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Standard Specification for Concentric-Lay-Stranded Aluminum-Clad Steel Conductors[1]

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1. Scope

1.1 This specification covers bare concentric-lay-stranded conductors made from bare, hard-drawn, round, aluminum-clad steel wires of 20.3 % conductivity for general use of electrical purposes. This specification does not apply to stranded conductors for reinforcement in ACSR conductors.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

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:*

B 354 Terminology Relating to Uninsulated Metallic Electrical Conductors[2]

B 415 Specification for Hard-Drawn Aluminum-Clad Steel Wire[2]

2.3 *Other Documents:*

C8.1 Definitions and General Standards for Wires and Cables[3]

NBS *Handbook 100—Copper Wire Tables of the National Institute of Standards and Technology*[4]

3. Description of Conductor

3.1 The designation of the finished conductor shall be expressed as the number of wires and the diameter of these individual wires, usually expressed as the AWG size of the wires.

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 Conductor size expressed as number and AWG size of individual wires (Section 3 and Table 1),

4.1.3 Direction of lay of outer layer, if other than left-hand (see 6.3),

4.1.4 Package size (see 15.1),

4.1.5 Special package markings if required (see 15.3),

4.1.6 Special lagging if required (see 15.2), and

4.1.7 Place of inspection if other than place of manufacture (Section 13).

5. Joints

5.1 Joints or splices may be made in the finished individual aluminum-clad steel wires composing concentric-lay stranded conductors using more than three wires, provided that such joints or splices have a protection and electrical conductance equivalent to that of the wire itself and that they do not decrease the strength of the finished stranded conductor below the minimum breaking strength shown in Table 1. Such joints or splices shall be not closer than 50 ft (15 m) to any other joint in the same layer in the conductor.

NOTE 1—Joints are made by electrical butt-welding. The ends must be cut and the end of each wire must be straightened for a distance of 12 to 15 in. (300 to 380 mm). The proper sleeve is slipped over the end of one of the wires. The wires are then butt-welded and dressed off to a finished diameter equal to that of the wire. The weld area is then tempered, the sleeve centered over the weld area and compressed to provide a finished joint that is smooth and neat in appearance. This joint has a tensile strength of approximately 90 % of rated breaking strength of the wire, but an allowance is made for this in the rated strength of the conductor as a whole. The completed conductor when containing such joints is required to have the full rated strength.

6. Lay

6.1 For 3-wire conductors, the preferred lay is 16½ times the outside diameter, but the lay shall not be less than 14 times nor more than 20 times this diameter.

6.2 For 7, 19, and 37-wire conductors, the preferred lay is 13½ times the diameter of that layer, but the lay shall not be less than 10 nor more than 16 times this diameter.

6.3 The direction of lay of the outer layer shall be left-hand unless the direction of lay is specified otherwise by the purchaser.

6.4 The direction of lay shall be reversed in consecutive layers.

6.5 All wires in the conductor shall lie naturally in their true

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[2] *Annual Book of ASTM Standards*, Vol 02.03.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 3460, Gaithersburg, MD 20899-3460.

TABLE 1 Construction Requirements and Breaking Strength of Concentric-Lay Stranded Aluminum-Clad Steel Conductors[A]

Size Designation[B]	Number and Diameter of Individual Wires		Conductor Diameter, in.[C]	Rated Breaking Strength min, lb[D]
	Number	Nominal Diameter, in.		
37 No. 5 AWG	37	0.1819	1.27	142 800
37 No. 6 AWG	37	0.1620	1.13	120 200
37 No. 7 AWG	37	0.1443	1.01	100 700
37 No. 8 AWG	37	0.1285	0.899	84 200
37 No. 9 AWG	37	0.1144	0.801	66 770
37 No. 10 AWG	37	0.1019	0.713	52 950
19 No. 5 AWG	19	0.1819	0.910	73 350
19 No. 6 AWG	19	0.1620	0.810	61 700
19 No. 7 AWG	19	0.1443	0.721	51 730
19 No. 8 AWG	19	0.1285	0.642	43 240
19 No. 9 AWG	19	0.1144	0.572	34 290
19 No. 10 AWG	19	0.1019	0.509	27 190
7 No. 5 AWG	7	0.1819	0.546	27 030
7 No. 6 AWG	7	0.1620	0.486	22 730
7 No. 7 AWG	7	0.1443	0.433	19 060
7 No. 8 AWG	7	0.1285	0.385	15 930
7 No. 9 AWG	7	0.1144	0.343	12 630
7 No. 10 AWG	7	0.1019	0.306	10 020
7 No. 11 AWG	7	0.0907	0.272	7 945
7 No. 12 AWG	7	0.0808	0.242	6 301
3 No. 5 AWG	3	0.1819	0.392	12 230
3 No. 6 AWG	3	0.1620	0.349	10 280
3 No. 7 AWG	3	0.1443	0.311	8 621
3 No. 8 AWG	3	0.1285	0.277	7 206
3 No. 9 AWG	3	0.1144	0.247	5 715
3 No. 10 AWG	3	0.1019	0.220	4 532

[A] For metric equivalents: Diameter (mm)—multiply diameter in inches by 25.4 (round to 4 significant figures).

Breaking Strength (kg)—multiply breaking strength in pounds by 0.45359 (round to 4 significant figures).

[B] The designation is a combination of the number of wires each of the AWG size indicated by" No."

[C] Diameter of circumscribing circle. See Table 3 for complete table of properties.

[D] See Section 7.

positions in the completed conductor. They shall tend to remain in position when the conductor is cut at any point and shall permit restranding by hand after being forcibly unraveled at the end of the conductor.

7. Strength of Conductor

7.1 The breaking strength of the completed conductors composed of 7 wires, 19 wires, and 37 wires shall be taken as 90 % of the sum of the breaking strengths of the aluminum-clad wires, calculated from their nominal diameter and the appropriate specified minimum tensile strength given in Table 1, Tensile Requirements, of Specification B 415 (20 % column only). The breaking strength of completed conductors composed of 3 wires shall be taken as 95 % of the sum of the breaking strengths of the aluminum-clad wires calculated in the same manner.

8. Construction

8.1 The number and diameter of the wires in the concentric-lay stranded conductors shall conform to the requirements prescribed in Table 1.

NOTE 2—For definitions of terms relating to conductors, reference should be made to ANSI C8.1 and Terminology B 354.

9. Physical and Electrical Tests

9.1 Tests for physical and electrical properties of wires composing concentric-lay stranded conductors made from aluminum-clad steel wire shall be made before stranding.

9.2 At the option of the purchaser, tension and elongation tests before stranding may be waived and the complete conductors may be tested as a unit. The breaking strength of the conductors so tested shall be not less than that required in Table 1.

9.3 Where breaking strength tests are required on the finished conductor, they shall be made on representative samples not less than 4 ft (1.25 m) in length. For lots of 10 000 lb (4540 kg) or less, two samples shall be taken from separate reels or coils in the lot except that but one sample shall be required where the total amount of conductor is 5000 ft (1525 m) or less. For quantities over 10 000 lb, one sample for each 10 000 lb or fraction thereof, shall be taken, but the minimum number of samples shall be three.

9.4 Specimens of the completed conductor shall be tested in a tension testing machine equipped with jaws suitable for gripping the conductor or equipped for holding properly socketed specimens. Any test in which the result is below the stated value, and which is obviously caused by improper socketing of the specimen or due to the break occurring in or at the gripping jaws of the machine, shall be disregarded and another sample from the same coil or reel shall be tested.

10. Density

10.1 For the purpose of calculating mass per unit length (see Note 4), cross-sections, etc., the density of the aluminum-clad steel wire shall be taken as 0.2381 lb/in.^{3}(6.590 g/cm^3) at 20°C (Note 3). Other constants are given in Table 2.

NOTE 3—The value of the density of aluminum-clad steel wire is an average value which has been found to be in accordance with usual values encountered in practice.

NOTE 4—The term mass per unit length is used in the specification as being more technically correct. It replaces the terms "weights" and "linear density".

11. Mass and Resistance

11.1 The mass and electrical resistance of a stranded conductor are greater than the total of the same characteristics of the wires composing the conductors, depending upon the lay or pitch. The standard increment of mass and resistance shall be taken as shown in Table 3.

11.2 In cases where the lay is definitely known, the increment may be calculated if desired.

NOTE 5—The increment of mass or electrical resistance of a completed concentric-lay stranded conductor, K, in percent is

$$K = 100\ (m - 1)$$

where m is the stranding factor, and is also the ratio of the mass or electrical resistance of a unit length of stranded conductor to that of a solid conductor of the same cross-sectional area or of a stranded conductor with infinite length of lay; that is, all wires parallel to the conductor axis. The stranding factor m for the completed, stranded conductor is the numerical average of the stranding factors for each of the individual wires in the conductor, including the straight core wire, if any (for which the stranding factor is unity). The stranding factor (m_{ind}) for any given wire in a concentric-lay stranded conductor is

$$m_{ind} = \sqrt{1 + (9.8696/n^2)}$$

TABLE 2 Approximate Properties of Concentric-Lay Stranded Aluminum-Clad Steel Conductors (for information only)[A]

No. and Size of Wires	Conductor Diameter, in.	Rated Breaking Strength, min, lb	Mass per Unit Length		Resistance at 20°C max, Ω/1000 ft	Nominal Cross Section	
			lb/1000 ft	lb/mile		cmils	in.^{2}
37 No. 5 AWG	1.27	142 800	2 802	14 800	0.04247	1 225 000	0.9619
37 No. 6 AWG	1.13	120 200	2 222	11 730	0.05356	971 300	0.7629
37 No. 7 AWG	1.01	100 700	1 762	9 305	0.06754	770 300	0.6050
37 No. 8 AWG	0.899	84 200	1 398	7 379	0.08516	610 900	0.4798
37 No. 9 AWG	0.801	66 770	1 108	5 852	0.1074	484 400	0.3805
37 No. 10 AWG	0.713	52 950	879.0	4 641	0.1354	384 200	0.3017
19 No. 5 AWG	0.910	73 350	1 430	7 552	0.08224	628 900	0.4940
19 No. 6 AWG	0.810	61 700	1 134	5 990	0.1037	498 800	0.3917
19 No. 7 AWG	0.721	51 730	899.5	4 750	0.1308	395 500	0.3107
19 No. 8 AWG	0.642	43 240	713.5	3 767	0.1649	313 700	0.2464
19 No. 9 AWG	0.572	34 290	565.8	2 987	0.2079	248 800	0.1954
19 No. 10 AWG	0.509	27 190	448.7	2 369	0.2622	197 300	0.1549
7 No. 5 AWG	0.546	27 030	524.9	2 772	0.2264	231 700	0.1820
7 No. 6 AWG	0.486	22 730	416.3	2 198	0.2803	183 800	0.1443
7 No. 7 AWG	0.433	19 060	330.0	1 743	0.3535	145 700	0.1145
7 No. 8 AWG	0.385	15 930	261.8	1 382	0.4458	115 600	0.09077
7 No. 9 AWG	0.343	12 630	207.6	1 096	0.5621	91 650	0.07198
7 No. 10 AWG	0.306	10 020	164.7	869.4	0.7088	72 680	0.05708
7 No. 11 AWG	0.272	7 945	130.6	689.4	0.8938	57 590	0.04523
7 No. 12 AWG	0.242	6 301	103.6	546.8	1.127	45 710	0.03590
3 No. 5 AWG	0.392	12 230	224.5	1 186.0	0.5177	99 310	0.07800
3 No. 6 AWG	0.349	10 280	178.1	940.2	0.6528	78 750	0.06185
3 No. 7 AWG	0.311	8 621	141.2	745.6	0.8232	62 450	0.04905
3 No. 8 AWG	0.277	7 206	112.0	591.3	1.038	49 530	0.03890
3 No. 9 AWG	0.247	5 715	88.81	468.9	1.309	39 280	0.03085
3 No. 10 AWG	0.220	4 532	70.43	371.8	1.651	31 150	0.02446
	Coefficient of linear expansion				(0.0000072/°F) (0.0000126/°C)		
	Final modulus of elasticity				23 000 000 psi (160 GPa)		
	Temperature coefficient of resistance				(0.0020/°F) (0.0036/°C)		

[A] For metric equivalents:
Diameter (mm)—multiply diameter in inches by 25.4 (round to 3 significant figures);
Rated Breaking Strength (kg)—multiply rated breaking strength in pounds by 0.45359 (round to 4 significant figures);
Mass/Unit Length in kg/km—multiply mass/unit length in pounds per 1000 feet by 1.48816 (round to 4 significant figures);
Resistance (ohms/km)—multiply resistance in ohms per 1000 feet by 3.281 (round to 4 significant figures);
Nominal Cross Section (mm^2)—multiply cross section in square inches by 645.16 (round to 4 significant figures).

TABLE 3 Standard Increments Due to Stranding

Type of Conductor	Increment (Increase) of Resistance and Mass, %
3-wire	0.8
7-wire	1.0
19-wire	1.4
37-wire	2.0

where n = length of lay/diameter of helical path of the wire

The derivation of the above is given in *NBS Handbook 100.*

12. Requirements for Wires

12.1 Before stranding, the aluminum-clad steel wires shall meet all the requirements of Specification B 415 (20.3 % conductivity only).

13. Inspection

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

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

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

14. Rejection

14.1 If the conductor fails in the first test to meet any requirement of this specification, two additional tests for these requirements shall be made on samples of conductor from the same coil or reel. If failure occurs in either of these tests, the lot of conductor shall be rejected. However, the lot may be resubmitted for inspection by testing every coil or reel for the requirement in which the specimen failed and sorting out the defective coils or reels.

15. Packaging and Package Marking

15.1 Lengths of conductor, reel sizes, or coils shall be agreed upon between the manufacturer and the purchaser at the time of placing individual orders.

15.2 When ordered on reels, the material shall be properly packaged to prevent damage to the conductor in ordinary handling and transportation. If wood lagging is required, it shall be specified at the time of purchase by the purchaser. Each reel shall contain one continuous length.

15.3 A weather-resistant tag shall be attached to the outside of each coil or reel showing the manufacturer's name or trademark with the net mass, length, and size of conductor. If additional information is required on the tags, it shall be arranged with the manufacturer at the time of purchase. Each

coil shall also have a tag inside the wrapping showing the manufacturer's name, the net mass, length and size of conductor.

16. Keywords

16.1 aluminum electrical conductor—aluminum-clad steel; aluminum electrical conductor—stranded; aluminum-clad steel electrical conductors; clad steel electrical conductor; concentric-lay-stranded aluminum-clad steel electrical conductors; electrical conductor