimal places.~~
- ~~8.2 For diameter measurements and diameter tolerances, specified diameters shall be rounded to the closest 0.0005 in. or 0.01 mm.~~
- ~~8.3 Determine the greatest and least diameter each to the nearest 0.001 in. or 0.01 mm, at the same cross section. The average of these two diameters shall not differ from the specified diameter by more than the tolerances shown in Table 4 or Table 5.~~

9. Workmanship, Finish, and Appearance

~~9.1 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.~~

10. Tensile Test

- ~~10.1 The Zn-5A1-MM-coated steel core wire shall conform to the tensile and elongation requirements prescribed in Table 6 or Table 7.~~
- ~~10.2 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 8 or Table 9 of this specification.~~

TABLE 1 Zn-5A1-MM Alloy Coating

Specified Diameter of Coated Wire, in.	Area Density of Coating, min, oz/ft ² of Uncoated Wire Surface		
	Class A	Class B	Class C
0.0500 to 0.0599, incl	0.60	1.20	1.80
0.0600 to 0.0749, incl	0.65	1.30	1.95
0.0750 to 0.0899, incl	0.70	1.40	2.10
0.0900 to 0.1039, incl	0.75	1.50	2.25
0.1040 to 0.1199, incl	0.80	1.60	2.40
0.1200 to 0.1399, incl	0.85	1.70	2.55
0.1400 to 0.1799, incl	0.90	1.80	2.70
0.1800 to 0.1900, incl	1.00	2.00	3.00

**TABLE 2 Zn-5A1-MM Alloy Coating**

Specified Diameter of Coated Wire, mm	Area Density of Coating, min, g/m ² of Uncoated Wire Surface		
	Class A	Class B	Class C
1.60 to 1.90, incl	210	420	630
Over 1.90 to 2.30, incl	220	440	660
Over 2.30 to 2.70, incl	230	460	690
Over 2.70 to 3.10, incl	240	480	720
Over 3.10 to 3.50, incl	260	520	780
Over 3.50 to 3.90, incl	270	540	810
Over 3.90 to 4.50, incl	275	550	825
Over 4.50 to 4.80, incl	300	600	900

TABLE 3 Chemical Requirements

Element	Composition, %
Carbon	0.50 to 0.85
Manganese	0.50 to 1.10
Phosphorus, max	0.035
Sulfur, max	0.045
Silicon	0.10 to 0.35

TABLE 4 10 Permissible Variations in Diameter of Zn-5A1-MM Alloy-Coated Steel Wire

NOTE 1—It is recognized that the surface of Zn-5A1-MM alloy coatings, particularly those produced by hot-dip 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. Therefore, it is intended that these tolerances be used in gaging the uniform areas of the coated wire.

Specified Diameter, in.	Permissible Variation, in.	
	Plus	Minus
0.0500 to 0.0749, incl	0.0015	0.001
0.0750 to 0.1199, incl	0.002	0.002
0.1200 to 0.1399, incl	0.003	0.002
0.1400 to 0.1900, incl	0.004	0.003

TABLE 5 11 Permissible Variations in Diameter of Zn-5A1-MM Alloy-Coated Steel Wire

NOTE 1—It is recognized that the surface of Zn-5A1-MM alloy coatings, particularly those produced by hot-dip 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. Therefore, it is intended that these tolerances be used in gaging the uniform areas of the coated wire.

Specified Diameter, mm	Permissible Variation, mm	
	Plus	Minus
1.60 to 2.30, incl	0.04	0.03
Over 2.30 to 3.05, incl	0.05	0.05
Over 3.05 to 3.60, incl	0.08	0.05
Over 3.60 to 4.80, incl	0.10	0.08

10.3-

8.3 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.

TABLE 6 4 Tensile Requirements

Specified Diameter, in.	Stress at 1 % Extension, min, Ksi			Ultimate Tensile Strength, min, Ksi			Elongation in 10 in., min, %		
	Class A	Class B	Class C	Class A	Class B	Class C	Class A	Class B	Class C
0.0500 to 0.0899, incl	190	180	170	210	200	190	3.0	3.0	3.0
0.0900 to 0.1199, incl	185	175	165	205	195	185	3.5	3.0	3.0
0.1200 to 0.1399, incl	180	170	160	205	195	185	4.0	3.0	3.0
0.1400 to 0.1900, incl	170	160	155	200	185	180	4.0	4.0	4.0

TABLE 7 5 Tensile Requirements

Specified Diameter, in.	Stress at 1 % Extension, min, MPa			Ultimate Tensile Strength, min, MPa			Elongation in 250 mm, min, %		
	Class A	Class B	Class C	Class A	Class B	Class C	Class A	Class B	Class C
1.60 to 2.30, incl	1310	1240	1170	1450	1380	1310	3.0	3.0	3.0
Over 2.30 to 3.05, incl	1280	1210	1140	1410	1340	1280	3.5	3.0	3.0
Over 3.05 to 3.60, incl	1240	1170	1100	1410	1340	1280	4.0	3.0	3.0
Over 3.60 to 4.80, incl	1170	1100	1070	1380	1280	1240	4.0	4.0	4.0

TABLE 8 6 Initial Settings for Determining Stress at 1 % Extension

Specified Diameter, in.	Initial Stress, Ksi	Initial Setting of Extensometer, in./in.
0.0500 to 0.0899, incl	14	0.0005 (0.05 % extension)
0.0900 to 0.1199, incl	28	0.0010 (0.10 % extension)
0.1200 to 0.1900, incl	42	0.0015 (0.15 % extension)

TABLE 9 7 Initial Settings for Determining Stress at 1 % Extension

Specified Diameter, mm	Initial Stress, MPa	Initial Setting of Extensometer, mm/mm
1.60 to 2.30, incl	100	0.0005 (0.05 % extension)
Over 2.30 to 3.05, incl	190	0.0010 (0.10 % extension)
Over 3.05 to 4.80, incl	290	0.0015 (0.15 % extension)

~~11.~~

9. Wrap Test

9.1 The material, as represented by the test specimens, shall not fracture when the Zn-5A1-MM alloy-coated wire is wrapped 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 two times the specified diameter of the wire under test, $\pm 5\%$.

120. Coating Test

120.1 The material, as represented by the test specimens, shall conform to the coating requirements of Table 1 or Table 2, for the diameter and class of coating specified.

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

131. Adherence of Coating Test

131.1 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 10 8 or Table 11 9, 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.

TABLE 10 8 Mandrel Size for Adherence Test

Specified Wire Diameter, in.	Ratio of Mandrel Diameter to Wire Diameter
0.0500 to 0.0899, incl	3
0.0900 to 0.1399, incl	4
0.1400 to 0.1900, incl	5



TABLE 11 9 Mandrel Size for Adherence Test

Specified Wire Diameter, mm	Ratio of Mandrel Diameter to Wire Diameter
1.60 to 2.30, incl	3
Over 2.30 to 3.05, incl	4
Over 3.05 to 4.80, incl	5

142. Joints

142.1 No joints shall be made in the finished wire.

142.2 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.

142.3 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.

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

153. Density and Resistivity

153.1 For the purpose of calculating mass per unit length, cross sections, etc, 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).

153.2 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.

14. Dimensions, Mass, and Permissible Variations

14.1 The specified diameter shall be expressed in decimal fractions of an inch to four decimal places or in millimetres and decimal fractions of a millimetre to two decimal places.

14.2 For diameter measurements and diameter tolerances, specified diameters shall be rounded to the closest 0.0005 in. or 0.01 mm.

14.3 Determine the greatest and least diameter each to the nearest 0.001 in. or 0.01 mm, at the same cross section. The average of these two diameters shall not differ from the specified diameter by more than the tolerances shown in Table 10 or Table 11.

15. Workmanship, Finish, and Appearance

15.1 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.

16. Number of Tests and Retests

16.1 One test specimen shall be taken from each 5000 lb or 2500 kg or fraction thereof in the inspection lot.

16.2 Each specimen shall be tested for compliance with Sections 8, 9, 11, and 14. At least half of the specimens shall be tested for compliance with Section 10.

16.3 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 lb or 2500 kg in the lot shall be sampled and tested for the property in which the original sample failed to comply.

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

16.5 Instead of rejecting the entire lot as provided in 16.4, the producer may test specimens from every coil in the lot for the property in which failure occurred and reject only the nonconforming coils.

17. Inspection

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

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

17.3 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.

18. Rejection and Rehearing

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

19. Certification

19.1 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.

20. Packaging and Package Marking

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

20.2 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.

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

20.4 The starting end shall be identified.

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

21. Keywords

21.1 coated steel wire; mischmetal alloy-coated steel wire; steel core-wire; steel wire; zinc-5% aluminum

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