Designation: B399/B399M – 23

Standard Specification for Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 and 6201-T83 Conductors[1]

This standard is issued under the fixed designation B399/B399M; 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-alloy 6201-T81 (hard: solution heat-treated, cold worked, and then artificially aged) wires or 6201-T83 (hard: higher conductivity, solution heat-treated, cold worked, and then artificially aged) wires, for use for electrical purposes. These conductors shall be constructed with a central core surrounded by one or more layers of helically laid wires (Explanatory Notes 1 and 2).

NOTE 1—The aluminum alloy and temper designations conform to ANSI H35.1/H35.1[M]. Aluminum-alloy 6201 corresponds to Unified Numbering System alloy A96201 in accordance with Practice E527.

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

1.2.1 For density, resistivity and temperature, the values stated in SI units are to be regarded as standard.

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 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]

B193 Test Method for Resistivity of Electrical Conductor Materials

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

B354 Terminology Relating to Uninsulated Metallic Electrical Conductors

B398/B398M Specification for Aluminum-Alloy 6201-T81 and 6201-T83 Wire for Electrical Purposes

B682 Specification for Standard Metric Sizes of 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 *ANSI Standards:*[3]

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

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

2.4 *NIST Standards:*[4]

NBS Handbook 100 Copper Wire Tables of the National Bureau of Standards

2.5 *Aluminum Association Publication:*[5]

Publication 50 Code Words for Overhead Aluminum Electrical Conductors

3. Classification

3.1 For the purpose of this specification, conductors are classified as follows (Explanatory Notes 1 and 2):

3.1.1 *Class AA*—For bare conductors usually used in overhead lines.

3.1.2 *Class A*—For conductors to be covered with weather-resistant materials.

4. Ordering Information

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

[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.

4.1.1 Quantity of each size, stranding, and class,
4.1.2 Conductor size, area, and aluminum 1350 equivalent size (if required) (Section 8 and Table 1, Table 2, or Table 3),
4.1.3 Number of wires (Table 1, Table 2 or Table 3),
4.1.4 Direction of lay of outer layer of aluminum wires if other than right-hand (see 7.4),
4.1.5 Compressed stranding, if required (see 8.2),
4.1.6 Special tension test, if required (see 9.2 and 14.2),
4.1.7 Place of inspection (see 15.2),
4.1.8 Special package marking, if required (Section 16),
4.1.9 Package size and type (see 16.1), and
4.1.10 Heavy wood lagging, if required (see 16.4).

5. Requirements of Wires

5.1 The aluminum-alloy wire used shall conform to the requirements of Specification B398/B398M before stranding.

6. Joints

6.1 In conductors composed of seven wires, only cold-pressure joints or electric-butt, cold-upset joints are permitted in the six outer finished wires; no joints are permitted in the center wire. In other conductors, cold-pressure welds, electric-butt, cold-upset welds, or electric-butt welds may be made in the finished wires composing conductors, but such joints shall be not closer than prescribed in Table 4. Following welding, electric-butt welds shall be annealed for a distance of at least 6 in. [150 mm] on each side of the weld.

7. Lay

7.1 For Class AA conductors, the length of lay of a layer of wires shall not be less than 10 nor more than 16 times the outside diameter of that layer. The length of lay of any aluminum-alloy layer shall not be less than the length of lay of the aluminum-alloy layer immediately beneath it.

7.2 For Class A conductors, the length of lay of a layer of wires shall not be less than 8 nor more than 16 times the outside diameter of that layer, except that for conductors composed of 37 wires or more, this requirement shall apply only to the two outer layers. The length of lay of the layers

TABLE 1 Construction Requirements of Concentric-Lay-Stranded Aluminum-Alloy 6201 Conductors Sized to Have Diameter Equal to ACSR, Class AA and Class A

NOTE 1—Metric values listed below represent a soft conversion and as such they may not be the same as those metric masses which are calculated from the basic metric density.

Conductor Size		Code Words[A]	Approximate Aluminum 1350 Size Having Equivalent Resistance			Size and Stranding of ACSR with Equal Diameter						Required Construction		Mass		Rated Strength		Nominal dc Resistance at 20 °C	
cmil	mm²		Size			cmil[B]	AWG	mm²	Stranding	Number of Wires	Diameter of Wires		Class	lb per 1000 ft	kg per km	kips	kN	ohm per 1000 ft	ohm per km
			cmil[B]	AWG	mm²						in.	mm							
1 439 200	729	—	1 272 000	...	644.5	1 272 000	...	644.5	54/7	61	0.1536	3.90	AA	1342	1999	46.8	207	0.01400	0.04597
1 348 800	685	—	1 192 500	...	604.2	1 192 500	...	604.2	54/7	61	0.1487	3.78	AA	1258	1878	43.9	194	0.01494	0.04893
1 259 600	638	—	1 113 000	...	564.0	1 113 000	...	564.0	54/7	61	0.1437	3.65	AA	1175	1751	41.0	181	0.01600	0.05248
1 165 100	590	—	1 033 500	...	523.7	1 033 500	...	523.7	54/7	61	0.1382	3.51	AA	1086	1620	37.9	167	0.01730	0.05675
1 077 400	547	—	954 000	...	483.4	954 000	...	483.4	54/7	61	0.1329	3.38	AA	1005	1502	35.0	156	0.01870	0.06120
927 200	470	Greeley	795 000	...	402.8	795 000	...	402.8	26/7	37	0.1583	4.02	AA	864.6	1289	30.5	135	0.02173	0.07133
740 800	375	Flint	636 000	...	322.3	636 000	...	322.3	26/7	37	0.1415	3.59	AA	690.8	1028	24.4	107	0.02720	0.08944
652 400	331	Elgin	556 500	...	282.0	556 500	...	282.0	26/7	19	0.1853	4.71	AA	608.3	908.3	21.9	97.0	0.03089	0.1012
559 500	284	Darien	477 000	...	241.7	477 000	...	241.7	26/7	19	0.1716	4.36	AA	521.7	778.3	18.8	83.1	0.03602	0.1181
465 400	236	Cairo	397 500	...	201.4	397 500	...	201.4	26/7	19	0.1565	3.98	AA	433.9	648.6	15.6	69.2	0.04330	0.1417
394 500	200	Canton	336 400	...	170.5	336 400	...	170.5	26/7	19	0.1441	3.66	AA, A	367.9	548.5	13.3	58.6	0.05107	0.1676
312 800	159	Butte	266 800	...	135.2	266 800	...	135.2	26/7	19	0.1283	3.26	A	291.6	435.1	10.5	46.5	0.06443	0.2112
246 900	125	Alliance	211 600	0000	107.2	211 600	0000	107.2	6/1	7	0.1878	4.77	AA	230.2	343.2	8.56	37.8	0.08162	0.2678
195 700	99.3	Amherst	167 800	000	85.0	167 800	000	85.0	6/1	7	0.1672	4.25	AA, A	182.5	272.5	6.79	30.0	0.1030	0.3373
155 400	78.6	Anaheim	133 100	00	67.4	133 100	00	67.4	6/1	7	0.1490	3.78	AA, A	144.9	215.6	5.39	23.8	0.1297	0.4264
123 300	62.4	Azusa	105 600	0	53.5	105 600	0	53.5	6/1	7	0.1327	3.37	AA, A	114.9	171.3	4.27	18.9	0.1635	0.5365
77 470	39.2	Ames	66 360	2	33.6	66 360	2	33.6	6/1	7	0.1052	2.67	AA, A	72.24	107.5	2.80	12.4	0.2601	0.8547
48 690	24.7	Alton	41 740	4	21.1	41 740	4	21.1	6/1	7	0.0834	2.12	A	45.40	67.80	1.76	7.83	0.4139	1.356
30 580	15.5	Akron	26 240	6	13.3	26 240	6	13.3	6/1	7	0.0661	1.68	A	28.52	42.58	1.11	4.92	0.6588	2.159

[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 here for information only.
[B] Conversion factors: 1 mil = 2.54 E-02 mm
1 cmil = 5.067 E-04 mm²
1 in. = 25.4 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 E-03 kN

TABLE 2 Construction Requirements of Concentric-Lay-Stranded Aluminum-Alloy 6201 Conductors Sized by Standard Areas, Class AA and Class A

NOTE 1—Metric values listed below represent a soft conversion and as such they may not be the same as those metric masses which are calculated from the basic metric density.

Conductor Size			Required Construction				Mass		Rated Strength		Nominal dc Resistance at 20 °C	
cmil	AWG	mm^2	Number of Wires	Diameter of Wires		Class	lb per 1000 ft	kg per 1000 m	kips	kN	ohm per 1000 ft	ohm per 1000 m
				in.	mm							
1 750 000	. . .	886	61	0.1694	4.30	AA	1632	2431	56.9	251	0.01151	0.03781
1 500 000	. . .	759	61	0.1568	3.98	AA	1399	2082	48.8	215	0.01344	0.04414
1 250 000	. . .	631	61	0.1431	3.63	AA	1165	1732	40.6	179	0.01613	0.05306
1 000 000	. . .	508	37	0.1644	4.18	AA	932.5	1393	32.9	146	0.02015	0.06597
900 000	. . .	456	37	0.1560	3.96	AA	839.7	1250	29.6	131	0.02238	0.07351
800 000	. . .	404	37	0.1470	3.73	AA	745.6	1109	26.3	116	0.02520	0.08285
750 000	. . .	381	37	0.1424	3.62	AA	699.6	1045	24.7	109	0.02686	0.08796
700 000	. . .	354	37	0.1375	3.49	AA	652.3	971.2	23.0	101	0.02881	0.09464
650 000	. . .	330	37	0.1325	3.37	AA	605.7	905.5	21.4	94.9	0.03102	0.10150
600 000	. . .	303	37	0.1273	3.23	AA, A	559.1	831.9	20.6	91.0	0.03361	0.11049
550 000	. . .	279	37	0.1219	3.10	AA, A	512.7	766.2	18.9	83.9	0.03665	0.11995
500 000	. . .	253	19	0.1622	4.12	AA	466.1	695.0	16.8	74.2	0.04031	0.13224
450 000	. . .	228	19	0.1539	3.91	AA	419.6	626.0	15.1	66.8	0.04478	0.14683
400 000	. . .	203	19	0.1451	3.69	AA, A	373.0	557.5	13.4	59.5	0.05037	0.16486
350 000	. . .	178	19	0.1357	3.45	A	326.3	487.3	11.8	52.0	0.05759	0.18860
300 000	. . .	152	19	0.1257	3.19	A	280.0	416.7	10.5	46.6	0.06712	0.22059
250 000	. . .	126	19	0.1147	2.91	A	233.1	346.7	8.76	38.8	0.08061	0.26509
211 600	0000	107	7	0.1739	4.42	AA, A	197.4	294.7	7.34	32.5	0.09519	0.31188
167 800	000	84.9	7	0.1548	3.93	AA, A	156.4	233.0	5.82	25.7	0.12013	0.39450
133 100	00	67.3	7	0.1379	3.50	AA, A	124.1	184.8	4.62	20.4	0.15137	0.49738
105 600	0	53.5	7	0.1228	3.12	AA, A	98.43	146.8	3.82	17.0	0.19089	0.62592
66 360	2	33.5	7	0.0974	2.47	AA, A	61.92	92.00	2.40	10.6	0.30343	0.99870
41 740	4	21.1	7	0.0772	1.96	A	38.90	57.90	1.51	6.69	0.48300	1.5860
26 240	6	13.2	7	0.0612	1.55	A	24.49	36.20	0.949	4.18	0.76856	2.5361

other than the two outer layers shall be at the option of the manufacturer, unless otherwise agreed upon.

7.3 Other lays for special purposes shall be furnished by agreement between the manufacturer and the purchaser.

7.4 The direction of lay of the outer layer shall be right-hand unless specified otherwise by the purchaser.

7.5 The direction of lay shall be reversed in successive layers, unless otherwise specified by the purchaser.

8. Construction

8.1 The cross-sectional areas and the numbers and diameters of wires in the concentric-lay-stranded conductors shall conform to the requirements prescribed in Table 1, Table 2, or Table 3 as applicable (Explanatory Notes 2 and 6).

8.2 Where compressed stranding is required in order that the conductor may be properly insulated, one or more layers of any stranded conductor consisting of 7 wires or more may be slightly compressed, thereby reducing the outside diameter of the conductor by not more than 3 %, provided that the area of cross section after compressing is in accordance with Section 12.

NOTE 2—The user's attention is called to the claim that certain compressed strand constructions may be subject to patent rights, for example: Patents 3,383,704 and 3,444,684.

8.3 The nominal wire diameter shall be as specified in Table 1 and Table 2 and this diameter shall be referred to as the "mean diameter". The nominal outside diameter of the conductor shall be calculated by summing the mean diameter of the core wire and twice the mean diameter of each layer. The minimum and maximum outside diameter shall be based on calculations made using the method described above and the mean diameter tolerances as specified by Specification B398/B398M for the corresponding mean diameter of each layer.

9. Rated Strength of Conductor

9.1 The rated strength of a conductor shall be taken as that percentage, indicated in Table 5 of the sum of the strengths of the 6201 wires, calculated on the basis of the nominal wire diameter and the specified minimum average tensile strength given in Specification B398/B398M.

9.2 Tests for determining the breaking strength of a conductor are not required by this specification but may be made if agreed upon between the manufacturer and the purchaser at the time of placing an order. When tested, the breaking strength of a 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. [25 mm] of the end of, either gripping device (Explanatory Note 3).

TABLE 3 Construction Requirements and Rated Strengths of Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors Sized by Standard Areas, Class AA and Class A

NOTE 1—Sizes were selected from Specification B682.

Conductor Size, mm²	Required Construction			Mass, kg per 1000 m	Rated Strength 6201-T81, kN	Nominal dc Resistance @ 20°C, ohm per 1000 m
	Number of Wires	Diameter of Wires, mm	Class			
630	37	4.66	AA	1731	181	0.05308
560	37	4.39	AA	1537	161	0.05981
500	37	4.15	AA	1373	143	0.06693
450	37	3.94	AA	1238	129	0.07426
400	37	3.71	AA	1097	115	0.08375
355	37	3.50	AA	976.7	102	0.09410
315	37	3.29	AA	863.0	90.2	0.10650
280	37	3.10	AA	766.2	83.9	0.11995
250	19	4.09	AA	684.9	73.1	0.13419
224	19	3.87	AA	613.2	65.5	0.14988
200	19	3.66	AA, A	548.5	58.6	0.16758
180	19	3.47	AA, A	493.0	52.6	0.18643
160	19	3.27	AA, A	437.8	46.7	0.20993
140	19	3.06	AA, A	383.4	42.9	0.23973
125	19	2.89	AA, A	342.0	38.3	0.26877
112	7	4.51	AA	306.8	33.8	0.29955
100	7	4.26	AA, A	273.8	30.2	0.33574
80.0	7	3.81	AA, A	219.0	24.1	0.41974
63.0	7	3.39	AA, A	173.4	19.1	0.53019
50.0	7	3.02	AA, A	137.6	15.9	0.66806
40.0	7	2.70	AA, A	110.0	12.7	0.83580
31.5	7	2.39	A	86.2	9.95	1.0667
25.0	7	2.13	A	68.4	7.90	1.3430
20.0	7	1.91	A	55.0	6.35	1.6702
16.0	7	1.71	A	44.1	5.09	2.0837

TABLE 4 Minimum Distance Between Joints in the Completed Conductor

Number of Wires in Conductor	Distance Between Joints, min. ft (m)
7	50 (15)[A]
19	50 (15)
37	25 (7.5)
61	25 (7.5)

[A] Only cold-pressure welds and electric-butt, cold-upset welds are permitted in the six outer wires of conductors composed of seven wires; no welds are permitted in the center or core wire.

TABLE 5 Rating Factors

Stranding		Rating Factor, %
Number of Wires in Conductor	Number of Layers	
7	1	96
19	2	93
37	3	91
61	4	90

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

10. Density

10.1 For the purpose of calculating mass, mass per unit length, cross sections, and so forth, the density of aluminum-alloy 6201 shall be taken from Specification B398/B398M.

11. Mass and Electrical Resistance

11.1 The mass and electrical resistance of a unit length of stranded conductor are a function of the length of lay. The appropriate mass and electrical resistance may be determined using an increment of 2 %. When greater accuracy is desired, the increment based on the specific lay of the conductor may be calculated (Explanatory Note 4).

11.2 The maximum electrical resistance of a unit length of stranded conductor shall not exceed 102 % of the nominal dc resistance shown in Table 1, Table 2, and Table 3 (Explanatory Note 7). When the dc resistance is measured at other than 20 °C, it is to be corrected by using the multiplying factor given in Table 6.

11.3 For conductors to be used in covered or insulated wires or cables dc resistance measurements may be used in lieu of the method outlined in Section 12.

12. Variation in Area

12.1 The area of cross section of the 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 of a conductor may be determined by calculations from diameter measurements, expressed to four decimal places, of its component wires at any point when measured perpendicularly to their axes.

12.1.2 The area of cross section of the wires of a conductor may be determined by Test Method B263. In applying this method, the increment in mass 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 question regarding area compliance, the actual mass increment due to stranding shall be calculated.

TABLE 6 Temperature Correction Factors for Conductor Resistance

Temperature, °C	Multiplying Factor for Conversion to 20 °C
0	1.075
5	1.055
10	1.036
15	1.018
20	1.000
25	0.983
30	0.966
35	0.951
40	0.935
45	0.920
50	0.906
55	0.892
60	0.878
65	0.865
70	0.852
75	0.840
80	0.828
85	0.816
90	0.805