Designation: B 786 – 02a

Standard Specification for 19 Wire Combination Unilay-Stranded Aluminum Conductors for Subsequent Insulation[1]

This standard is issued under the fixed designation B 786; 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] 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.

Current edition approved ~~April~~ Oct. 10, 2002. Published ~~May~~ Decemeber 2002. Originally ~~published as B 786 – 88.~~ approved in 1988. Last previous edition approved in 2002 as B 786 – 0~~0~~2.

1. Scope

1.1 This specification covers bare combination unilay-stranded conductors made from round wires of aluminum 1350 and 8000 series of aluminum alloys, for insulated conductors for electrical purposes. Aluminum 1350 wires in tempers -H19 (extra hard), -H16 or -H26 (¾ hard), -H14 or -H24 (½ hard), and -H142 or -H242 (½ hard) and 8000 series aluminum alloys wires in tempers "0" and H1X or H2X are permitted. These conductors shall be constructed with a central core wire surrounded by two layers of helically laid wires, resulting in an outer diameter equal to the compressed-stranded equivalent conductors.

NOTE 1—For the purpose of this specification, combination unilay conductor is defined as follows: a central core wire surrounded by a layer of six helically laid wires of the same diameter as the core wire with a helically laid outer layer containing six smaller wires alternated between six wires of the same diameter as the wires in the layer underneath. Both layers have a common length and direction of lay (see Fig. 1).

1.1.1 For the purpose of this specification, normal conductor classification (Class AA, A, B, C) is not applicable, as these conductors are intended for subsequent insulation. The descriptive term combination unilay-stranded shall be used in place of conductor classification (Note 2 and Note 3).

NOTE 2—Prior to 1975, aluminum 1350 was designated as EC aluminum.

NOTE 3—The aluminum and temper designations conform to ANSI Standard H35.1. Aluminum 1350 corresponds to Unified Numbering System A91350 in accordance with Practice E 527. Unified Numbering System alloy designations for 8000 Series aluminum alloys in accordance with Practice E 527 are listed in Table number 1 of Specification B 800.

1.2 The values stated in inch-pound 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.

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 193 Test Method for Resistivity of Electrical Conductor Materials[2]
B 230 Specification for Aluminum 1350-H19 Wire for Electrical Purposes[2]
B 263 Test Method for Determination of Cross-Sectional Area of Stranded Conductors[2]
B 609 Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes[2]
B 800 Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes—Annealed and Intermediate Tempers[2]
B 801 Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation[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] *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.

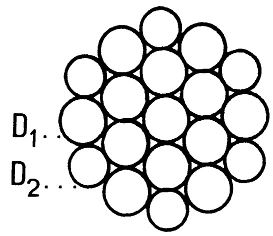

FIG. 1 Cross Section of Conductor

2.3 *ANSI Standard:*
ANSI H35.1 Alloy and Temper Designation Systems for Aluminum[5]
2.4 *NIST Standard:*
NBS Handbook 100[6]

3. Ordering Information

3.1 Orders for materials under this specification shall include the following information:
3.1.1 Conductor alloy,
3.1.2 Quantity of each size,
3.1.3 Conductor size: Circular-mil area or American Wire Gage, AWG (Section 6 and Table 1),
3.1.4 Stranding (see Explanatory Note 1),
3.1.5 Temper (see Section 11),
3.1.6 Details of special-purpose lays, if required (see 5.2),
3.1.7 When physical tests shall be made (see Sections 7 and 8),
3.1.8 Package size (see 16.1),
3.1.9 Heavy wood lagging, if required (see 17.2),
3.1.10 Special package marking, if required (Section 17), and
3.1.11 Place of inspection (Section 15).

4. Joints

4.1 Electric-butt welds, cold pressure welds, or electric-butt cold-upset welds may be made in the finished individual wires composing the conductor but shall not be closer together than 1 ft (Explanatory Note 2).

5. Lay

5.1 For combination unilay conductors the lay of a layer of wires shall be not less than 8 nor more than 16 times the outside diameter of the outer layer.
5.2 Other lays for special purposes shall be furnished by special agreement between the manufacturer and the purchaser.

NOTE 4—Certain types of insulation conductors may require shorter lay than other conductors. It is expected that special requirements regarding length of lay will be specified by the purchaser in such instances.

5.3 The direction of lay shall be left-hand unless the direction of lay is specified otherwise by the purchaser.

6. Construction (Explanatory Note 1)

6.1 The areas of cross section, numbers, and diameters of wires in the various conductors shall conform to the requirements prescribed in Table 1 (Note 3) (see Fig. 1).
6.2 The diameters of the wires listed in Table 2 are nominal. In order to produce an essentially round 19-wire construction, the outer 12-wire layer in the combination unilay product is comprised of 6 wires of the same diameter as the wires in the 7-wire core, and 6 wires approximately 25 % smaller. The 2-wire sizes are alternated around the 7-wire core.

7. Mechanical and Electrical Tests of Conductors not Annealed after Stranding

7.1 Wires composing the conductors shall be tested prior to stranding in accordance with the applicable specification (see 11.1.2), and tests on the completed conductor are not required. However, when requested by the purchaser and agreed to by the manufacturer at time of ordering, the tension tests of wires before stranding may be waived and the completed conductor tested in accordance with 7.2, or wires removed from the completed conductor tested in accordance with 7.5.
7.2 When the completed conductor is tested as a unit, the breaking strength shall be not less than the rated strength of 1350-H19 conductors or the minimum rated strength of 1350-H16, -H26, -H14, -H24, -H142, and -H242 conductors if failure occurs in the

[5] Available from American National Standards Institute, 11 West 42nd 25 W. 43rd St., 13th 4th Floor, New York, NY 10036.
[6] Available from the National Institute of Standards and Technology, (NIST), 100 Bureau Drive, Stop 3460, Gaithersburg, MD 20899-3460.

TABLE 1 Construction Requirements for 19-Wire Combination Unilay Stranded Aluminum Conductors

Area of Cross-Section, cmil	Size, American (or Brown and Sharpe) Wire Gage	Wire D_1[A] Diameter		Wire D_2[B] Diameter	
		mils	mm	mils	mm
~~556 500~~		~~185.3~~	~~4.71~~	~~135.6~~	~~3.50~~
556 500		185.3	4.71	135.6	3.44
~~500 000~~		~~175.6~~	~~4.46~~	~~128.5~~	~~3.31~~
500 000		175.6	4.46	128.5	3.26
~~477 000~~		~~171.5~~	~~4.36~~	~~125.5~~	~~3.24~~
477 000		171.5	4.36	125.5	3.19
~~450 000~~		~~166.6~~	~~4.23~~	~~121.9~~	~~3.14~~
450 000		166.6	4.23	121.9	3.10
~~397 500~~		~~156.6~~	~~3.99~~	~~114.6~~	~~2.96~~
397 500		156.6	3.99	114.6	2.91
~~350 000~~		~~146.9~~	~~3.98~~	~~107.5~~	~~2.95~~
350 000		146.9	3.98	107.5	2.73
~~336 400~~		~~144.0~~	~~3.73~~	~~105.4~~	~~2.77~~
336 400		144.0	3.73	105.4	2.68
~~300 000~~		~~136.0~~	~~3.66~~	~~99.6~~	~~2.72~~
300 000		136.0	3.66	99.6	2.53
~~266 800~~		~~128.3~~	~~3.45~~	~~93.9~~	~~2.57~~
266 800		128.3	3.45	93.9	2.38
~~250 000~~		~~124.2~~	~~3.26~~	~~90.9~~	~~2.42~~
250 000		124.2	3.26	90.9	2.31
~~211 600~~	~~0000~~	~~114.2~~	~~3.15~~	~~83.6~~	~~2.34~~
211 600	0000	114.2	3.15	83.6	2.12
~~167 800~~	~~000~~	~~101.7~~	~~2.90~~	~~74.5~~	~~2.16~~
167 800	000	101.7	2.90	74.5	1.89
~~133 100~~	~~00~~	~~90.6~~	~~2.58~~	~~66.3~~	~~1.92~~
133 100	00	90.6	2.58	66.3	1.68
~~105 600~~	~~0~~	~~80.7~~	~~2.30~~	~~59.1~~	~~1.71~~
105 600	0	80.7	2.30	59.1	1.50
~~83 690~~	~~1~~	~~71.8~~	~~2.05~~	~~52.6~~	~~1.52~~
83 690	1	71.8	2.05	52.6	1.34
~~66 360~~	~~2~~	~~64.0~~	~~1.82~~	~~46.8~~	~~1.36~~
66 360	2	64.0	1.82	46.8	1.19
~~52 620~~	~~3~~	~~57.0~~	~~1.62~~	~~41.7~~	~~1.21~~
52 620	3	57.0	1.62	41.7	1.06
~~41 740~~	~~4~~	~~50.7~~	~~1.45~~	~~37.1~~	~~1.08~~
41 740	4	50.7	1.45	37.1	0.94
~~33 090~~	~~5~~	~~45.2~~	~~1.29~~	~~33.1~~	~~0.96~~
33 090	5	45.2	1.29	33.1	0.84
~~26 240~~	~~6~~	~~40.2~~	~~1.15~~	~~29.4~~	~~0.85~~
26 240	6	40.2	1.15	29.4	0.75
~~20 820~~	~~7~~	~~35.8~~	~~1.02~~	~~26.2~~	~~0.76~~
20 820	7	35.8	1.02	26.2	0.67
~~16 510~~	~~8~~	~~31.9~~	~~0.81~~	~~23.4~~	~~0.60~~
16 510	8	31.9	0.81	23.4	0.59
~~13 090~~	~~9~~	~~28.4~~	~~0.72~~	~~20.8~~	~~0.54~~
13 090	9	28.4	0.72	20.8	0.53
~~10 380~~	~~10~~	~~25.3~~	~~0.64~~	~~18.5~~	~~0.48~~
10 380	10	25.3	0.64	18.5	0.47
~~6 530~~	~~12~~	~~20.1~~	~~0.51~~	~~14.7~~	~~0.38~~
6 530	12	20.1	0.51	14.7	0.37

[A] Equation to calculate D_1:

$$D_1 = \sqrt{\frac{\text{area of cross section (cmil)}}{16.2149}}$$

[B] Equation to calculate D_2:

$$D_2 = D_1 \times 0.732.$$

free length at least 1 in. (25 mm) beyond the end of either gripping device. The strength shall be not less than 95 % of the rated or minimum rated strength if failure occurs inside, or within 1 in. of the end of either gripping device. The breaking strength of 1350-H16, -H26, -H14, -H24, -H142, and -H242 conductors shall be not greater than their maximum rated strengths. 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 3).

7.3 The rated strength of 1350-H19 conductors and the minimum rated strength of 1350-H16, -H26, -H14, -H24, -H142, and -H242 conductors shall be taken as 93 % of the sum of the specified minimum average tensile strengths of the component wires for 1350-H19 conductors, as prescribed in Table 1, Tensile Requirements, of Specification B 230, and of the sum of the specified minimum tensile strengths of the component wires for 1350-H16, -H26, -H14, -H24, -H142, and -H242 conductors, as prescribed in Specification B 609, as applicable. The maximum rated strength of the 1350-H16, -H26, -H14, -H24, -H142 and -H242

TABLE 2 Diameters, Areas and Mass of 19-Wire Combination Unilay Stranded Aluminum Conductor[A]

Size of Conductor, cmil or AWG	Nominal Conductor Diameter[B]		Nominal Area		Mass		Direct Current Resistance at 20°C	
	in.	mm	in.^{2}	mm^2	lb/1000 ft	kg/km	Ω/1000 ft	Ω/km
556 500	0.827	21.0	0.4371	282	521	775	0.0312	0.1024
500 000	0.784	19.9	0.3927	253	468	697	0.0347	0.1139
477 000	0.766	19.5	0.3746	242	447	665	0.0364	0.1194
450 000	0.744	18.9	0.3534	228	421	627	0.0385	0.1263
397 500	0.699	17.8	0.3122	201	372	554	0.0436	0.1431
350 000	0.656	16.7	0.2749	177	328	488	0.0495	0.1624
336 400	0.643	16.3	0.2642	170	315	469	0.0516	0.1693
300 000	0.607	15.4	0.2356	152	281	418	0.0578	0.1896
266 800	0.573	14.6	0.2095	135	250	372	0.0650	0.2133
250 000	0.554	14.1	0.1963	127	234	348	0.0694	0.2277
0000	0.510	13.0	0.1662	107	198	295	0.0820	0.2690
000	0.454	11.5	0.1318	85.0	157	234	0.103	0.3389
00	0.404	10.3	0.1045	67.4	125	185	0.130	0.4275
0	0.360	9.14	0.08291	53.5	98.9	147	0.164	0.5387
1	0.321	8.15	0.06573	42.4	78.4	117	0.207	0.6798
2	0.286	7.26	0.05212	33.6	62.1	92.4	0.261	0.8573
3	0.254	6.45	0.04133	26.7	49.3	73.4	0.330	1.0814
4	0.226	5.74	0.03278	21.1	39.1	58.2	0.416	1.3633
5	0.202	5.13	0.02599	16.8	31.0	46.1	0.523	1.72
6	0.179	4.55	0.02061	13.3	24.6	36.6	0.661	2.1684
7	0.160	4.06	0.01635	10.5	19.5	29.0	0.834	2.7362
8	0.143	3.63	0.01297	8.37	15.5	23.1	1.05	3.4464
9	0.127	3.23	0.01028	6.63	12.3	18.3	1.32	4.3307
10	0.113	2.87	0.00816	5.26	9.73	14.5	1.67	5.4790
12	0.090	2.29	0.00513	3.31	6.12	9.11	2.67	8.7598

[A] Mass and electrical resistance are based on aluminum 1350.
[B] To calculate the diameter, multiply the large wire diameter in Table 1 times 3 and add two times the small wire diameter.
Example: AWG 4/0 diameter = [3(114.2) + 2(83.6)] = 509.8

conductors shall be taken as the sum of the specified maximum strengths of the component wires, as prescribed in Specification B 609, as applicable. The rated strengths shall be calculated using specified nominal wire diameters.

7.4 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 E 29.

7.5 When wires are removed from the completed conductor and tested, 1350-H19 wires shall have minimum tensile strengths not less than 95 % of the tensile strengths prescribed for individual tests in Table 1, Tensile Requirements, of Specification B 230. 1350-H16, -H26, -H14, -H24, -H142, and -H242 wires shall have tensile strengths not less than 95 % of the minimum tensile strength nor more than 105 % of the maximum tensile strength prescribed in Specification B 609, as applicable (Explanatory Note 4).

7.6 All wires composing the conductors shall be capable of meeting the bending properties stated in Specification B 230 after stranding. Routine production testing after stranding is not required.

7.7 Mechanical and electrical tests of conductors in 8000 series aluminum alloys in “0” temper, H1X or H2X wire and not annealed after stranding shall be in accordance with Section 9 of Specification B 801.

8. Mechanical and Electrical Tests of Conductors Annealed after Stranding

8.1 Tensile properties and electrical resistivity shall be determined on samples taken from 10 % of the reels or coils of conductor, but from not less than five (or all if the lot is less than five) reels or coils. Resistivity shall be determined as prescribed in the Resistivity section of Specification B 230 on one wire from each conductor sample except this test is not required if performed previously on the 1350-H19 wire. At the manufacturer’s option, tension tests shall be made either on one of the inner seven wires and one wire from each additional layer of each conductor sample to determine conformance with 8.2 or on the conductor as a unit to determine conformation with 8.3.

8.2 When wires removed from the completed conductor are tested, 1350-H26, -H24, and -H242 wires shall have tensile strengths not less than 95 % of the minimum tensile strength nor more than 105 % of the maximum tensile strength prescribed in Specification B 609, as applicable (Explanatory Note 4).

8.3 When the completed conductor is tested as a unit, the breaking strengths of 1350-H26, -H24, and -H242 conductors shall conform with 7.2, 7.3, and 7.4.

8.4 All wires composing the conductors shall be capable of meeting the bending properties stated in Specification B 230 after stranding. Routine production testing after stranding is not required.

8.5 Mechanical and electrical tests of conductors of 8000 series aluminum alloys fabricated from wires other than H2X and annealed after stranding to meet “0” temper or H2X requirements shall be in accordance with Section 10 of Specification B 801.

9. Mass and 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 using the standard increment of 2 %. When greater accuracy is desired, the increment based on the specific lay of the conductor may be calculated (Explanatory Note 1).

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

9.3 For conductors to be used in covered or insulated wires or cables, d-c resistance measurement may be used instead of the method outlined in Section 14, to determine compliance with this specification; however, the referee method shall be that outlined in Section 12.

10. Workmanship, Finish, and Appearance

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

11. Requirements for Wires

11.1 The purchaser shall designate the temper of wires to be used in the conductor.

11.1.1 For conductors of aluminum 1350 with tempers other than 1350-H19, the manufacturer shall have the following options on manufacturing method:

11.1.1.1 Strand the conductor from wires drawn to final temper,

11.1.1.2 Strand the conductor from wires drawn to H19 temper and annealed to final temper prior to stranding, and

11.1.1.3 Strand the conductor from 1350-H19 wires and anneal the stranded conductor to final temper.

11.1.2 Before stranding, the aluminum wire used shall meet all of the requirements of Specification B 230 or B 609, whichever is applicable.

11.1.3 For tempers of 8000 series aluminum alloys conductors, the manufacturer shall have the following options on manufacturing method:

11.1.3.1 Strand the conductor from wires annealed to final temper prior to stranding, and

11.1.3.2 Strand the conductor from as drawn wires and anneal the stranded conductor to final temper.

11.1.4 Before stranding, the aluminum wire used shall meet all of the requirements of Specification B 800.

11.2 All wires in the conductor shall be of the same temper.

12. Retest

12.1 If upon testing a sample from any reel or coil of conductor the results do not conform to the requirements of Sections 7 and 8, two additional samples shall be tested, and the average of the three tests shall determine the acceptance of the reel or coil.

13. Density

13.1 For the purpose of calculating mass, cross sections, etc., the density of aluminum 1350 shall be taken as 0.0975 lb/in.^{3} (2705 kg/m^3) and 8000 Series aluminum alloys shall be taken as 0.098 lb/in.^{3} (2710 kg/m^3) at 20°C.

14. Variance in Area

14.1 The area of cross section of the completed conductor shall be not less than 98 % of the area indicated in Column 1 of Table 1. Unless otherwise specified by the purchaser, the manufacturer shall determine the cross-sectional area by the following method:

TABLE 3 Temperature Correction Factors for Conductor Resistance

Temperature, °C	Multiplying Factor for Conversion to 20°C
0	1.088
5	1.064
10	1.042
15	1.020
20	1.000
25	0.980
30	0.961
35	0.943
40	0.925
45	0.908
50	0.892
55	0.876
60	0.861
65	0.846
70	0.832
75	0.818
80	0.805
85	0.792
90	0.780

14.1.1 The area of cross section of a conductor may be determined by Test Method B 263. In applying that method, the increment in mass resulting from stranding may be the applicable value specified in 9.1 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.

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 upon between the manufacturer and the purchaser at the time of 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. Product Marking

16.1 The net mass, length (or lengths and number of lengths, if more than one length is included in the package), size, kind of conductor, purchase order number, and any other marks required by the purchase order 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 required by the purchaser, shall appear on the outside of each package.

17. Packaging and Package Marking

17.1 Package sizes for conductors shall be agreed upon between the manufacturer and the purchaser in the placing of individual order (Explanatory Note 7).

17.2 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 purchase.

18. Keywords

18.1 aluminum alloy conductors; aluminum electrical conductor; combination stranded conductor; electrical conductor; electrical conductor-aluminum; insulated electrical conductor; stranded conductor; unilay stranded conductor; 8000-series aluminum alloy conductors

EXPLANATORY NOTES

NOTE 1—The construction details in paragraphs 6.1 and 6.2 are considered typical and are not intended to restrict other constructions that otherwise meet physical, electrical and mechanical requirements of this specification.

NOTE 2—The behavior of properly spaced wire joints 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 conductors with more than seven wires.

NOTE 3—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 4—Wires unlaid from conductors may have different physical properties from those of the wire when prepared for cabling, on account of the deformation caused by laying and again straightening for test.

NOTE 5—The increment of mass or electrical resistance of a completed concentric-lay-stranded conductor (k) in percent is as follows:

$$k = 100\,(m - 1) \tag{1}$$

where m is the stranding factor, and 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 lay, that is, all wires parallel to the conductor axis. For combination unilay conductors the stranding factor m for the completed stranded conductor is the ratio of the *sum of the individual weights of the twisted strand components* to the *sum of the equivalent weights of the strand components if they were untwisted*.The derivation of the above is given in the *NBS Handbook 100.*

$$m = \frac{W}{W'} = \frac{[1m_1 + 6m_2 + 6m_3 + (6 \times 0.732^2)m_4]\times\left[\delta \times 12 \times \frac{\pi}{4} \times D_1^{\,2}\right]}{[1 + 6 + 6 + (6 \times 0.732^2)]\times\left[\delta \times 12 \times \frac{\pi}{4} \times D_1^{\,2}\right]} = \frac{[1m_1 + 6m_2 + 6m_3 + (3.215)m_4]}{[16.215]} \tag{2}$$

W	=	the weight of all the strand components in the twisted conductor (lb/ft)
W'	=	the equivalent weight of all the strand components if they were untwisted (lb/ft)
D_1	=	diameter of larger strand component (refer to Fig. 1) (in.)
D_2	=	diameter of smaller strand component (refer to Fig. 1) (in.) = $0.732 \times D_1$
δ	=	density of metal (lb/in.^{3})
12	=	number of inches in 1 foot
LOL	=	length of lay (in.)

$$m_1 = \text{ratio increase for the center wire} = 1 \tag{3}$$

$$m_2 = \text{ratio increase for the wires in the inner layer} = \sqrt{1 + \frac{\pi^2 \times (2 \times D_1)^2}{LOL^2}} \tag{4}$$

$$m_3 = \textit{ratio increase for the wires of diameter } D_1 \textit{ the outer layer} = \sqrt{1 + \frac{\pi^2 \times (3.464 \times D_1)^2}{LOL^2}} \tag{5}$$

$$m_4 = \textit{ratio increase for the wires of diameter } D_2 \textit{ the outer layer} = \sqrt{1 + \frac{\pi^2 \times (3.732 \times D_1)^2}{LOL^2}} \tag{6}$$

For the above equations m_2, m_3 and m_4 may be simplified using the following approximation:

$$y = \sqrt{1 + x^2} \cong 1 + \frac{x^2}{2} \textit{ where } x \leq 0.125 \tag{7}$$

The simplified ratio increase equations then become:

$$m_2 \cong 1 + \frac{\pi^2 \times (2 \times D_1)^2}{2 \times (LOL^2)} = 1 + \frac{19.7392 \times D_1^{\,2}}{LOL^2} \tag{8}$$

$$m_3 = 1 + \frac{\pi^2 \times (3.464 \times D_1)^2}{2 \times (LOL^2)} = 1 + \frac{59.2141 \times D_1^{\,2}}{LOL^2} \tag{9}$$

$$m_4 = 1 + \frac{\pi^2 \times (3.732 \times D_1)^2}{2 \times (LOL^2)} = 1 + \frac{68.7310 \times {D_1}^2}{LOL^2} \quad (10)$$

Combining the terms, the combined m value for the conductor becomes:

$$m = \frac{[1m_1 + 6m_2 + 6m_3 + (3.215)m_4]}{[16.215]} \tag{11}$$

$$= \frac{\left[1 + 6 \times \left(1 + 19.7392 \times \left(\frac{D_1^{\,2}}{LOL^2}\right)\right) + 6 \times \left(1 + 59.2141 \times \left(\frac{D_1^{\,2}}{LOL^2}\right)\right) + (6 \times 0.732^2) \times \left(1 + 68.7310 \times \left(\frac{D_1^{\,2}}{LOL^2}\right)\right)\right]}{[16.215]}$$

$$= \frac{16.215 + 694.686 \frac{D_1^{\,2}}{LOL^2}}{16.215}$$

$$= 1 + 42.8422 \frac{D_1^{\,2}}{LOL^2}$$

NOTE 6—The d-c resistance on a given construction shall be calculated using the following formula:
Inch-Pound Units:

$$R = \left(\frac{k}{100} + 1\right)\frac{\rho}{A} \tag{12}$$

or Metric Units:

$$R\left[\left(\frac{K}{100} + 1\right)\frac{\rho}{A}\right]1000 \tag{13}$$

where:
R = conductor resistance in Ω/1000 ft (Ω/km),
k = increment due to stranding from Table 2 and Explanatory Note 5,
ρ = volume resistivity in ohms-cmil/ft (Ω-mm^2/m), determined in accordance with Test Method B 193, and
A = cross-sectional area of conductor in kcmil (mm^2) determined in accordance with Section 6 of this specification.

NOTE 7—To cooperate with the manufacturer in avoiding the accumulation of excessive amount of scrap wire, it is suggested that package sizes permit ordinary variations of plus and minus 10 % in package lengths, and that occasional short lengths be permitted, such packages to be distinctly marked.