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Standard Specification for Compact Round Concentric-Lay-Stranded Aluminum Conductors, Steel-Reinforced (ACSR/COMP)[1]

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1. Scope

1.1 This specification covers compact round concentric-lay-stranded conductors made from aluminum 1350-H19 (extra hard) wires and round zinc-coated, aluminum-coated, or aluminum-clad steel core wires usually used in overhead lines. These conductors shall be constructed with one steel core wire surrounded by one or more layers of helically-laid compacted or otherwise shaped aluminum wires (Explanatory Note 1 and Note 2).

1.2 Compact ACSR covered by this specification has five types of steel core wire which are designated by abbreviations as follows (Explanatory Note 2).

1.2.1 *ACSR/GA/COMP*—Compact ACSR using Class A zinc-coated steel wire,

1.2.2 *ACSR/GB/COMP*—Compact ACSR using Class B zinc-coated steel wire,

1.2.3 *ACSR/GC/COMP*—Compact ACSR using Class C zinc-coated steel wire,

1.2.4 *ACSR/AZ/COMP*—Compact ACSR using aluminum-coated (aluminized) steel wire, and

1.2.5 *ACSR/AW/COMP*—Compact ACSR using aluminum-clad steel wire.

1.3 The SI values of density and resistivity are to be regarded as standard. For all other properties the inch-pound values are to be regarded as standard and the SI units may be approximate.

NOTE 1—Prior to 1975, aluminum 1350 was designated as EC aluminum.

NOTE 2—The aluminum and temper designations conform to ANSI H35.1. Aluminum 1350 corresponds to Unified Numbering System A91350 in accordance with Practice E 527.

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 230 Specification for Aluminum 1350-H19 Wire for Electrical Purposes[2]

B 232 Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated Steel Reinforced (ACSR)[2]

B 263 Test Method for Determination of Cross-Sectional Area of Stranded Conductors[2]

B 341 Specification for Aluminum-Coated (Aluminized) Steel Core Wire for Aluminum Conductors, Steel-Reinforced (ACSR/AZ)[3]

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

B 498 Specification for Zinc-Coated (Galvanized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR)[2]

B 502 Specification for Aluminum-Clad Steel Core Wire for Aluminum Conductors, Aluminum-Clad Steel Reinforced[2]

B 802 Specification for Zinc-5 % Aluminum-Mischmetal Alloy-Coated Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR)[2]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[3]

E 527 Practice for Numbering Metals and Alloys (UNS)[4]

2.3 *Other Documents*:

ANSI H35.1, American National Standard Alloy and Temper Designation Systems For Aluminum[5]

NBS *Handbook 100—Copper Wire Tables of the National Bureau of Standards* [6]

3. Ordering Information

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

3.1.1 Quantity of each size and stranding (Table 1),

3.1.2 Conductor size: circular-mil area or AWG (Section 6, and Table 1),

3.1.3 Steel wire coating or aluminum-clad (see 11.3),

3.1.4 Special tension test, if required (see 15.3),

3.1.5 Place of inspection (Section 16), and

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[1] This specification is under the jurisdiction of ASTM Committee B-1 on Electrical Conductors, and is the direct responsibility of Subcommittee B01.07 on Conductors of Light Metals.

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

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] *Annual Book of ASTM Standards*, Vol 01.01.

[5] Available from the American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10018.

[6] Available from the National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161.

TABLE 1 Construction Requirements for Compact Round Concentric-Lay-Stranded Aluminum Conductors, Steel Reinforced

Required Construction								Nominal Mass for Conductors With:			
Conductor Size (Aluminum Wires)			Number of Aluminum Wires	Steel Wire Diameter		Compact Conductor Diameter		Coated Steel Core Wire		Aluminum-Clad Steel Core Wire	
cmil	mm^2	AWG		in.	mm	in.	mm	lb/1000 ft	kg/km	lb/1000 ft	kg/km
336 400	170.5	...	18	0.1367	3.472	0.628	15.95	364.8	542.8	357.2	531.5
266 800	135.2	...	18	0.1217	3.091	0.559	14.20	289.1	430.2	283.1	421.3
211 600	107.2	0000	6	0.1878	4.770	0.517	13.13	290.8	432.7	276.5	411.5
167 800	85.03	000	6	0.1672	4.247	0.461	11.71	230.5	343.0	219.2	326.1
133 100	67.44	00	6	0.1489	3.782	0.410	10.41	182.8	272.0	173.8	258.7
105 600	53.51	0	6	0.1327	3.371	0.365	9.27	145.2	216.0	138.1	205.4
83 690	42.41	1	6	0.1181	3.000	0.326	8.28	115.0	171.1	109.4	162.7
66 360	33.62	2	7	0.1299	3.299	0.298	7.57	106.6	158.7	99.8	148.5
66 360	33.62	2	6	0.1052	2.672	0.290	7.37	91.2	135.8	86.8	129.1
52 620	26.66	3	6	0.0937	2.380	0.258	6.55	72.4	107.7	68.8	102.4
41 740	21.15	4	7	0.1029	2.614	0.236	5.99	67.0	99.6	62.7	93.3
41 740	21.15	4	6	0.0834	2.118	0.229	5.82	57.3	85.3	54.5	81.1
26 240	13.30	6	6	0.0661	1.679	0.182	4.62	36.0	53.6	...	...

3.1.6 Packaging and Package Marking (Section 17).

4. Joints

4.1 Electric-butt welds, electric-butt, cold-upset welds, or cold-pressure welds in the individual round-drawn or shaped aluminum wires may be made during the stranding process. No weld shall occur within 50 ft (15 m) of a weld in the same wire or in any other wire of the completed conductor.

4.2 There shall be no joints of any kind made in the finished coated, or aluminum-clad steel wires.

5. Lay

5.1 The preferred lay of the aluminum wires of aluminum conductors, steel-reinforced, having a single wire steel core and one layer of aluminum wires is 14 times the outside diameter of the conductor but the lay shall be not less than 13 nor more than 16 times that diameter.

5.2 The preferred lay of the outside layer of aluminum wires of aluminum conductors, steel-reinforced, having multiple layers of aluminum wires is 12 times the outside diameter of the conductor but the lay shall be not less than 11 nor more than 14 times that diameter.

5.3 The preferred lay of the layer immediately beneath the outside layer of aluminum wires of aluminum conductors, steel-reinforced, having multiple layers of aluminum wires is 14 times the outside diameter of such layer but the lay shall be not less than 11 nor more than 17.5 times that diameter.

5.4 The direction of lay of the outside layer of aluminum wires shall be right hand.

5.5 The direction of lay shall be reversed in successive layers.

6. Construction

6.1 The diameter of the steel core wire, the number of aluminum wires, the aluminum cross-sectional area, the diameter and weight of the compact round concentric-lay-stranded aluminum conductors, steel-reinforced, shall be as shown in Table 1.

7. Rated Strength of Conductor

7.1 The rated strength of a completed conductor shall be taken as the aggregate strength of the aluminum and steel components, calculated as follows: The strength contribution of the aluminum wires shall be taken as the percentage, according to the number of layers of aluminum wires, indicated in Table 2, of the sum of the strengths of the 1350-H19 wires, calculated on the basis of the nominal wire diameter for the corresponding noncompacted construction given in Specification B 232 and the appropriate specified minimum average tensile strength given in Specification B 230. The strength contribution of the steel core shall be taken as 96 % of the strength of the steel wire calculated from its specified nominal diameter and the appropriate specified minimum stress at 1 % extension given in Specification B 341, B 498, B 502, or B 802, whichever is applicable.

7.2 Rated strength and breaking strength values shall be rounded to three significant figures, in the final value only, in accordance with Practice E 29.

7.3 Rated strength of conductors are given in Table 3.

8. Density

8.1 For the purpose of calculating mass, mass per unit length, cross sections, etc., the density of aluminum 1350 shall be taken as 2705 kg/m^3(0.0975 $lb/in.^3$) at 20°C.

8.2 For the purpose of calculating mass, mass per unit length, cross sections, etc., the density of coated steel wire shall be taken as 7780 kg/m^3(0.281 $lb/in.^3$) at 20°C.

8.3 For the purpose of calculating mass, mass per unit length, cross sections, etc., the density of aluminum-clad steel wire shall be taken as 6590 kg/m^3(0.2381 $lb/in.^3$) at 20°C.

9. Mass and Electrical Resistance

9.1 The mass and electrical resistance of a unit length of stranded conductor are a function of the length of lay. The approximate mass and electrical resistance may be determined

TABLE 2 Strength Rating Factors

Stranding				Rating Factor, %	
Number of Wires		Number of Layers		Aluminum	Steel
Aluminum	Steel	Aluminum	Steel		
6	1	1	[A]	96	96
7	1	1	[A]	96	96
18	1	2	[A]	93	96

[A] Central steel wire only: the 96 % Rating Factor is applied to the single steel wire core in the event it contains a weld (made prior to drawing).

TABLE 3 Rated Strengths for Compact Round Concentric-Lay-Stranded Aluminum Conductors, Steel-Reinforced

Conductor Size			Number of Aluminum Wires	Rated Strength For Conductors With:									
				Aluminum-Coated Steel Core Wire		Aluminum-Clad Steel Core Wire		Coated Steel Core Wire:					
								Class A		Class B		Class C	
cmil	mm^2	AWG		kips	kN	kips	kN	kips	kN	kips	kN	kips	kN
336 400k	170.5	...	18	8.26	36.7	8.54	38.0	8.68	38.6	8.54	38.0	8.40	37.4
266 800	135.2	...	18	6.54	29.1	6.82	30.4	6.88	30.6	6.77	30.1	6.66	29.6
211 600	107.2	0000	6	7.42	33.0	7.69	34.2	8.35	37.1	8.08	36.0	7.95	35.4
167 800	85.03	000	6	5.88	26.2	6.30	28.0	6.62	29.4	6.41	28.5	6.30	28.0
133 100	67.44	00	6	4.88	21.7	5.13	22.8	5.30	23.6	5.13	22.8	5.05	22.5
105 600	53.51	0	6	3.98	17.7	4.25	18.9	4.38	19.5	4.25	18.9	4.12	18.3
83 690	42.41	1	6	3.29	14.6	3.45	15.3	3.55	15.8	3.45	15.3	3.34	14.9
66 360	33.62	2	7	3.26	15.0	3.51	15.6	3.64	16.2	3.51	15.6	3.39	15.1
66 360	33.62	2	6	2.64	11.7	2.76	12.3	2.85	12.7	2.76	12.3	2.68	11.9
52 620	26.66	3	6	2.13	9.48	2.23	9.92	2.30	10.2	2.23	9.92	2.17	9.63
41 740	21.15	4	7	2.16	9.60	2.28	10.1	2.36	10.5	2.28	10.1	2.20	9.78
41 740	21.15	4	6	1.76	7.81	1.78	7.93	1.86	8.28	1.81	8.05	1.76	7.81
26 240	13.30	6	6	1.12	5.00	Not Standard	Not Standard	1.19	5.29	1.16	5.14	1.12	5.00

using an increment of 1.5 % for conductors composed of 1 steel and 6 or 7 aluminum wires and an increment of 2 % for conductors composed of 1 steel and 18 aluminum wires. When greater accuracy is desired, the increment based on the specific lay of the conductor may be calculated (Explanatory Note 3).

9.2 In the calculation of the electrical resistance of a completed conductor, coated steel wires may be included.

10. Workmanship, Finish, and Appearance

10.1 The conductor shall be clean and free of imperfections not consistent with good commercial practice.

11. Requirements for Wires

11.1 Before stranding and compacting, the round aluminum wire used shall conform to the requirements of Specification B 230.

11.2 Aluminum wires shaped before stranding shall meet the requirements of Specification B 230, except for shape, tensile and elongation requirements, and diameter tolerances. The minimum tensile and elongation requirements shall be 96 % of those for round wires of the same nominal area, provided the completed conductor is capable of meeting the requirements of Section 7. The area tolerances for the shaped wires shall be such that the finished conductor conforms to Section 12.

11.3 Before stranding, the steel core wire used shall conform to the requirements of Specification B 341, B 498, B 502, or B 802, whichever is applicable.

12. Variation in Area

12.1 The cross-sectional area of the aluminum in wires of a compact round ACSR shall be not less than 98 % of the cross-sectional area as specified in column 1 of Table 1. The manufacturer shall determine the cross-sectional area by Test Method B 263. In applying this method, the increment in weight resulting from stranding may be the applicable value specified in 9.1 or may be calculated from the measured dimensions of the sample under test. In case of question regarding area compliance, the actual mass increment due to stranding shall be calculated.

13. Variation in Diameter

13.1 The diameter of the compact round ACSR shall vary by not more than + 1–2 % from the diameter specified in Table 1.

14. Sampling

14.1 The aluminum cross-sectional area (Section 12) and the conductor diameter (Section 13) shall be measured on a sample of completed conductor. At least one sample shall be tested for each size of conductor on each order of quantities from 5000 to 100 000 ft (1500 to 30 000 m) and one additional sample tested from each 100 000 ft thereafter.

15. Mechanical and Electrical Tests

15.1 Tests for mechanical and electrical properties of aluminum wires composing the conductors shall be made before stranding (Explanatory Note 4).

15.2 Tests for the mechanical and electrical properties of the steel core wire shall be made before, but not after stranding, unless otherwise agreed by the manufacturer and the purchaser as provided in 15.3 (Explanatory Note 4).

15.3 At the option of the purchaser, at the time of placing the order, tension and elongation tests of wire before stranding may be waived, and the completed conductor may be tested as a unit. The minimum breaking strength of conductors so tested shall be not less than the rated strength if failure occurs in the free length at least 1 in. (25 mm) beyond the end of either gripping device, or shall be not less than 95 % of the rated strength if failure occurs inside, or within 1 in. of the end of, either gripping device. The free length between grips of the test specimen shall be not less than 24 in. (600 mm), and care shall be taken to ensure that the wires in the conductor are evenly gripped during the test (Explanatory Note 5).

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 agreed to between the manufacturer and the purchaser at the time of 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. Packaging and Package Marking

17.1 Package sizes and kind of package, reels, or coils shall be agreed upon between the manufacturer and the purchaser.

17.2 The conductors shall be protected against damage in ordinary handling and shipping.

17.3 There shall be only one length of conductor on a reel.

17.4 The net mass, length, size, kind of conductor, stranding, kind of coating, class of zinc coating (if used), and any other necessary identification shall be marked on a tag attached to the end of the conductor inside the package. This same information, together with the purchase order number, the manufacturer's serial number (if any), and all shipping marks and other information required by the purchaser shall appear on the outside of the package.

18. Keywords

18.1 aluminum conductors; aluminum conductors; steel-reinforced; aluminum electrical conductor; compact round stranded conductors; concentric-lay-stranded conductors; electrical conductor; electrical conductor-aluminum; steel-reinforced conductors; stranded conductors

EXPLANATORY NOTES

NOTE 1—In this specification, only compact round concentric-lay-stranded aluminum conductors, steel-reinforced, are specially designated. Conductor constructions not included in this specification should be specifically agreed upon between the manufacturer and the purchaser at the time of purchase.

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

NOTE 3—To test stranded conductors for breaking strength successfully as a unit requires adequate means of gripping the ends of the test specimen without causing damage that may result in failure below the actual strength of the conductor. Various means are available, such as compression sleeves, split sleeves, and preformed grips, but ordinary jaws or clamping devices usually are not suitable.

NOTE 4—The increment of mass, mass per unit length, 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 stranding, 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:

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

where n =

$$\frac{\text{length of lay}}{\text{diameter of helical path of wire}}$$

The derivation of the above as given in *NBS Handbook 100* is based on the round-wire constructions which are applicable to compacted wire constructions.

NOTE 5—Individual wires are not to be unlaid from compact round conductors for testing purposes. Some physical properties of the individual wires may be altered by the deformation brought about by compacting, unlaying, and straightening for test. If tests on steel wires are to be made after stranding, the purchaser and the manufacturer should agree on the properties to be met at the time of placing the order.