



Standard Specification for Extra-High-Strength and Ultra-High-Strength Class A Zinc–5% Aluminum-Mischmetal Alloy-Coated Steel Core Wire for Use in Overhead Electrical Conductors¹

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1. Scope

1.1 This specification covers round, extra-high-strength, and ultra-high-strength, Class A coated zinc–5 % aluminum-mischmetal (Zn–5Al–MM) alloy-coated, steel core wire for use in Overhead Electrical Conductors.

1.2 This specification covers wire of diameter from 0.0500 to 0.1900 in. inclusive or 1.27 to 4.82 mm inclusive.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

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.*

2. Referenced Documents

2.1 ASTM Standards:²

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

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

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

B 193 Test Method for Resistivity of Electrical Conductor Materials

B 750 Specification for GALFAN (Zinc-5 % Aluminum-Mischmetal) Alloy in Ingot Form for Hot-Dip Coatings

¹ This test method is under the jurisdiction of ASTM Committee B01 on Electrical Conductors and is the direct responsibility of Subcommittee B01.05 on Conductors of Ferrous Metals.

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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.

E 1277 Test Method for Chemical Analysis of Zinc-5 % Aluminum-Mischmetal Alloys by ICP Emission Spectrometry

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 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)³

3. Terminology

3.1 Abbreviations:

3.1.1 **MM**—mischmetal

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

3.2 Definitions of Terms Specific to This Standard:

3.3 **Lot, n**—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.

3.4 **Product Code, n**—Defines product coating type, coating class, and strength grade.

•**Extra High Strength Grade Zn–5Al–MM, Class A Coated**, use Code MA4.

•**Ultra High Strength Grade Zn–5Al–MM, Class A Coated**, use Code MA5.

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 or millimeter (Section 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).

4.1.6 Product Code

³ Available from the International Lead Zinc Research Organization (ILZRO), 1822 NC Highway 54 East, Suite 120, Durham NC 27713, <http://www.ilzro.org>.

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–5Al–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 electro-galvanized), 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 Coating Material Analysis*—Refer to Specification [B 750](#).

7. Tensile Test

7.1 The Zn–5Al–MM-coated steel core wire shall conform to the tensile and elongation requirements prescribed in [Table 2](#), [Table 3](#), [Table 4](#), or [Table 5](#) depending on which strength grade and unit base ordered.

7.2 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 6](#) or [Table 7](#) of this specification.

7.3 *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.

7.4 The nominal diameter requested shall be used to determine the applicable strength specification from the tables.

8. Wrap Test

8.1 The material, as represented by the test specimens, shall not fracture when the Zn–5Al–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 four times the specified diameter of the wire under test, ± 5 %.

9. Coating Test

9.1 The Zn–5Al–MM alloy-coated wire shall conform to the coating requirements prescribed in [Table 8](#) or [Table 9](#).

TABLE 1 Chemical Requirements

Element	Composition, %
Carbon	0.50 to 1.00
Manganese	0.40 to 1.30
Phosphorus, max	0.035
Sulfur, max	0.045
Silicon	0.15 to 0.60

TABLE 2 Grade 4 Extra-High-Strength Tensile Requirements

Specified Diameter, in.	Stress at 1% Extension, min, kpsi	Ultimate Tensile Strength, min, kpsi	Elongation in 10 in., min %
0.0500 to 0.0899, incl	225	265	3.0
0.0900 to 0.1199, incl	220	260	3.0
0.1200 to 0.1399, incl	215	255	3.5
0.1400 to 0.1900, incl	210	250	3.5

TABLE 3 Grade 4 Extra-High-Strength Tensile Requirements (Metric)

Specified Diameter, mm	Stress at 1% Extension, min, MPa	Ultimate Tensile Strength, min, MPa	Elongation in 250 mm, min %
1.27 to 2.28, incl	1550	1825	3.0
2.29 to 3.04, incl	1515	1790	3.0
3.05 to 3.55, incl	1480	1760	3.5
3.56 to 4.82, incl	1450	1725	3.5

TABLE 4 Grade 5 Ultra-High-Strength Tensile Requirements

Specified Diameter, in.	Stress at 1% Extension, min, kpsi	Ultimate Tensile Strength, min, kpsi	Elongation in 10 in., min %
0.0500 to 0.0899, incl	230	285	3.0
0.0900 to 0.1199, incl	225	275	3.0
0.1200 to 0.1399, incl	220	270	3.5
0.1400 to 0.1900, incl	215	265	3.5

TABLE 5 Grade 5 Ultra-High-Strength Tensile Requirements (Metric)

Specified Diameter, mm	Stress at 1% Extension, min, MPa	Ultimate Tensile Strength, min, MPa	Elongation in 250 mm, min %
1.27 to 2.28, incl	1580	1965	3.0
2.29 to 3.04, incl	1550	1900	3.0
3.05 to 3.55, incl	1515	1860	3.5
3.56 to 4.82, incl	1480	1825	3.5

TABLE 6 Initial Settings for Determining Stress at 1% Extension

Specified Diameter, in.	Initial Stress, kpsi	Initial Setting of Extensometer, in./in.
0.0500 to 0.0899, incl	18	0.0005 (0.05 % extension)
0.0900 to 0.1199, incl	36	0.0010 (0.10 % extension)
0.1200 to 0.1900, incl	54	0.0015 (0.15 % extension)

9.2 The coating test shall be conducted in accordance with Test Method [A 90/A 90M](#).

10. Adherence of Coating Test

10.1 The Zn–5Al–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](#) or [Table 11](#), without cracking or flaking the coating to such an extent that any Zn–5Al–MM alloy can be removed by rubbing with the bare fingers.

11. Joints

11.1 No joints shall be made in the finished wire.

TABLE 7 Initial Settings for Determining Stress at 1% Extension (Metric)

Specified Diameter, mm	Initial Stress, MPa	Initial Setting of Extensometer, mm/mm
1.27 to 2.28, incl	125	0.0005 (0.05 % extension)
2.29 to 3.04, incl	250	0.0010 (0.10 % extension)
3.05 to 4.82, incl	375	0.0015 (0.15 % extension)

TABLE 8 Zn-5Al-MM Alloy Coating

Specified Diameter of Coated Wire, in.	Area Density of Zn-5Al-MM Alloy Coating min of Uncoated Wire Surface, oz/ft ²
0.0500 to 0.0599, incl	0.60
0.0600 to 0.0749, incl	0.65
0.0750 to 0.0899, incl	0.70
0.0900 to 0.1039, incl	0.75
0.1040 to 0.1199, incl	0.80
0.1200 to 0.1399, incl	0.85
0.1400 to 0.1799, incl	0.90
0.1800 to 0.1900, incl	1.00

TABLE 9 Zn-5Al-MM Alloy Coating (Metric)

Specified Diameter of Coated Wire, mm	Area Density of Zn-5Al-MM Alloy Coating min of Uncoated Wire Surface, g/m ²
1.27 to 1.52, incl	183
1.53 to 1.90, incl	198
1.91 to 2.28, incl	214
2.29 to 2.64, incl	229
2.65 to 3.04, incl	244
3.05 to 3.55, incl	259
3.56 to 4.57, incl	274
4.58 to 4.82, incl	305

TABLE 10 Mandrel Size for Adherence Test

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

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

TABLE 11 Mandrel Size for Adherence Test (Metric)

Specified Wire Diameter, mm	Ratio of Mandrel Diameter to Wire Diameter
1.27 to 3.55, incl	4
3.56 to 4.82, incl	5

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

11.3 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.

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

12. Density and Resistivity

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

12.2 A maximum resistivity of Zn-5Al-MM alloy-coated steel wire is not guaranteed but a typical value of 0.19157 Ωmm²/m may be used for calculating purposes. 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-5Al-MM alloy-coated wire from Section 4 shall be expressed in decimal fractions of an inch to four decimal places, or in millimeters to two decimal places.

13.2 To determine the applicable tolerance range from Table 12 or Table 13, round the specified diameter to the nearest 0.001 in. (0.01 mm) in accordance with the rounding method of Practice E 29.

13.3 Measure the largest and smallest diameter taken at the same cross section rounded to the nearest 0.001 in. (0.01 mm) in accordance with the rounding method of Practice E 29. Calculate the average of the two measurements. The calculated value shall not differ from the specified diameter by more than the applicable tolerance range shown in Table 12 or Table 13.

14. Workmanship, Finish, and Appearance

14.1 The Zn-5Al-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 (2500 kg) or fraction thereof in the inspection lot.

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

TABLE 12 Permissible Variations in Diameter of Zn-5Al-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, 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 13 Permissible Variations in Diameter of Zn-5Al-MM Alloy-Coated Steel Wire (Metric)

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, mm	Permissible Variation, mm	
	Plus	Minus
1.27 to 2.28, incl	0.038	0.025
2.29 to 3.04, incl	0.051	0.051
3.05 to 3.55, incl	0.076	0.051
3.56 to 4.82, incl	0.102	0.076

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 lb (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 Paragraph 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 requirements 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. Package 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. (See Explanatory Note 1.)

19.2 Package dimensions, kind of package (coils, reels, or reel-less 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 wire diameter, 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; extra high strength steel wire (Grade 4); ultra high strength steel wire (Grade 5); MA4; MA5; steel core wire; steel wire; zinc-5% aluminum-mischmetal alloy-coated steel wire

EXPLANATORY NOTES

NOTE 1—Steel wire cannot be produced to exact specified lengths. Since welding of steel wires for use in electrical conductors is not accepted, the random lengths of wire that result from normal production can result in otherwise good product being rejected and scrapped. In order to reduce cost, the purchaser and manufacturer should, at the time of

purchase, have an agreed upon method to permit the acceptance of odd lengths of steel wire. A typical agreement would be to permit lengths other than the specified length for up to 5 % of the purchased quantity with any single piece being not less than 50 % of the specified length.

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