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Standard Specification for Shaped Wire Compact Concentric-Lay-Stranded Aluminum Conductors (AAC/TW)[1]

This standard is issued under the fixed designation B778; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers shaped wire compact concentric-lay-stranded aluminum conductor (AAC/TW) and its component wires for use as overhead electrical conductors (Explanatory Note 1 and Note 2).

1.2 The values stated in inch-pound units are to be regarded as the standard with the exception of temperature and resistivity. The SI equivalents of inch-pound units may be approximate.

NOTE 1—AAC/TW is designed to increase the aluminum area for a given diameter of conductor by the use of trapezoidally shaped wires (TW). The conductors consist of a central core of one round aluminum wire or a seven-strand compact round core surrounded by two or more layers of trapezoidal aluminum 1350-H19 wires. For the purposes of this specification, the sizes listed are tabulated on the basis of the finished conductor having an area equal to that of specific sizes of standard AAC (Table 1) or in fixed diameter increments (Table 2) so as to facilitate conductor selection.

NOTE 2—The aluminum and temper designations conform to ANSI Standard H 35.1. Aluminum 1350 corresponds to Unified Numbering System (UNS) A91350 in accordance with Practice E527.

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:*[2]

B230/B230M Specification for Aluminum 1350–H19 Wire for Electrical Purposes

B263 Test Method for Determination of Cross-Sectional Area of Stranded Conductors

B354 Terminology Relating to Uninsulated Metallic Electrical Conductors

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

2.3 *Other Documents:*

ANSI H35.1 American National Standard Alloy and Temper Designation Systems for Aluminum[3]

NBS Handbook 100 — Copper Wire Tables[4]

Aluminum Association Publication 50 Code Words for Overhead Aluminum Electrical Conductors[5]

3. Ordering Information

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

3.1.1 Quantity of each size,

3.1.2 Conductor size: kcmil area and diameter (Table 1 and Table 2),

3.1.3 Special tension test, if required (see 8.2),

3.1.4 Place of inspection (Section 15),

3.1.5 Package size and type (see 15.1),

3.1.6 Special package markings, if required (Section 15), and

3.1.7 Heavy wood lagging, if required (see 15.3).

4. Requirement for Wires

4.1 Before stranding, the trapezoidal aluminum wires shall conform to the requirements of Specification B230/B230M except for shape and diameter tolerance. The tensile strength and elongation requirements of trapezoidal wires shall be the same as for round wires of equal area. The area tolerances shall be such that the finished conductor conforms to Section 11.

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

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

[4] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.

[5] Available from Aluminum Association, Inc., 1525 Wilson Blvd., Suite 600, Arlington, VA 22209, http://www.aluminum.org.

TABLE 1 Construction Requirements for Shaped Wire Compact Concentric-Lay-Stranded Aluminum Conductors Sized to Have Areas Equal to AAC Size

Code Word[A]	AAC/TW Conductor size		Nominal Outside Diameter		Number of Aluminum Wires	Number of Layers	Nominal Mass		Rated Strength	
	kcmil	mm	in.	mm			lb/1000 ft	kg/km	1000 lbf	kN
Tulip/TW	336.4	170	0.612	15.5	17	2	315.3	469.4	6.02	26.8
Canna/TW	397.5	201	0.661	16.8	17	2	372.6	554.7	6.96	31
Cosmos/TW	477.0	242	0.720	18.3	17	2	447.1	665.6	8.36	37.2
Zinnia/TW	500.0	253	0.736	18.7	17	2	468.7	697.7	8.76	39
Mistletoe/TW	556.5	282	0.775	19.7	17	2	521.6	776.5	9.75	43.4
Meadowsweet/TW	600.0	304	0.803	20.4	17	2	562.4	837.2	10.52	46.8
Orchid/TW	636.0	322	0.825	21.0	17	2	596.1	887.4	11.1	49.4
Verbena/TW	700.0	355	0.864	21.9	17	2	656.1	976.7	12.3	54.7
Nasturtium/TW	750.0	380	0.893	22.7	17	2	702.1	1045	13.1	58.3
Arbutus/TW	795.0	403	0.919	23.3	17	2	745.1	1109	13.6	60.5
Cockscomb/TW	900.0	456	0.990	25.1	31	3	843.6	1256	15.4	68.5
Magnolia/TW	954.0	483	1.018	25.9	31	3	894.2	1331	16.4	72.9
Hawkweed/TW	1000.0	507	1.041	26.4	31	3	937.3	1395	17.1	76.1
Bluebell/TW	1033.5	524	1.057	26.8	31	3	968.7	1442	17.7	78.7
Marigold/TW	1113.0	564	1.095	27.8	31	3	1043.2	1553	19.1	85.0
Hawthorn/TW	1192.5	604	1.132	28.8	31	3	1117.7	1664	20.4	90.7
Narcissus/TW	1272.0	644	1.168	29.7	31	3	1192.2	1775	21.8	97.0
Columbine/TW	1351.5	685	1.202	30.5	31	3	1266.3	1885	23.2	103
Carnation/TW	1431.0	725	1.236	31.4	31	3	1341.3	1997	24.0	107
Coreopsis/TW	1590.0	805	1.315	33.4	49	4	1490.3	2219	27.0	120
Jessamine/TW	1750.0	887	1.377	35.0	49	4	1640.3	2442	29.7	132
Cowslip/TW	2000.0	1013	1.468	37.3	49	4	1893.0	2818	33.9	151
Lupine/TW	2500.0	1266	1.648	41.9	71	5	2366.2	3522	41.9	186
Trillium/TW	3000.0	1520	1.799	45.7	71	5	2839.5	4227	50.3	224

[A] Code words shown in this column are obtained from "Publication 50, Code Words for Overhead Aluminum Electrical Conductors," by the Aluminum Association. They are provided for information only.

TABLE 2 Construction Requirements for Shaped Wire Compact Concentric-Lay-Stranded Aluminum Conductors, in Fixed-Diameter Increments

Code Word[A]	AAC/TW Conductor Size		Nominal Outside Diameter		Number of Aluminum Wires	Number of Layers	Nominal Mass		Rated Strength	
	kcmil	mm	in.	mm			lb/1000 ft	kg/km	1000 lbf	kN
Logan/TW	322.5	163	0.60	15.2	17	2	302.3	450	5.88	26.2
	384.5	195	0.65	16.5	17	2	360.4	536.5	6.74	30
Wheeler/TW	449.4	228	0.70	17.8	17	2	421.2	627	7.88	35.1
	521.7	264	0.75	19.1	17	2	489.0	728	9.14	40.7
Robson/TW	595.8	302	0.80	20.3	17	2	558.4	831.3	10.44	46.4
	678.2	344	0.85	21.6	17	2	635.7	946.3	11.88	52.8
McKinley/TW	761.5	386	0.90	22.9	17	2	713.7	1062.5	13.07	58.1
	854.2	433	0.95	24.1	17	2	800.6	1191.8	14.86	66.1
Rainer/TW	918.8	465	1.00	25.4	31	3	861.2	1282	15.76	70.1
	1020.0	517	1.05	26.7	31	3	956.0	1423.2	17.50	77.8
Helens/TW	1123.1	569	1.10	27.9	31	3	1052.7	1567.1	19.26	85.7
	1234.2	625	1.15	29.2	31	3	1156.8	1722.1	21.17	94.2
Mazama/TW	1346.8	682	1.20	30.5	31	3	1262.3	1879.1	23.10	102.7
	1467.9	744	1.25	31.8	31	3	1375.9	2048.2	24.65	109.6
Hood/TW	1583.2	802	1.30	33	34	3	1483.9	2209	26.59	118.3
	1682.7	852	1.35	34.3	49	4	1577.5	2348.4	28.55	127
Whitney/TW	1812.7	918	1.40	35.6	49	4	1699.0	2529.2	30.74	136.7
	1954.3	990	1.45	36.8	49	4	1832.1	2727.4	33.16	147.5
Powell/TW	2093.6	1061	1.50	38.1	49	4	1981.6	2949.9	35.51	157.9
	2245.4	1137	1.55	39.4	49	4	2125.7	3164.4	37.30	165.9
Jefferson/ TW	2388.1	1210	1.60	40.6	52	4	2260.3	3364.8	39.67	176.5
	2514.8	1274	1.65	41.9	71	5	2379.5	3542.3	42.17	187.6
Shasta/TW	2667.2	1351	1.70	43.2	71	5	2524.5	3758.1	44.74	199
	2844.5	1441	1.75	44.5	71	5	2692.2	4007.8	47.70	212.2
Adams/TW	3006.2	1523	1.80	45.7	71	5	2873.0	4276.9	50.43	224.3

[A] Code words shown in this column are obtained from "Publication 50, Code Words for Overhead Aluminum Electrical Conductors," by the Aluminum Association. They are provided for information only.

5. Joints

5.1 Electric-butt welds, electric-butt cold-upset welds, or cold-pressure welds may be made in the individual aluminum wires during the stranding process. No weld shall occur within 50 ft (15 m) of any other weld in the completed conductor (Explanatory Note 3).

6. Lay

6.1 The preferred lay of the outside layer of aluminum wires of shaped wire aluminum conductors, having multiple layers of aluminum wires is 11 times the outside diameter of the conductor but the lay shall not be less than 10 nor more than 14 times that diameter (Explanatory Note 1).

6.2 The preferred lay of the layer immediately beneath the outside layer of aluminum wires is 13 times the outside diameter of such layer but the lay shall be not less than 10 nor more than 16 times that diameter.

6.3 The lay of the inner layers of aluminum wires shall be not less than 10 nor more than 17 times the outside diameter of such layer.

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

6.5 The direction of lay of the aluminum wires shall be reversed in successive layers.

6.6 For the purpose of this specification the lay factor is the length of lay of a given layer divided by its outside diameter.

7. Construction

7.1 The nominal aluminum cross-sectional area, the outside diameter, the nominal number of aluminum wires, the number of layers, the linear density, and the rated strength, of the shaped wire compact concentric-lay-stranded aluminum conductors, shall be as shown in Table 1 and Table 2.

NOTE 3—Exception to 7.1. Because the final design of a shaped wire compact conductor is contingent on several factors such as layer diameter, wire width and thickness, and the like, the actual configuration of a given size may vary between manufacturers. This might result in a slight variation in the number of wires and number of layers, from that shown in Table 1 and Table 2, and also in the dimensions of the individual wires.

8. Rated Strength of Conductor

8.1 The rated strength of a conductor, as shown in Table 1 and Table 2, shall be taken as the percentage, indicated in Table 3, in accordance with the number of aluminum layers, of the sum of the wire strengths calculated from the specified diameter of the round wires having the same area as the trapezoidal wires used in the manufacture of the conductor, and the appropriate minimum average tensile strength given in Specification B230/B230M.

8.1.1 The rated strengths of conductors calculated in accordance with 8.1 and 8.3 are listed in Table 1 and Table 2.

8.2 Tests to confirm that the rated strength of the conductor is met are not required by this specification, but shall be made if agreed upon between the manufacturer and the purchaser at the time of placing an order. When tested, the breaking strength of the conductor 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 (Explanatory Note 2).

8.3 Rated strength and breaking strength values shall be rounded to three significant figures in the final value only, in accordance with Practice E29.

9. Density

9.1 For the purpose of calculating mass per unit length, cross-sections, and the like, the density of aluminum 1350 shall be taken as 0.0975 lb/in.^{3} (2705 kg/m^3) at 20°C.

10. Mass and Electrical Resistance

10.1 The mass per unit length and electrical resistance of a unit length of stranded conductor are a function of the length of lay. The approximate linear density and electrical resistance of a stranded conductor may be determined using the standard increments shown in Table 4. When greater accuracy is desired, the increment based on the actual lay of the conductor may be calculated (Explanatory Note 3).

11. Variations in Area

11.1 The area of cross-section of the aluminum wires of the conductor shall be not less than 98 % nor more than 102 % of the area specified in column 1 of Table 1 and Table 2. The total area of the aluminum wires in the conductor shall be determined by Test Method B263. In applying this method, the increment in linear density resulting from stranding may be the applicable value specified in Table 4, or it may be calculated from the measured dimensions of the sample under test. In case of questions regarding area compliance, the actual linear density increment due to stranding shall be calculated.

11.2 The diameter of the finished conductor shall be not less than 99 % nor more than 101 % of that shown in Table 1 and Table 2 when measured with a diameter tape between the closing dies and the capstan of the strander.

12. Workmanship, Finish, and Appearance

12.1 The conductor shall be clean and free from imperfections not consistent with good commercial practice.

13. Mechanical and Electrical Tests

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

14. Inspection

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

TABLE 3 Rating Factors

Number of Layers	Rating Factor, %
2	0.93
3	0.91
4	0.90
5 and above	0.89

TABLE 4 Standard Increments Due to Stranding

Size of Conductor, kcmil	Increment (Increase) of Mass per Unit Length and Electrical Resistance, %
Over 3 000 to 4 000	4
Over 2 000 to 3 000	3
2 000 and under	2

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

14.3 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.

15. Packaging and Package Marking

15.1 Package sizes and kind of package, reels, etc. shall be agreed upon between the manufacturer and the purchaser.

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

15.3 The conductors shall be protected against damage in ordinary handling and shipping. If heavy wood lagging is required, it shall be specified by the purchaser at the time of placing the order.

15.4 The net mass, length, size, kind of conductor, stranding, and any other necessary identification shall be marked on a tag attached to 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.

16. Keywords

16.1 AAC/TW; aluminum conductor; compact conductor; compact conductor, aluminum; concentric-lay-stranded aluminum conductor; electrical conductor; electrical conductor, aluminum; shaped wire compact conductor; shaped wire compact conductor, aluminum; shaped wire conductor; shaped wire conductor, aluminum; trapezoidal conductor; trapezoidal conductor, aluminum

EXPLANATORY NOTES

NOTE 1—In this specification only shaped wire compact concentric-lay-stranded aluminum conductors are specifically designated. Conductor constructions not included in this specification should be agreed upon between the manufacturer and the purchaser when placing the order.

NOTE 2—For definitions of terms relating to conductors, refer to Terminology B354.

NOTE 3—The behavior of properly spaced joints in aluminum wires in stranded conductors is related to both their tensile strength and elongation. Because of its higher elongation properties, the lower-strength electric-butt weld gives equivalent overall performance to that of a cold-pressure weld or an electric-butt, cold-upset weld in stranded conductors.

NOTE 4—The lay factor with respect to the outside diameter of a layer of wires varies for different layers and for different diameters of conductor, being larger for the inside layers than for the outside layer.

NOTE 5—To obtain the actual breaking strength of AAC/TW tested as a unit requires special devices for gripping the ends of the aluminum wires without causing damage thereto and resultant failure below the actual strength of the conductor. Various special dead-end devices are available for this purpose, such as compression sleeves. Ordinary jaws or clamping devices usually are not suitable.

NOTE 6—The increment of mass or electrical resistance of a completed concentric-lay-stranded conductor, k, in percent is given by the following equation:

$$k = 100(m - 1)$$

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:

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

where n = length of lay/diameter of helical path of the wire. This is assumed to be ID + t for a given layer where t equals the thickness of the layer. To be more precise, for trapezoidal wire, this diameter should be that of the centroid (the center of mass of the wire) which is on a diameter slightly larger than the average layer diameter used in the above formula. Using the average layer diameter for the helical path of the wire introduces a small error which is considered to be negligible and may be ignored. The derivation of the above is given in the *NBS Handbook 100*.[4]

NOTE 7—Wires unlaid from conductors may have different physical properties from those of the wire before stranding because of the deformation brought about by laying and again straightening for test.