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Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Aluminum Matrix Composite Reinforced (ACAMCR), Formerly ACCR[1]

This standard is issued under the fixed designation B978/B978M; 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 concentric-lay-stranded conductors made from round aluminum-zirconium alloy wires and an aluminum matrix composite (AMC) core wire(s) for use as overhead electrical conductors (Explanatory Note 1 and Explanatory Note 2).

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 The following documents form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[2]

B263/B263M Test Method for Determination of Cross-Sectional Area of Stranded Conductors

B354 Terminology Relating to Uninsulated Metallic Electrical Conductors

B941 Specification for Heat Resistant Aluminum-Zirconium Alloy Wire for Electrical Purposes

B976 Specification for Fiber Reinforced Aluminum Matrix Composite (AMC) Core Wire for Aluminum Conductors

Aluminum Matrix Composite Reinforced (ACAMCR) (formerly known as ACCR)

B1008 Test Method for Stress-Strain Testing for Overhead Electrical Conductors

2.3 *NIST Document:*[3]

NBS Handbook 100 Copper Wire Tables

2.4 *Aluminum Association Documents:*[4]

Publication 50 Code Words for Overhead Aluminum Electrical Conductors

3. Terminology

3.1 *Acronyms:*

3.1.1 *ACAMCR*—aluminum conductor, aluminum matrix composite reinforced

3.1.2 *AMC*—aluminum matrix composite

3.1.3 *Al-Zr*—aluminum zirconium

4. Ordering Information

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

4.1.1 Quantity of each size, stranding, and class,

4.1.2 Conductor size, area (Section 8 and Table 1 and Table 2),

4.1.3 Number of wires, aluminum-zirconium alloy and AMC (see Table 1 and Table 2),

4.1.4 Type of AMC core wires (see 5.3),

4.1.5 Direction of lay of outer layer of aluminum-zirconium alloy wires if other than right-hand (see 7.3),

4.1.6 Special tension test, if desired (see 14.3),

4.1.7 Place of inspection (Section 16),

4.1.8 Package size and type (see 17.1),

4.1.9 Heavy wood lagging, if required (see 17.3), and

4.1.10 Special package marking, if required (see 17.4).

5. Requirement for Wires

5.1 Tests for mechanical and electrical properties of aluminum-zirconium alloy and core wires shall be made before stranding.

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

[4] Available from Aluminum Association, 1400 Crystal Dr., Suite 430, Arlington, VA 22202, http://www.aluminum.org.

TABLE 1 Construction Requirements of Aluminum Conductors, Aluminum Matrix Composite Reinforced (ACAMCR)

Designation	Nominal, kcmil	Stranding, Aluminum-Zirconium Alloy/AMC	Rated Strength, lb	Cross Sectional Area, in.^{2}		Layers of Aluminum-Zirconium Alloy	Diameter				Total Mass (lb)/1000 ft
							Individual Wires				
				Aluminum-Zirconium Alloy	Total		Aluminum-Zirconium Alloy, in.	AMC, in.	AMC Core, in.	Complete Cable, in.	
300-T16	297	26/7	12100	0.233	0.271	2	0.107	0.083	0.249	0.677	337
336-T16	340	26/7	13900	0.267	0.310	2	0.114	0.089	0.267	0.724	385
477-T16	470	26/7	19200	0.369	0.429	2	0.134	0.105	0.314	0.852	533
557-T16	573	26/7	23100	0.450	0.524	2	0.149	0.116	0.347	0.941	650
636-T16	656	26/19	25600	0.516	0.598	2	0.159	0.074	0.371	1.006	740
795-T16	824	26/19	32200	0.648	0.751	2	0.178	0.083	0.416	1.128	930
954-T13	967	54/19	33200	0.760	0.856	3	0.134	0.080	0.402	1.205	1059
1033-T13	1036	54/19	35600	0.814	0.917	3	0.139	0.083	0.416	1.247	1134
1272-T11	1236	51/19	38500	0.972	1.075	3	0.156	0.083	0.416	1.350	1.325
1351-T13	1334	54/19	45300	1.048	1.180	3	0.157	0.094	0.472	1.415	1460
1590-T11	1594	51/19	49500	1.252	1.385	3	0.094	0.177	0.472	1.532	1.706

Conversion factors:
1 cmil = 5.067 E – 4.0 mm^2
1 in. = 2.54 E + 01 mm
1lb/1000 ft = 1.488 E + 00 kg/km
1 ft = 3.048 E – 01 m
1 lb = 4.536 E – 01 kg
1 lbf = 4.448 N

TABLE 2 Construction Requirements of Aluminum Conductors, Aluminum Matrix Composite Reinforced (ACAMCR) – Metric

Designation	Nominal, mm^2	Stranding Aluminum-Zirconium Alloy/AMC	Rated Strength, kN	Cross Sectional Area, mm^2		Layers of Aluminum-Zirconium Alloy	Diameter				Total Mass kg/m
							Individual Wires				
				Aluminum-Zirconium Alloy	Total		Aluminum-Zirconium Alloy, mm	AMC, mm	AMC Core, mm	Complete Cable, mm	
300-T16	150	26/7	53.8	150	175	2	2.7	2.1	6.3	17.2	0.501
336-T16	172	26/7	61.8	172	200	2	2.9	2.3	6.8	18.4	0.573
477-T16	238	26/7	85.4	238	277	2	3.4	2.7	8.0	21.6	0.793
556-T16	291	26/7	102.8	291	338	2	3.8	2.9	8.8	23.9	0.967
636-T16	333	26/19	113.9	332	385	2	4.0	1.9	9.4	25.5	1.101
795-T16	418	26/19	143.2	418	484	2	4.5	2.1	10.6	28.6	1.384
954-T13	490	54/19	147.7	490	552	3	3.4	2.0	10.2	30.6	1.576
1033-T13	525	54/19	158.4	525	591	3	3.5	2.1	10.6	31.7	1.687
1272-T11	627	51/19	171.3	627	694	3	4.0	2.1	10.6	34.3	1.972
1351-T13	676	54/19	201.5	676	761	3	4.0	2.4	12.0	35.9	2.172
1590-T11	806	51/19	220.2	808	894	3	4.5	2.4	12.0	38.9	2.539

Conversion factors:
1 cmil = 5.067 E – 4.0 mm^2
1 in. = 2.54 E + 01 mm
1 lb/1000 ft = 1.488 E + 00 kg/km
1 ft = 3.048 E – 01 m
1 lb = 4.536 E – 01 kg
1 lbf = 4.448 N

5.2 Before stranding, the aluminum-zirconium alloy wire used shall meet the requirements of Specification B941.

5.3 Before stranding, the AMC core wire used shall meet the requirements of Specification B976.

6. Joints

6.1 Electric-butt welds, cold-pressure welds, and electric-butt, cold-upset welds in the finished individual aluminum-zirconium alloy wires composing the conductor may be made during the stranding process. No weld shall occur within 50 ft [15 m] of any weld in the completed conductor (Explanatory Note 3).

6.2 There shall be no joints of any kind made in the finished AMC core wires.

7. Lay

7.1 The length of lay of the various layers of wires in a conductor shall conform to Table 3 (see Explanatory Note 4). These are expressed in values of lay factor.

7.2 In a conductor having multiple layers of Al-Zr alloy wires, the length of lay of any Al-Zr layer shall not be less than the length of lay of the Al-Zr layer immediately beneath it. Similarly, in a conductor having multiple layers of AMC wires

TABLE 3 Lay Factors for Aluminum Conductors, Composite-Reinforced, Aluminum Matrix Concentric-Lay-Stranded

		Ratio of Length of Lay of a Layer to Nominal Outside Diameter of That Layer														
		Aluminum-Zirconium Alloy Wire Layers									AMC Layers					
		First (Outside)			Second			Third			12 Wire			6 Wire		
Standing Class	Stranding	Min	Preferred	Max	Min	Preferred	Max	Min	Preferred	Max	Min	Preferred	Max	Min	Preferred	Max
AA	26/7	10	11.5	13	10	13	16	—	—	—	—	—	—	58	66	80
	26/19	10	11.5	13	10	13	16	—	—	—	58	66	80	58	66	80
	54/19	10	11.5	13	10	13	16	10	13.5	17	58	66	80	58	66	80

in the core, the length of lay of an AMC layer shall not be less than the length of lay of the AMC layer immediately beneath it.

7.3 The direction of lay of the outside layer of aluminum-zirconium alloy wires shall be right hand unless otherwise specified in the purchase order. The direction of lay of the aluminum-zirconium alloy wires shall be reversed in successive layers.

7.4 The direction of lay of the core wires shall preferably be unidirectional in successive layers. Use of core wires reversed in successive layers may be acceptable upon agreement between the supplier and the purchaser.

7.5 The direction of lay of the inner Al-Zr alloy wires may be either unidirectional or reversed relative to the direction of lay of the outside layer of the core wires.

8. Construction

8.1 The number and diameter of aluminum-zirconium alloy and AMC wires and the area of cross section of aluminum-zirconium alloy wires shall conform to the requirements prescribed in Table 1 and Table 2.

9. Rated Strength of Conductor

9.1 The rated strength of a completed conductor shall be taken as the sum of the aluminum-zirconium alloy load rating and the AMC load rating, calculated as follows.

9.1.1 The strength contribution of the aluminum alloy wires shall be taken as:

$$\text{Aluminum zirconium alloy load} = (\text{min wire strength} \times \text{nominal wire area}) \times (0.967) \times \text{number strands} \times \text{stranding derating factor}$$

(See Explanatory Note 5) for more information.)

9.1.2 The minimum aluminum-zirconium alloy wire strength and nominal diameter may be obtained from Specification B941. The number of strands is found in Table 1 and Table 2, and the stranding derating factor is found in Table 4. The strength contribution of the AMC core wires shall be taken as:

$$\text{Core load} = \text{min wire load} \times \text{number strands} \times \text{stranding factor}$$

9.1.3 The minimum core wire strength may be obtained from Specification B976. The number of strands is found in Table 1 and Table 2, and the stranding factor is found in Table 4.

TABLE 4 Standard Increments and Rating Factors for Mass Per Unit Length, Resistivity, and Rated Strength Determination

Stranding Design Aluminum-Zirconium Alloy/AMC	Standard Increments Due to Stranding (for mass per unit length and resistivity) Increase		Stranding Derating Factors (for rated strength)	
	Aluminum-Zirconium Alloy (%)	Core (%)	Aluminum-Zirconium Alloy (%)	Core (%)
Round Wires				
26/7	2.5	0	93	96
26/19	2.5	0	93	92
54/19	3.0	0	91	92

9.2 Rated strengths of various constructions are given in Table 1 and Table 2.

10. Density

10.1 For the purpose of calculating mass per unit length, cross sections, etc., the density of the aluminum-zirconium alloy shall be taken from Specification B941.

10.2 For the purpose of calculating mass per unit length, cross sections, etc., the density of the AMC wire shall be taken from Specification B976.

11. Mass Per Unit Length and Electrical Resistance

11.1 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 mass and electrical resistance may be determined using the standard increments shown in Table 4. When greater accuracy is desired the increment based on the specific lay of the conductor may be calculated (Explanatory Note 6).

11.2 In the calculation of the electrical resistance of a conductor, the AMC core wires may be included. The electrical resistance of the AMC core wires shall be taken as 39.88 Ω·cmil/ft [0.0642 $\Omega \cdot mm^2/m$] at 68 °F [20 °C]. The electrical resistance of aluminum-zirconium wires shall be taken as 17.28 Ω·cmil/ft [0.02873 $\Omega \cdot mm^2/m$] at 68 °F [20 °C]. These are typical DC resistance values, not minimum values.

12. Cross-sectional Area

12.1 The area of cross section of the aluminum-zirconium alloy wires of a conductor shall be not less than 98 % of the area specified. Unless otherwise specified by the purchaser, the manufacturer may have the option of determining the cross-sectional area by either of the following methods, except that in case of question regarding area compliance, the method of 12.1.2 shall be used:

12.1.1 The area of cross section may be determined by calculations from diameter measurements, expressed to four decimal places for inches or three decimal places for millimeters, of the component aluminum-zirconium alloy wires at any point when measured perpendicularly to their axes.

12.1.2 The area of cross section of the aluminum-zirconium alloy wires of a conductor may be determined by Test Method B263/B263M. In applying that test method the increment in mass per unit length resulting from stranding may be the applicable value specified in 11.1 or may be calculated from the measured component dimensions of the sample under test. In case of questions regarding area compliance, the actual mass per unit length increment due to stranding shall be calculated.

13. Workmanship, Finish, and Appearance

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

14. Mechanical, Electrical and Dimensional Tests

14.1 *Classification of Tests:*

14.1.1 *Type Tests*—Type tests are intended to verify the main characteristics of a conductor which depend mainly on its