Designation: B 397 – 85 (Reapproved 1999)

Standard Specification for Concentric-Lay-Stranded Aluminum-Alloy 5005-H19 Conductors[1]

This standard is issued under the fixed designation B 397; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers concentric-lay-stranded conductors, made of round aluminum-alloy 5005-H19 (extra-hard) wires, for general use for electrical purposes. These conductors shall be constructed with a central core wire surrounded by one or more layers of helically laid wires (Explanatory Note 1 and Explanatory Note 2).

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

NOTE 1—The alloy and temper designations conform to ANSI H35.1. Aluminum-alloy 5005 corresponds to unified numbering system alloy A95505 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 263 Test Method for Determination of Cross-Sectional Area of Stranded Conductors[2]

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

B 396 Specification for Aluminum-Alloy 5005-H19 Wire for Electrical Purposes[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 *American National Standard:*

ANSI H35.1 American National Standard Alloy and Temper Designation System is for Aluminum[5]

2.4 *National Institute of Standards and Technology:*

NBS Handbook 100—Copper Wire Tables[6]

3. Classification

3.1 For the purposes of this specification, conductors are classified as follows (Explanatory Note 1 and Explanatory Note 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 suitable weather-resistant materials and usually used as line wire or as tree wire.

4. Ordering Information

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

4.1.1 Quantity,

4.1.2 Conductor size: circular-mil area or aluminum 1350 equivalent size (Section 7 and Table 1 or Table 2),

4.1.3 Class (Section 3),

4.1.4 When physical tests shall be made (see 14.2 and 14.4),

4.1.5 Package size (see 16.1),

4.1.6 Special package marking, if required (Section 17),

4.1.7 Heavy wood lagging, if required (see 16.2), and

4.1.8 Place of inspection (Section 15).

4.2 In addition, Supplementary Requirements shall apply only when specified by the purchaser in the inquiry, contract, or purchase order for direct procurement by agencies of the U.S. Government (S2, S3, and S4).

5. Joints

5.1 Joints may be made in the six outer wires of seven-wire conductors by cold-pressure welding or by electric-butt, cold-upset welding, but not by electric-butt welding. Joints are not permitted in the finished center wire of seven-wire conductors.

5.2 Joints may be made in any of the wires in conductors of 19 or more wires by electric-butt welding, cold-pressure welding, or electric-butt, cold-upset welding.

5.3 The minimum distance between a wire joint and another joint either in the same wire or in other wires of the completed conductor shall be as prescribed in Table 3.

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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 American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

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

TABLE 1 Construction Requirements of Concentric-Lay-Stranded Aluminum-Alloy 5005 Conductor Sized to Have Diameter Equal to ACSR Class AA and Class A[A]

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

Conductor Size, cmil	Approximate Aluminum 1350 Size Having Equivalent Resistance			Size and Stranding of ACSR with Equal Diameter Size					Required Construction			Weight		Rated Strength	
	mm^2	cmil	AWG	mm^2	cmil	AWG	mm^2	Stranding	Number of wires	Diameter of wires, in.	mm^2	Class	lbs/1000 ft	kg/km	KIPS	KN
927 200	469.8	795 000	...	402.8	795 000	...	402.8	26/7	37	0.1583	4.021	AA	873.5	1300.	23.9	106
740 800	375.4	636 000	...	322.3	636 000	...	322.3	26/7	37	0.1415	3.594	AA	697.9	1039.	19.3	85.9
652 400	330.6	556 500	...	282.0	556 500	...	282.0	26/7	19	0.1853	4.707	AA	614.6	914.5	16.2	72.1
587 200	297.5	506 500	...	256.6	556 500	...	282.0	18/1	19	0.1758	4.465	AA	553.2	823.2	14.6	65.0
559 500	283.5	477 000	...	241.7	477 000	...	241.7	26/7	19	0.1716	4.359	AA	527.1	784.3	13.9	61.8
503 600	255.2	434 500	...	220.2	477 000	...	241.7	18/1	19	0.1628	4.135	AA	474.4	705.9	12.5	55.6
465 400	235.8	397 500	...	201.4	397 500	...	201.4	26/7	19	0.1565	3.975	AA	438.4	652.4	12.2	54.3
419 600	212.6	362 000	...	183.4	397 500	...	201.4	18/1	19	0.1486	3.774	AA	395.3	588.2	11.2	49.8
394 500	199.9	336 400	...	170.5	336 400	...	170.5	26/7	19	0.1441	3.660	AA, A	371.7	553.1	10.5	46.7
355 100	179.9	306 400	...	155.3	336 400	...	170.5	18/1	19	0.1367	3.472	A	334.5	497.7	9.60	42.7
312 800	158.5	266 800	...	135.2	266 800	...	135.2	26/7	19	0.1283	3.259	A	297.7	438.4	8.45	37.6
281 400	142.6	242 900	...	123.1	266 800	...	135.2	18/1	19	0.1217	3.091	A	265.1	394.5	7.61	33.9
246 900	125.1	211 600	0000	107.2	211 600	0000	107.2	6/1	7	0.1878	4.770	AA	232.6	346.1	6.33	28.2
195 700	99.16	167 800	000	85.02	167 800	000	85.02	6/1	7	0.1672	4.247	AA, A	184.4	274.3	5.02	22.3
155 400	78.74	133 100	00	67.44	133 100	00	67.44	6/1	7	0.1490	3.785	AA, A	146.4	217.9	4.28	19.0
123 300	62.48	105 600	0	53.51	105 600	0	53.51	6/1	7	0.1327	3.371	AA, A	116.1	172.8	3.44	15.3
77 470	39.25	66 360	2	33.62	66 360	2	33.62	6/1	7	0.1052	2.672	AA, A	72.98	108.6	2.22	9.88
48 690	24.67	41 740	4	21.15	41 740	4	21.15	6/1	7	0.0834	2.118	A	45.87	68.25	1.43	6.36
30 580	15.49	26 240	6	13.30	26 240	6	13.30	6/1	7	0.0661	1.679	A	28.81	42.87	0.922	4.10

[A]Conversion factors: 1 cmil = 5067 E − 04 mm^2. 1 in. = 25.4 mm. 1 lbf = 4.448 E − 03 kN. 1 lb/1000 ft = 1.488 E + 00 kg/km. 1 ft = 3.048 E − 01 m. 1 lb = 4.536 E − 01 kg.

TABLE 2 Construction Requirements of Concentric-Lay-Stranded Aluminum-Alloy 5005 Conductors Sized by Standard Areas, Class AA and Class A[A]

Conductor Size		Required Construction		
cmil	AWG	Number of Wires	Diameter of Wires, in.	Class
1 000 000	...	37	0.1644	AA
900 000	...	37	0.1560	AA
800 000	...	37	0.1470	AA
750 000	...	37	0.1424	AA
700 000	...	37	0.1375	AA
650 000	...	37	0.1325	AA
600 000	...	37	0.1273	AA, A
550 000	...	37	0.1219	AA, A
500 000	...	19	0.1622	AA
450 000	...	19	0.1539	AA
400 000	...	19	0.1451	AA, A
350 000	...	19	0.1357	A
300 000	...	19	0.1257	A
250 000	...	19	0.1147	A
211 600	4/0	7	0.1739	AA, A
167 800	3/0	7	0.1548	AA, A
133 100	2/0	7	0.1379	AA, A
105 600	0	7	0.1228	AA, A
66 360	2	7	0.0974	AA, A
41 740	4	7	0.0772	A
26 240	6	7	0.0612	A

[A] Conversion factors: 1 cmil = 5.067 E − 04 mm^2(approximately). 1 in. = 25.4 mm.

TABLE 3 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)

[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 of core wire.

6. Lay

6.1 For Class AA conductors, the preferred lay of a layer of wires is 13.5 times the outside diameter of that layer, but the lay shall be not less than 10 nor more than 16 times this diameter.

6.2 For Class A conductors, the lay of a layer of wires shall be not 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 lay of the layers other than the two outer layers shall be at the option of the manufacturer, unless otherwise agreed upon.

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

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

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

7. Construction

7.1 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 or Table 2 as applicable (Explanatory Note 2, Explanatory Note 3, Explanatory Note 4, Explanatory Note 5, and Explanatory Note 6).

7.2 Where compressed stranding is required to insulate the conductor properly, one or more layers of any stranded conductor 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 11.

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. Rated Strength of Conductor

8.1 The rated strength of a completed conductor shall be taken as that percentage, indicated in Table 4, of the sum of the strengths of the 5005-H19 wires, calculated from their specified nominal wire diameter and the appropriate specified minimum average tensile strength given in Specification B 396.

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

9. Density

9.1 For the purpose of calculating weights (Note 3), cross sections, etc., the density of aluminum-alloy 5005 shall be taken as 0.098 $lb/in.^3$(2700 kg/m^3) at 20°C.

NOTE 3—The term "weight" is used in this specification because of established trade usage in place of the technically correct term," mass."

10. Weight and Electrical Resistance

10.1 The weight and electrical resistance of a unit length of stranded conductor are a function of the length of lay. The approximate weight 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 5).

11. Variation in Area

11.1 The cross-sectional area of the completed conductor shall be not less than 98 % of the area specified. The manufacturer may have the option of determining the cross-sectional area by either of the following methods, except that in the case of question regarding area compliance, the method described in 11.1.2 shall be used.

TABLE 4 Rating Factors

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

11.1.1 The cross-sectional area 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.

11.1.2 The cross-sectional area of a conductor may be determined by Method B 263. In applying that method, the increment in weight resulting from stranding may be the applicable value specified in 10.1 or may be calculated from the measured component dimensions of the sample under test. In case of question regarding area compliance, the actual weight increment due to stranding shall be calculated.

12. Finish

12.1 The conductor shall be free of all imperfections not consistent with good commercial practice.

13. Requirements of Wires

13.1 Before stranding, the aluminum alloy wire used shall conform to the requirements of Specification B 396.

14. Mechanical and Electrical Tests of Conductors

14.1 Tests for the mechanical and electrical properties of aluminum wires composing the conductors shall be made before, but not after, stranding unless otherwise agreed to between the manufacturer and the purchaser as provided in 14.2.

14.2 When requested by the purchaser at the time of placing the order, tension and elongation tests of wires before stranding may be waived and tests made on wires removed from the completed conductor. When so tested, the wires shall have minimum tensile strengths not less than 95 % of the tensile strength prescribed for individual tests in Table 1 of Specification B 396 (Explanatory Note 3).

14.3 All wires composing the conductors shall be capable of meeting the bending properties stated in Specification B 396 after stranding. Routine production testing after stranding is not required.

14.4 Tests for demonstration of rated strength of the completed conductor are not required by this specification but may be made if agreed to between the manufacturer and the purchaser at the time of placing an order. If tested, the breaking strength of the completed conductor shall be not less than the rate 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 4).

15. Inspection

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

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

15.3 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.

16. Packaging and Shipping

16.1 Package sizes for conductors shall be agreed to between the manufacturer and the purchaser in the placing of individual orders.

16.2 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.

16.3 Only one length shall be included in any one package.

17. Marking

17.1 The net weight (Note 3), length, size, and kind of conductor shall be marked on a tag attached to the end of the conductor inside of the package. The same information, together with the manufacturer's serial number (if any) and all shipping marks and other information required by the purchaser, shall appear on the outside of each package.

EXPLANATORY NOTES

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

NOTE 2—For definitions of terms relating to conductors, refer to Terminology B 354.

NOTE 3—Wires unlaid from conductors may have different physical properties from those of the wire when prepared for cabling, because of the deformation caused by laying and again straightening for test.

NOTE 4—To test stranded conductors for breaking strength successfully as a unit requires an 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 5—The increment of weight 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 weight 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 lay 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. The derivation of the above is given in *NBS Handbook 100*.

NOTE 6—The electrical characteristics of any conductor in service are influenced by conductivity, physical size, power frequency, temperature coefficient of resistance, etc., and it is not likely that one type of conductor may be stated to be the exact equivalent of another type except on a

closely defined basis. For example, a conductor made of high-strength aluminum alloy may be designed to be the equivalent of a conductor made of aluminum 1350 on the basis of d-c resistance at 20°C, but it may not be an exact equivalent in other ways. The constructions shown in Table 1 were designed to have physical diameters the same as those of standard sizes and strandings of ACSR as shown, for which suitable accessories and fittings are readily available. The approximate 1350 equivalent sizes shown in Table 2 are those standard sizes of 26/7 and 6/1 ACSR having approximately the same d-c resistance at 20°C (68°F). There are, however, no standard sizes of aluminum 1350 conductors that correspond to the alloy 5005 conductors having diameters the same as 18/1 ACSR strandings.

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order, for agencies of the U. S. Government.

S1. Referenced Documents

S1.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent reference herein:

S1.1.1 *Federal Standards:*[7]

Fed. Std. No. 102 Preservation, Packaging and Packing Levels

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

Fed. Std. No. 184 Identification Marking of Aluminum, Magnesium and Titanium

S1.1.2 *Military Standards:*[7]

MIL-STD-129 Marking for Shipment and Storage

MIL-STD-649 Preparation for Storage and Shipment of Aluminum and Magnesium Products

S2. Identification Marking

S2.1 All material shall be properly marked for identification in accordance with Fed. Std. No. 184 except that the ASTM specification number shall be shown.

S3. Inspection

S3.1 The purchaser shall have the right to perform any of the inspections and tests set forth in this specification when such inspections and tests are deemed necessary to assure that the material conforms to the prescribed requirements.

S4. Preparation for Delivery

S4.1 *Preservation, Packaging, Packing:*

S4.1.1 *Military Agencies*—The material shall be separated by size, composition, grade type, temper, and class, as applicable, and shall be preserved and packaged, Level A or C, and packed Level A, B, or C as specified in the contract or purchase order, in accordance with the requirements of MIL-STD-649.

S4.1.2 *Civil Agencies*—The requirements of Fed. Std. No. 102 shall be referenced for definitions of the various levels of packaging protection.

S4.2 *Marking:*

S4.2.1 *Military Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with MIL-STD-129.

S4.2.2 *Civil Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with Fed. Std. No. 123.

[7] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.