



# Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric- Stranded Members, for Electrical Conductors<sup>1</sup>

This standard is issued under the fixed designation B173; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

## 1. Scope

1.1 This specification covers bare rope-lay-stranded conductors having concentric-stranded members made from round copper wires, either uncoated or coated with tin, lead, or lead-alloy for use as electrical conductors (Explanatory [Note 1](#) and [Note 2](#)).

1.2 Coated wires shall include only those wires with finished diameters and densities substantially equal to the respective diameters and densities of uncoated wires.

1.3 The values stated in inch-pound or SI units are to be regarded separately as standard. Each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. For conductor sizes designated by AWG or kcmil, the requirements in SI units have been numerically converted from corresponding values, stated or derived, in inch-pound units. For conductor sizes designated by SI units only, the requirements are stated or derived in SI units.

1.3.1 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 at the time of reference form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards*:<sup>2</sup>

- [B3 Specification for Soft or Annealed Copper Wire](#)
- [B8 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft](#)
- [B33 Specification for Tin-Coated Soft or Annealed Copper](#)

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee B01 on Electrical Conductors and is the direct responsibility of Subcommittee B01.04 on Conductors of Copper and Copper Alloys.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[Wire for Electrical Purposes](#)

[B172 Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors](#)

[B189 Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes](#)

[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](#)

2.3 *American National Standard*:

[ANSI C42.35 Definitions of Electrical Terms](#)<sup>3</sup>

## 3. Classification

3.1 For the purpose of this specification rope-lay-stranded conductors having concentric-stranded members are classified as follows:

3.1.1 *Class G*—Conductors consisting of 7 to 61 rope-lay-stranded members, each of which consists of 7 to 19 concentric-stranded wires, with total conductor sizes ranging from No. 14 AWG (2.08 mm<sup>2</sup>) to 5 000 000 cmil (2534 mm<sup>2</sup>). (Typical use is for rubber-sheathed conductor, apparatus conductor, portable conductor, and similar applications.)

3.1.2 *Class H*—Conductors consisting of 19 to 91 rope-lay-stranded members, each of which consists of 7 to 19 concentric-stranded wires, with total conductor sizes ranging from No. 9 AWG (6.63 mm<sup>2</sup>) to 5 000 000 cmil (2534 mm<sup>2</sup>). Class K construction produces a conductor with greater flexibility than class G. (Typical use is for rubber-sheathed cord and applications where flexibility is required such as on take-up reels over sheaves and extra-flexible apparatus conductor.)

## 4. Ordering Information

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

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

- 4.1.1 Quantity of each size and class;
- 4.1.2 Conductor size: circular-mil area or AWG (Section 7);
- 4.1.3 Class (Section 3 and Tables 1 and 2);
- 4.1.4 Whether coated or uncoated; if coated, designate type of coating (see 11.1);
- 4.1.5 Details of special-purpose lays, if required (see 6.2 and 6.3) and (Explanatory Note 3);
- 4.1.6 Package size (see 14.1);
- 4.1.7 Special package marking, if required (Section 15);
- 4.1.8 Lagging, if required (see 14.2); and
- 4.1.9 Place of inspection (Section 13).

## 5. Joints

5.1 Necessary joints in wires or in groups of wires shall be made in accordance with accepted commercial practice, taking into account the size of the wire or group of wires as related to the size of the entire conductor.

5.2 Concentric-stranded members forming the completed conductor may be joined as a unit by soldering, brazing, or welding.

5.3 Joints shall be so constructed and so disposed throughout the conductor that the diameter or configuration of the completed conductor is not substantially affected, and so that the flexibility of the completed conductor is not adversely affected.

## 6. Lay (Explanatory Note 3)

6.1 Conductors of the same size and description furnished on one order shall have the same lay.

6.2 The length of lay of the outer layer of the rope-lay stranded conductor shall be not less than 8 nor more than 16 times the outside diameter of the completed conductor. The length of lay of the other layers shall be at the option of the manufacturer unless specifically agreed upon. The direction of lay of the outer layer shall be left-hand, unless the direction of lay is specified otherwise by the purchaser. The direction of lay of the other layers shall be reversed in successive layers, unless otherwise agreed upon between the manufacturer and the purchaser.

6.3 The length of lay of the individual wires composing the stranded members shall be not less than 8 nor more than 16 times the outside diameter of that layer. Unless otherwise specified, the direction of lay of the outer layer of wires shall be at the option of the manufacturer. The direction of lay shall be reversed in successive layers, unless otherwise agreed upon between the manufacturer and the purchaser.

## 7. Construction

7.1 The area of cross section and the number and diameter of wires for a variety of strand constructions in general use are shown in Tables 1 and 2.

## 8. Physical and Electrical Tests

8.1 Tests for the electrical properties of wires composing conductors made from soft or annealed copper wire, bare or coated, shall be made before stranding.

8.2 Tests for the physical properties of soft or annealed copper wire, bare or coated, may be made upon the wires before stranding or upon wires removed from the completed stranded conductors, but need not be made upon both. Care shall be taken to avoid mechanical injury and stretching when removing wires from the conductor for the purpose of testing.

8.3 The physical properties of wire when tested before stranding shall conform to the applicable requirements of 11.1.

8.4 The physical properties of wires removed from the completed stranded conductor shall be permitted to vary from the applicable requirements of 11.1 by the following amounts: (Explanatory Note 4):

8.4.1 *Average of Results Obtained on All Wires Tested*—The percent minimum elongation may be reduced by the value of 5 % from the values required for unstranded wires as specified by Specifications B3, B33, or B189, as applicable. For example, where the unstranded wire specification requires minimum elongation of 30 %, wire of that material removed from Specification B173 stranded conductor shall meet a minimum elongation value of 25 %, a value 5 % reduction.

8.4.2 *Results Obtained on Individual Wires*—The percent minimum elongation may be reduced by the value of 15 % from the values required for unstranded wires as specified by Specifications B3, B33, or B189, as applicable. For example, where the unstranded wire specification requires minimum elongation of 30 % wire of that material removed from Specification B173 stranded conductor shall meet a minimum elongation value of 15 %. If the reduction results in minimum elongation of less than 5 %, a minimum of 5 % shall apply.

8.5 In the event that the requirements prescribed in 8.4.2 are met, but those prescribed in 8.4.1 are not met, a retest shall be permitted wherein all wires of a conductor of 100 wires or less, or 100 wires selected at random throughout a conductor of more than 100 wires shall be tested for the purpose of final determination for conformance to 8.4.

8.6 Elongation tests to determine compliance shall not be made on the conductor as a unit.

8.7 If a tinning, lead-coating, or lead-alloy-coating test is required, it shall be made on the wires prior to stranding.

## 9. Density

9.1 For the purpose of calculating mass, cross sections, etc., the density of copper shall be taken as 8.89 g/cm<sup>3</sup> (0.32117 lb/in.<sup>3</sup>) at 20°C (Explanatory Note 5).

## 10. Mass and Resistance

10.1 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 increments shown in Explanatory Note 6. When greater accuracy is desired, the increment based on the specific lay of the conductor may be calculated (Explanatory Note 7).

10.2 The maximum electrical resistance of a unit of stranded conductor shall not exceed 2 % over the nominal DC resistance shown in Table 1 and Table 2. When the DC

TABLE 1 Constructional and DC Resistance Requirements of Rope-Lay Stranded Copper Conductors Having Concentric-Stranded Members—Class G<sup>A</sup>

| Area of Cross<br>Section |                 | Completed Conductor <sup>B</sup> |                       |                         |      |                                            |                     |      |                 |                                  |                               | Uncoated Copper               |                               |                               | Tinned Copper                 |                   |         |                 |
|--------------------------|-----------------|----------------------------------|-----------------------|-------------------------|------|--------------------------------------------|---------------------|------|-----------------|----------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------|---------|-----------------|
|                          |                 | Size<br>AWG                      | Number<br>of<br>Wires | Diameter<br>of<br>Wires |      | Number<br>of<br>Wires<br>in Each<br>Member | Nominal<br>Diameter |      | Nominal<br>Mass | Nominal DC<br>Resistance<br>@20C | Maximum DC<br>Resistance @20C | Nominal DC<br>Resistance @20C | Maximum DC<br>Resistance @20C | Nominal DC<br>Resistance @20C | Maximum DC<br>Resistance @20C |                   |         |                 |
|                          |                 |                                  |                       | in.                     | mm   |                                            | in.                 | mm   |                 |                                  |                               |                               |                               |                               |                               | lb/<br>1000<br>ft | kg/km   | ohm/<br>1000 ft |
| cmil                     | mm <sup>2</sup> | ...                              | 1159                  | 0.0657                  | 1.67 | 19                                         | 2.957               | 75.1 | 16 052          | 23 888                           | 0.00220                       | 0.00721                       | 0.00224                       | 0.00735                       | 0.00229                       | 0.00750           | 0.00234 | 0.00765         |
| 5 000 000                | 2534            | ...                              | 1159                  | 0.0623                  | 1.58 | 19                                         | 2.804               | 71.2 | 14 433          | 21 479                           | 0.00244                       | 0.00801                       | 0.00249                       | 0.00817                       | 0.00254                       | 0.00833           | 0.00259 | 0.00850         |
| 500 000                  | 2280            | ...                              | 1159                  | 0.0587                  | 1.49 | 19                                         | 2.642               | 67.1 | 12 814          | 19 069                           | 0.00275                       | 0.00902                       | 0.00281                       | 0.00920                       | 0.00286                       | 0.00938           | 0.00292 | 0.00957         |
| 500 000                  | 2073            | ...                              | 1159                  | 0.0550                  | 1.40 | 19                                         | 2.475               | 62.9 | 11 249          | 16 741                           | 0.00314                       | 0.0103                        | 0.00320                       | 0.0105                        | 0.00327                       | 0.0107            | 0.00334 | 0.0109          |
| 500 000                  | 1773            | ...                              | 1159                  | 0.0509                  | 1.29 | 19                                         | 2.291               | 58.2 | 9635            | 14 338                           | 0.00366                       | 0.0120                        | 0.00373                       | 0.0122                        | 0.00381                       | 0.0125            | 0.00389 | 0.0128          |
| 500 000                  | 1520            | ...                              | 703                   | 0.0596                  | 1.51 | 19                                         | 2.086               | 53.0 | 8012            | 11 924                           | 0.00440                       | 0.0144                        | 0.00449                       | 0.0147                        | 0.00457                       | 0.0150            | 0.00466 | 0.0153          |
| 500 000                  | 1267            | ...                              | 703                   | 0.0533                  | 1.35 | 19                                         | 1.866               | 47.4 | 6408            | 9536                             | 0.00550                       | 0.0180                        | 0.00561                       | 0.0184                        | 0.00572                       | 0.0188            | 0.00583 | 0.0192          |
| 900 000                  | 1013            | ...                              | 703                   | 0.0520                  | 1.32 | 19                                         | 1.820               | 46.2 | 6099            | 9077                             | 0.00579                       | 0.0190                        | 0.00591                       | 0.0194                        | 0.00602                       | 0.0197            | 0.00614 | 0.0201          |
| 800 000                  | 963             | ...                              | 703                   | 0.0506                  | 1.29 | 19                                         | 1.771               | 45.0 | 5775            | 8594                             | 0.00611                       | 0.0200                        | 0.00623                       | 0.0204                        | 0.00635                       | 0.0208            | 0.00648 | 0.0212          |
| 750 000                  | 912             | ...                              | 703                   | 0.0499                  | 1.27 | 19                                         | 1.747               | 44.4 | 5617            | 8358                             | 0.00628                       | 0.0206                        | 0.00641                       | 0.0210                        | 0.00653                       | 0.0214            | 0.00666 | 0.0218          |
| 700 000                  | 887             | ...                              | 703                   | 0.0492                  | 1.25 | 19                                         | 1.722               | 43.7 | 5460            | 8125                             | 0.00647                       | 0.0212                        | 0.00660                       | 0.0216                        | 0.00672                       | 0.0221            | 0.00685 | 0.0225          |
| 600 000                  | 861             | ...                              | 703                   | 0.0477                  | 1.21 | 19                                         | 1.670               | 42.4 | 5132            | 7638                             | 0.00687                       | 0.0225                        | 0.00701                       | 0.0230                        | 0.00715                       | 0.0234            | 0.00729 | 0.0239          |
| 500 000                  | 811             | ...                              | 427                   | 0.0593                  | 1.51 | 7                                          | 1.601               | 40.7 | 4772            | 7102                             | 0.00726                       | 0.0238                        | 0.00741                       | 0.0243                        | 0.00755                       | 0.0248            | 0.00770 | 0.0253          |
| 400 000                  | 760             | ...                              | 427                   | 0.0573                  | 1.46 | 7                                          | 1.547               | 39.3 | 4456            | 6631                             | 0.00778                       | 0.0255                        | 0.00794                       | 0.0260                        | 0.00809                       | 0.0265            | 0.00825 | 0.0270          |
| 300 000                  | 709             | ...                              | 427                   | 0.0552                  | 1.40 | 7                                          | 1.490               | 37.8 | 4135            | 6154                             | 0.00838                       | 0.0275                        | 0.00855                       | 0.0281                        | 0.00871                       | 0.0286            | 0.00888 | 0.0292          |
| 250 000                  | 659             | ...                              | 427                   | 0.0541                  | 1.37 | 7                                          | 1.461               | 37.1 | 3972            | 5911                             | 0.00871                       | 0.0286                        | 0.00888                       | 0.0292                        | 0.00906                       | 0.0297            | 0.00924 | 0.0303          |
| 200 000                  | 633             | ...                              | 427                   | 0.0530                  | 1.35 | 7                                          | 1.431               | 36.3 | 3812            | 5673                             | 0.00907                       | 0.0298                        | 0.00925                       | 0.0304                        | 0.00944                       | 0.0310            | 0.00963 | 0.0316          |
| 100 000                  | 557             | ...                              | 427                   | 0.0508                  | 1.29 | 7                                          | 1.372               | 34.8 | 3502            | 5212                             | 0.00990                       | 0.0325                        | 0.0101                        | 0.0332                        | 0.0103                        | 0.0338            | 0.0105  | 0.0345          |
| 000 000                  | 507             | ...                              | 427                   | 0.0484                  | 1.23 | 7                                          | 1.307               | 33.2 | 3179            | 4731                             | 0.01090                       | 0.0357                        | 0.0111                        | 0.0364                        | 0.0113                        | 0.0372            | 0.0115  | 0.0379          |
| 900 000                  | 456             | ...                              | 427                   | 0.0459                  | 1.17 | 7                                          | 1.239               | 31.5 | 2859            | 4255                             | 0.0121                        | 0.0397                        | 0.0123                        | 0.0405                        | 0.0126                        | 0.0413            | 0.0129  | 0.0421          |
| 800 000                  | 405             | ...                              | 427                   | 0.0433                  | 1.10 | 7                                          | 1.169               | 29.7 | 2544            | 3787                             | 0.0136                        | 0.0447                        | 0.0139                        | 0.0456                        | 0.0142                        | 0.0464            | 0.0145  | 0.0473          |
| 750 000                  | 380             | ...                              | 427                   | 0.0419                  | 1.06 | 7                                          | 1.131               | 28.7 | 2383            | 3546                             | 0.0145                        | 0.0476                        | 0.0148                        | 0.0486                        | 0.0151                        | 0.0495            | 0.0154  | 0.0505          |
| 700 000                  | 355             | ...                              | 427                   | 0.0405                  | 1.03 | 7                                          | 1.094               | 27.8 | 2226            | 3313                             | 0.0156                        | 0.0510                        | 0.0159                        | 0.0520                        | 0.0162                        | 0.0531            | 0.0165  | 0.0542          |
| 650 000                  | 329             | ...                              | 427                   | 0.0390                  | 0.99 | 7                                          | 1.053               | 26.7 | 2064            | 3072                             | 0.0168                        | 0.0550                        | 0.0171                        | 0.0561                        | 0.0174                        | 0.0572            | 0.0177  | 0.0583          |
| 600 000                  | 304             | ...                              | 427                   | 0.0375                  | 0.95 | 7                                          | 1.013               | 25.7 | 1908            | 2840                             | 0.0181                        | 0.0595                        | 0.0185                        | 0.0607                        | 0.0189                        | 0.0619            | 0.0193  | 0.0631          |
| 550 000                  | 279             | ...                              | 427                   | 0.0359                  | 0.91 | 7                                          | 0.969               | 24.6 | 1749            | 2603                             | 0.0198                        | 0.0650                        | 0.0202                        | 0.0663                        | 0.0206                        | 0.0676            | 0.0210  | 0.0690          |
| 500 000                  | 253             | ...                              | 259                   | 0.0439                  | 1.12 | 7                                          | 0.922               | 23.4 | 1579            | 2350                             | 0.0217                        | 0.0711                        | 0.0221                        | 0.0725                        | 0.0225                        | 0.0740            | 0.0230  | 0.0755          |
| 450 000                  | 228             | ...                              | 259                   | 0.0417                  | 1.06 | 7                                          | 0.876               | 22.3 | 1425            | 2120                             | 0.0241                        | 0.0790                        | 0.0246                        | 0.0806                        | 0.0251                        | 0.0822            | 0.0255  | 0.0838          |
| 400 000                  | 203             | ...                              | 259                   | 0.0393                  | 1.00 | 7                                          | 0.825               | 21.0 | 1265            | 1883                             | 0.0271                        | 0.0889                        | 0.0276                        | 0.0907                        | 0.0282                        | 0.0924            | 0.0288  | 0.0942          |
| 350 000                  | 177             | ...                              | 259                   | 0.0368                  | 0.93 | 7                                          | 0.773               | 19.6 | 1109            | 1651                             | 0.0310                        | 0.102                         | 0.0316                        | 0.104                         | 0.0322                        | 0.106             | 0.0328  | 0.108           |
| 300 000                  | 152             | ...                              | 259                   | 0.0340                  | 0.86 | 7                                          | 0.714               | 18.1 | 947             | 1409                             | 0.0361                        | 0.119                         | 0.0368                        | 0.121                         | 0.0376                        | 0.123             | 0.0384  | 0.125           |
| 250 000                  | 127             | ...                              | 259                   | 0.0311                  | 0.79 | 7                                          | 0.653               | 16.6 | 792             | 1179                             | 0.0434                        | 0.142                         | 0.0443                        | 0.145                         | 0.0451                        | 0.148             | 0.0460  | 0.151           |
| 211 600                  | 107             | 0000                             | 133                   | 0.0399                  | 1.01 | 7                                          | 0.599               | 15.2 | 667             | 992                              | 0.0510                        | 0.167                         | 0.0520                        | 0.170                         | 0.0530                        | 0.174             | 0.0541  | 0.177           |
| 167 800                  | 85.0            | 000                              | 133                   | 0.0355                  | 0.90 | 7                                          | 0.533               | 13.5 | 528             | 785                              | 0.0643                        | 0.211                         | 0.0656                        | 0.215                         | 0.0668                        | 0.219             | 0.0681  | 0.223           |
| 133 100                  | 67.4            | 00                               | 133                   | 0.0316                  | 0.80 | 7                                          | 0.474               | 12.0 | 418             | 622                              | 0.0810                        | 0.266                         | 0.0826                        | 0.271                         | 0.0843                        | 0.276             | 0.0860  | 0.282           |
| 105 600                  | 53.5            | 0                                | 133                   | 0.0282                  | 0.72 | 7                                          | 0.423               | 10.7 | 333             | 495                              | 0.102                         | 0.335                         | 0.104                         | 0.342                         | 0.106                         | 0.348             | 0.108   | 0.355           |
| 83 690                   | 42.4            | 1                                | 133                   | 0.0251                  | 0.64 | 7                                          | 0.377               | 9.6  | 264             | 393                              | 0.129                         | 0.423                         | 0.132                         | 0.431                         | 0.134                         | 0.440             | 0.137   | 0.449           |
| 66 360                   | 33.6            | 2                                | 49                    | 0.0368                  | 0.93 | 7                                          | 0.331               | 8.4  | 207             | 308                              | 0.161                         | 0.528                         | 0.164                         | 0.539                         | 0.167                         | 0.549             | 0.170   | 0.560           |
| 52 620                   | 26.7            | 3                                | 49                    | 0.0328                  | 0.83 | 7                                          | 0.295               | 7.5  | 164             | 245                              | 0.203                         | 0.666                         | 0.207                         | 0.679                         | 0.211                         | 0.693             | 0.215   | 0.707           |
| 41 740                   | 21.1            | 4                                | 49                    | 0.0292                  | 0.74 | 7                                          | 0.263               | 6.7  | 130             | 194                              | 0.256                         | 0.840                         | 0.261                         | 0.857                         | 0.266                         | 0.873             | 0.271   | 0.890           |
| 33 090                   | 16.8            | 5                                | 49                    | 0.0260                  | 0.66 | 7                                          | 0.234               | 5.9  | 103             | 154                              | 0.323                         | 1.06                          | 0.329                         | 1.08                          | 0.336                         | 1.10              | 0.343   | 1.12            |
| 26 240                   | 13.3            | 6                                | 49                    | 0.0231                  | 0.59 | 7                                          | 0.208               | 5.3  | 81.5            | 121                              | 0.407                         | 1.34                          | 0.415                         | 1.37                          | 0.423                         | 1.39              | 0.431   | 1.42            |
| 20 820                   | 10.5            | 7                                | 49                    | 0.0206                  | 0.52 | 7                                          | 0.185               | 4.7  | 64.8            | 96.5                             | 0.513                         | 1.68                          | 0.523                         | 1.71                          | 0.534                         | 1.75              | 0.545   | 1.79            |
| 16 510                   | 8.37            | 8                                | 49                    | 0.0184                  | 0.47 | 7                                          | 0.166               | 4.2  | 51.7            | 77.0                             | 0.647                         | 2.12                          | 0.660                         | 2.16                          | 0.687                         | 2.25              | 0.701   | 2.30            |
| 13 090                   | 6.63            | 9                                | 49                    | 0.0163                  | 0.41 | 7                                          | 0.148               | 3.8  | 40.6            | 60.4                             | 0.816                         | 2.68                          | 0.832                         | 2.73                          | 0.867                         | 2.84              | 0.884   | 2.90            |
| 10 380                   | 5.26            | 10                               | 49                    | 0.0146                  | 0.37 | 7                                          | 0.131               | 3.3  | 32.6            | 48.5                             | 1.03                          | 3.38                          | 1.05                          | 3.45                          | 1.09                          | 3.59              | 1.11    | 3.66            |



TABLE 1 Continued

| Area of Cross Section |                 | Size AWG | Diameter of Wires |        | Number of Wires | Completed Conductor <sup>B</sup> |                  |              | Uncoated Copper            |              |        | Tinned Copper              |              |        |                            |              |                            |
|-----------------------|-----------------|----------|-------------------|--------|-----------------|----------------------------------|------------------|--------------|----------------------------|--------------|--------|----------------------------|--------------|--------|----------------------------|--------------|----------------------------|
|                       |                 |          | in.               | mm     |                 | in Each Member                   | Nominal Diameter | Nominal Mass | Nominal DC Resistance @20C | ohm/ 1000 ft | ohm/km | Maximum DC Resistance @20C | ohm/ 1000 ft | ohm/km | Nominal DC Resistance @20C | ohm/ 1000 ft | Maximum DC Resistance @20C |
| cmil                  | mm <sup>2</sup> |          |                   |        |                 |                                  |                  | lb/ 1000 ft  |                            |              |        |                            |              |        |                            |              |                            |
|                       |                 |          |                   |        |                 |                                  |                  |              |                            |              |        |                            |              |        |                            |              |                            |
| 6530                  | 3.31            | 12       | 49                | 0.0115 | 0.29            | 7                                | 0.104            | 2.6          | 20.2                       | 30.1         | 1.64   | 5.37                       | 1.67         | 1.74   | 1.77                       | 5.81         | 5.81                       |
| 4110                  | 2.08            | 14       | 49                | 0.0092 | 0.23            | 7                                | 0.083            | 2.1          | 12.9                       | 19.2         | 2.60   | 8.53                       | 2.65         | 2.79   | 2.85                       | 9.33         | 9.33                       |

<sup>A</sup> The constructions shown in this table are typical of those used in the industry. It is not intended that this table preclude other constructions that may be desirable for specific applications. The constructions shown provide for a finished, non-covered, stranded conductor approximately of the area indicated. When specified by the purchaser, the number or size of wires may be increased to provide additional area to compensate for draw-down during subsequent processing.

<sup>B</sup> Values for the nominal diameter and mass of the completed conductor are approximate. The mass values are based upon the standard stranding increments listed in Explanatory Note 6.

TABLE 2 Constructional and DC Resistance Requirements of Rope-Lay Stranded Copper Conductors Having Concentric-Stranded Members—Class H<sup>A</sup>

| Area of Cross Section |      | Size AWG | Number of Wires | Diameter of Wires |      | Number of Wires in Each Member | Nominal Diameter |      | Completed Conductor <sup>B</sup> |      |            |        | Uncoated Copper            |         |                            |         | Tinned Copper              |         |                            |         |
|-----------------------|------|----------|-----------------|-------------------|------|--------------------------------|------------------|------|----------------------------------|------|------------|--------|----------------------------|---------|----------------------------|---------|----------------------------|---------|----------------------------|---------|
|                       |      |          |                 |                   |      |                                |                  |      | in.                              | mm   | lb/1000 ft | kg/km  | Nominal DC Resistance @20C |         | Maximum DC Resistance @20C |         | Nominal DC Resistance @20C |         | Maximum DC Resistance @20C |         |
|                       |      |          |                 | in.               | mm   |                                |                  |      |                                  |      |            |        | ohm/1000 ft                | ohm/km  | ohm/1000 ft                | ohm/km  | ohm/1000 ft                | ohm/km  | ohm/1000 ft                | ohm/km  |
| 5 000 000             | 2534 | ...      | 1729            | 0.0538            | 1.37 | 19                             | 2.959            | 75.2 | 2.959                            | 75.2 | 16 057     | 23 896 | 0.00220                    | 0.00721 | 0.00224                    | 0.00735 | 0.00229                    | 0.00750 | 0.00234                    | 0.00765 |
| 4 500 000             | 2280 | ...      | 1729            | 0.0510            | 1.30 | 19                             | 2.805            | 71.2 | 2.805                            | 71.2 | 14 429     | 21 473 | 0.00244                    | 0.00801 | 0.00249                    | 0.00817 | 0.00254                    | 0.00833 | 0.00259                    | 0.00850 |
| 4 000 000             | 2027 | ...      | 1729            | 0.0481            | 1.22 | 19                             | 2.646            | 67.2 | 2.646                            | 67.2 | 12 835     | 19 101 | 0.00275                    | 0.00902 | 0.00281                    | 0.00920 | 0.00286                    | 0.00938 | 0.00292                    | 0.00957 |
| 3 500 000             | 1773 | ...      | 1729            | 0.0450            | 1.14 | 19                             | 2.475            | 62.9 | 2.475                            | 62.9 | 11 234     | 16 718 | 0.00314                    | 0.0103  | 0.00320                    | 0.0105  | 0.00327                    | 0.0107  | 0.00334                    | 0.0109  |
| 3 000 000             | 1520 | ...      | 1729            | 0.0417            | 1.06 | 19                             | 2.294            | 58.3 | 2.294                            | 58.3 | 9647       | 14 356 | 0.00366                    | 0.0120  | 0.00373                    | 0.0122  | 0.00381                    | 0.0125  | 0.00389                    | 0.0128  |
| 2 500 000             | 1267 | ...      | 1159            | 0.0464            | 1.18 | 19                             | 2.088            | 53.0 | 2.088                            | 53.0 | 8006       | 11 915 | 0.00440                    | 0.0144  | 0.00449                    | 0.0147  | 0.00457                    | 0.0150  | 0.00466                    | 0.0153  |
| 2 000 000             | 1013 | ...      | 1159            | 0.0415            | 1.05 | 19                             | 1.868            | 47.4 | 1.868                            | 47.4 | 6405       | 9531   | 0.00550                    | 0.0180  | 0.00561                    | 0.0184  | 0.00572                    | 0.0188  | 0.00583                    | 0.0192  |
| 1 900 000             | 963  | ...      | 1159            | 0.0405            | 1.03 | 19                             | 1.823            | 46.3 | 1.823                            | 46.3 | 6100       | 9077   | 0.00579                    | 0.0190  | 0.00591                    | 0.0194  | 0.00602                    | 0.0197  | 0.00614                    | 0.0201  |
| 1 800 000             | 912  | ...      | 1159            | 0.0394            | 1.00 | 19                             | 1.773            | 45.0 | 1.773                            | 45.0 | 5773       | 8591   | 0.00611                    | 0.0200  | 0.00623                    | 0.0204  | 0.00635                    | 0.0208  | 0.00648                    | 0.0212  |
| 1 750 000             | 887  | ...      | 1159            | 0.0389            | 0.99 | 19                             | 1.751            | 44.5 | 1.751                            | 44.5 | 5627       | 8374   | 0.00628                    | 0.0206  | 0.00641                    | 0.0210  | 0.00653                    | 0.0214  | 0.00666                    | 0.0218  |
| 1 700 000             | 861  | ...      | 1159            | 0.0383            | 0.97 | 19                             | 1.724            | 43.8 | 1.724                            | 43.8 | 5455       | 8118   | 0.00647                    | 0.0212  | 0.00660                    | 0.0216  | 0.00672                    | 0.0221  | 0.00685                    | 0.0225  |
| 1 600 000             | 811  | ...      | 1159            | 0.0372            | 0.94 | 19                             | 1.674            | 42.5 | 1.674                            | 42.5 | 5146       | 7658   | 0.00687                    | 0.0225  | 0.00701                    | 0.0230  | 0.00715                    | 0.0234  | 0.00729                    | 0.0239  |
| 1 500 000             | 760  | ...      | 703             | 0.0462            | 1.17 | 19                             | 1.617            | 41.1 | 1.617                            | 41.1 | 4815       | 7165   | 0.00733                    | 0.0240  | 0.00748                    | 0.0245  | 0.00762                    | 0.0250  | 0.00777                    | 0.0255  |
| 1 400 000             | 709  | ...      | 703             | 0.0446            | 1.13 | 19                             | 1.561            | 39.6 | 1.561                            | 39.6 | 4487       | 6677   | 0.00785                    | 0.0258  | 0.00801                    | 0.0263  | 0.00817                    | 0.0268  | 0.00833                    | 0.0273  |
| 1 300 000             | 659  | ...      | 703             | 0.0430            | 1.09 | 19                             | 1.505            | 38.2 | 1.505                            | 38.2 | 4171       | 6207   | 0.00846                    | 0.0277  | 0.00863                    | 0.0283  | 0.00879                    | 0.0289  | 0.00897                    | 0.0295  |
| 1 250 000             | 633  | ...      | 703             | 0.0422            | 1.07 | 19                             | 1.477            | 37.5 | 1.477                            | 37.5 | 4017       | 5978   | 0.00879                    | 0.0289  | 0.00897                    | 0.0295  | 0.00915                    | 0.0300  | 0.00933                    | 0.0306  |
| 1 200 000             | 608  | ...      | 703             | 0.0413            | 1.05 | 19                             | 1.446            | 36.7 | 1.446                            | 36.7 | 3847       | 5726   | 0.00916                    | 0.0301  | 0.00934                    | 0.0307  | 0.00953                    | 0.0313  | 0.00972                    | 0.0319  |
| 1 100 000             | 557  | ...      | 703             | 0.0396            | 1.01 | 19                             | 1.386            | 35.2 | 1.386                            | 35.2 | 3537       | 5264   | 0.00999                    | 0.0328  | 0.0102                     | 0.0335  | 0.0104                     | 0.0341  | 0.0106                     | 0.0348  |
| 1 000 000             | 507  | ...      | 703             | 0.0377            | 0.96 | 19                             | 1.320            | 33.5 | 1.320                            | 33.5 | 3206       | 4771   | 0.0110                     | 0.0361  | 0.0112                     | 0.0368  | 0.0114                     | 0.0375  | 0.0116                     | 0.0383  |
| 900 000               | 456  | ...      | 703             | 0.0358            | 0.91 | 19                             | 1.253            | 31.8 | 1.253                            | 31.8 | 2891       | 4302   | 0.0122                     | 0.0409  | 0.0124                     | 0.0409  | 0.0127                     | 0.0417  | 0.0130                     | 0.0425  |
| 800 000               | 405  | ...      | 703             | 0.0337            | 0.86 | 19                             | 1.180            | 30.0 | 1.180                            | 30.0 | 2562       | 3812   | 0.0137                     | 0.0451  | 0.0140                     | 0.0460  | 0.0143                     | 0.0469  | 0.0146                     | 0.0478  |
| 750 000               | 380  | ...      | 703             | 0.0327            | 0.83 | 19                             | 1.145            | 29.1 | 1.145                            | 29.1 | 2359       | 3582   | 0.0147                     | 0.0481  | 0.0150                     | 0.0491  | 0.0152                     | 0.0500  | 0.0155                     | 0.0510  |
| 700 000               | 355  | ...      | 703             | 0.0316            | 0.80 | 19                             | 1.106            | 28.1 | 1.106                            | 28.1 | 2252       | 3359   | 0.0157                     | 0.0515  | 0.0160                     | 0.0525  | 0.0163                     | 0.0536  | 0.0166                     | 0.0547  |
| 650 000               | 329  | ...      | 703             | 0.0304            | 0.77 | 19                             | 1.064            | 27.0 | 1.064                            | 27.0 | 2085       | 3102   | 0.0169                     | 0.0555  | 0.0172                     | 0.0566  | 0.0176                     | 0.0577  | 0.0180                     | 0.0589  |
| 600 000               | 304  | ...      | 703             | 0.0292            | 0.74 | 19                             | 1.022            | 26.0 | 1.022                            | 26.0 | 1923       | 2862   | 0.0183                     | 0.0601  | 0.0187                     | 0.0613  | 0.0191                     | 0.0625  | 0.0195                     | 0.0638  |
| 550 000               | 279  | ...      | 703             | 0.0280            | 0.71 | 19                             | 0.980            | 24.9 | 0.980                            | 24.9 | 1768       | 2632   | 0.0200                     | 0.0656  | 0.0204                     | 0.0669  | 0.0208                     | 0.0682  | 0.0212                     | 0.0696  |
| 500 000               | 253  | ...      | 427             | 0.0342            | 0.87 | 7                              | 0.923            | 23.4 | 0.923                            | 23.4 | 1587       | 2362   | 0.0218                     | 0.0715  | 0.0222                     | 0.0729  | 0.0226                     | 0.0743  | 0.0231                     | 0.0758  |
| 450 000               | 228  | ...      | 427             | 0.0325            | 0.83 | 7                              | 0.878            | 22.3 | 0.878                            | 22.3 | 1433       | 2133   | 0.0242                     | 0.0794  | 0.0247                     | 0.0810  | 0.0252                     | 0.0826  | 0.0257                     | 0.0843  |
| 400 000               | 203  | ...      | 427             | 0.0306            | 0.78 | 7                              | 0.826            | 21.0 | 0.826                            | 21.0 | 1271       | 1891   | 0.0272                     | 0.0893  | 0.0277                     | 0.0911  | 0.0283                     | 0.0929  | 0.0289                     | 0.0948  |
| 350 000               | 177  | ...      | 427             | 0.0286            | 0.73 | 7                              | 0.772            | 19.6 | 0.772                            | 19.6 | 1110       | 1652   | 0.0311                     | 0.102   | 0.0317                     | 0.104   | 0.0324                     | 0.106   | 0.0330                     | 0.108   |
| 300 000               | 152  | ...      | 427             | 0.0265            | 0.67 | 7                              | 0.716            | 18.2 | 0.716                            | 18.2 | 953        | 1418   | 0.0363                     | 0.119   | 0.0370                     | 0.121   | 0.0377                     | 0.124   | 0.0385                     | 0.126   |
| 250 000               | 127  | ...      | 427             | 0.0242            | 0.61 | 7                              | 0.653            | 16.6 | 0.653                            | 16.6 | 795        | 1183   | 0.0436                     | 0.143   | 0.0445                     | 0.146   | 0.0453                     | 0.149   | 0.0462                     | 0.152   |
| 211 600               | 107  | 0000     | 259             | 0.0286            | 0.73 | 7                              | 0.601            | 15.3 | 0.601                            | 15.3 | 670        | 997    | 0.0512                     | 0.168   | 0.0522                     | 0.171   | 0.0533                     | 0.175   | 0.0544                     | 0.178   |
| 167 800               | 85   | 000      | 259             | 0.0255            | 0.65 | 7                              | 0.536            | 13.6 | 0.536                            | 13.6 | 533        | 793    | 0.0646                     | 0.212   | 0.0659                     | 0.216   | 0.0672                     | 0.220   | 0.0685                     | 0.225   |
| 133 100               | 67.4 | 00       | 259             | 0.0227            | 0.58 | 7                              | 0.477            | 12.1 | 0.477                            | 12.1 | 422        | 628    | 0.0814                     | 0.267   | 0.0830                     | 0.272   | 0.0847                     | 0.278   | 0.0864                     | 0.283   |
| 105 600               | 53.5 | 0        | 259             | 0.0202            | 0.51 | 7                              | 0.424            | 10.8 | 0.424                            | 10.8 | 334        | 497    | 0.103                      | 0.337   | 0.105                      | 0.344   | 0.107                      | 0.350   | 0.109                      | 0.357   |
| 83 690                | 42.2 | 1        | 259             | 0.0180            | 0.46 | 7                              | 0.378            | 9.6  | 0.378                            | 9.6  | 265        | 395    | 0.129                      | 0.425   | 0.132                      | 0.434   | 0.138                      | 0.451   | 0.141                      | 0.460   |
| 66 360                | 33.6 | 2        | 259             | 0.0160            | 0.41 | 7                              | 0.335            | 8.5  | 0.335                            | 8.5  | 210        | 312    | 0.163                      | 0.536   | 0.167                      | 0.547   | 0.173                      | 0.569   | 0.176                      | 0.580   |
| 52 620                | 26.7 | 3        | 133             | 0.0199            | 0.51 | 7                              | 0.299            | 7.6  | 0.299                            | 7.6  | 166        | 247    | 0.205                      | 0.672   | 0.209                      | 0.685   | 0.218                      | 0.714   | 0.222                      | 0.729   |
| 41 740                | 21.1 | 4        | 133             | 0.0177            | 0.45 | 7                              | 0.266            | 6.8  | 0.266                            | 6.8  | 131        | 195    | 0.258                      | 0.848   | 0.264                      | 0.865   | 0.274                      | 0.900   | 0.279                      | 0.918   |
| 33 090                | 16.8 | 5        | 133             | 0.0158            | 0.40 | 7                              | 0.237            | 6.0  | 0.237                            | 6.0  | 105        | 156    | 0.326                      | 1.07    | 0.332                      | 1.09    | 0.346                      | 1.14    | 0.353                      | 1.16    |
| 26 240                | 13.3 | 6        | 133             | 0.0140            | 0.36 | 7                              | 0.210            | 5.3  | 0.210                            | 5.3  | 82.1       | 122    | 0.411                      | 1.35    | 0.419                      | 1.38    | 0.437                      | 1.43    | 0.446                      | 1.46    |
| 20 820                | 10.5 | 7        | 133             | 0.0125            | 0.32 | 7                              | 0.188            | 4.8  | 0.188                            | 4.8  | 65.4       | 97.4   | 0.518                      | 1.70    | 0.528                      | 1.73    | 0.550                      | 1.81    | 0.561                      | 1.85    |
| 16 510                | 8.37 | 8        | 133             | 0.0111            | 0.28 | 7                              | 0.167            | 4.2  | 0.167                            | 4.2  | 51.6       | 76.8   | 0.653                      | 2.14    | 0.666                      | 2.18    | 0.694                      | 2.28    | 0.708                      | 2.33    |
| 13 090                | 6.63 | 9        | 133             | 0.0099            | 0.25 | 7                              | 0.149            | 3.8  | 0.149                            | 3.8  | 41.0       | 61.1   | 0.824                      | 2.70    | 0.840                      | 2.75    | 0.885                      | 2.90    | 0.903                      | 2.96    |

<sup>A</sup> The constructions shown in this table are typical of those used in the industry. It is not intended that this table preclude other constructions that may be desirable for specific applications. The constructions shown provide for a finished, non-covered, stranded conductor approximately of the area indicated. When specified by the purchaser, the number or size of wires may be increased to provide additional area to compensate for draw-down during subsequent processing.

<sup>B</sup> Values for the nominal diameter and mass of the completed conductor are approximate. The mass values are based upon the standard stranding increments listed in Explanatory Note 6.

resistance is measured at other than 20°C, it is to be corrected by using the multiplying factor given in **Table 3**.

10.3 For conductors to be used in covered or insulated wires or cables, direct current (DC) resistance measurements shall be used instead of the method outlined in Section 12 to determine compliance with this specification.

## 11. Requirements for Wires

11.1 The purchaser shall designate the type of wire and type of coating, if any, to be used in the conductor.

11.1.1 Before stranding, uncoated wire shall meet the requirements of Specification **B3**.

11.1.2 Before stranding, tinned wire shall meet the requirements of Specification **B33**.

11.1.3 Before stranding, lead coated and lead-alloy coated wire shall meet the requirements of Specification **B189**.

11.2 These requirements shall not prohibit the manufacture of conductors from uncoated hard-drawn wires which are annealed after stranding.

## 12. Variation in Area

12.1 The calculated area of cross section of a stranded conductor expressed in circular mils shall be the product of the square of the specified diameter in mils of the individual wires times the number of wires prescribed (**Note 1**).

**NOTE 1**—The calculated area of such cables as may incorporate more than one size of component wires should be the sum of the areas of the different sizes of wires.

**TABLE 3 Temperature Correction Factors for Conductor Resistance**

| Temperature,<br>°C | Multiplying Factor<br>for Conversion<br>to 20°C |
|--------------------|-------------------------------------------------|
| 0                  | 1.085                                           |
| 5                  | 1.063                                           |
| 10                 | 1.041                                           |
| 15                 | 1.020                                           |
| 20                 | 1.000                                           |
| 25                 | .981                                            |
| 30                 | .962                                            |
| 35                 | .944                                            |
| 40                 | .927                                            |
| 45                 | .911                                            |
| 50                 | .895                                            |
| 55                 | .879                                            |
| 60                 | .864                                            |
| 65                 | .850                                            |
| 70                 | .836                                            |
| 75                 | .822                                            |
| 80                 | .809                                            |
| 85                 | .797                                            |
| 90                 | .784                                            |

12.2 The area of cross section of a completed stranded conductor designated as an AWG size shall be not less than 98 % of the area indicated in Column 1 of **Tables 1 and 2** for sizes 211 600 cmil (107 mm<sup>2</sup>) and smaller. The area of cross section of a completed stranded conductor not designated as an AWG size shall be not less than 98 % of a calculated value obtained as prescribed in **10.1**.

12.3 The area of cross section of a conductor shall be determined by Test Method **B263**. In applying this method, the increment of linear density resulting from stranding may be the applicable value listed in Explanatory **Note 6** or may be calculated from the measured component dimensions of the sample under test. In case of question regarding area compliance, the actual linear density increment due to stranding shall be calculated.

## 13. Inspection

13.1 All tests and inspection shall be made at the place of manufacture unless otherwise especially agreed upon between the manufacturer and the purchaser at the time of purchase. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities, without charge, to satisfy him that the material is being furnished in accordance with this specification.

## 14. Packaging and Package Marking

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

14.2 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.

## 15. Marking

15.1 The net mass, length (or 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.

## 16. Keywords

16.1 copper electrical conductor; electrical conductor—copper; rope-lay-stranded copper conductors; stranded copper conductor

## EXPLANATORY NOTES

NOTE 1—In this specification only rope-lay-stranded conductors constructed with concentric-stranded members are designated. Requirements for rope-lay-stranded conductors constructed with *bunch-stranded* members will be found in Specification B172. Requirements for concentric-lay-stranded conductors will be found in Specification B8.

NOTE 2—For definitions of terms relating to conductors, reference should be made to ANSI C42.35 and Terminology B354.

NOTE 3—Certain types of insulated conductors may require a shorter lay than other conductors. It is expected that departures from the provisions of this specification because of special requirements relative to length of lay, direction of lay, and direction of lay of successive layers will be agreed upon by the manufacturer and the purchaser.

NOTE 4—Wires removed from stranded conductors and straightened for tests will have altered physical properties due to cold working of the material. The reduced elongation requirement for wires removed from stranded conductors reflects this condition.

NOTE 5—The value of density of copper is in accordance with the International Annealed Copper Standard. The corresponding value at 0°C is 8.90 g/cm<sup>3</sup> (0.32150 lb/in.<sup>3</sup>). Density calculations involving coated wire should consider the variation of coated wire density from the density of uncoated copper wire. The relative affect of the coating density on the overall wire density becomes greater as wire diameters decrease.

NOTE 6—The following values approximate the incremental increase in mass and the incremental decrease in resistance of rope-lay stranded conductor as a result of stranding. The values are sufficiently accurate for most purposes and may be used when more precise values are not available. They are as follows:

| Construction                                       | Increment of<br>Linear Density<br>and Resistance, % |
|----------------------------------------------------|-----------------------------------------------------|
| Rope-lay-stranded conductors<br>(Classes G and H): |                                                     |
| 49 wires or less                                   | 3                                                   |
| 133 wires                                          | 4                                                   |
| 259 wires                                          | 4.5                                                 |
| 427 wires                                          | 5                                                   |
| Over 427 wires                                     | 6                                                   |

NOTE 7—Any calculation of the increment of mass or electrical resistance,  $k$ , of a rope-lay-stranded conductor involves two independent calculations:

(1) Determination of the increment due to stranding of the individual members, and

(2) Determination of the increment due to twisting these members to form the completed conductor.

In the case of a rope-lay-stranded conductor having concentric-stranded members, the increment  $k$ , in percent, may be expressed as:

$$k = k_m + k_a + k_m k_a / 100$$

where:

$k_m$  = is the increment of mass or electrical resistance, in percent, of an individual concentric-stranded member before twisting into the completed conductor, calculated as described in Specification B8, Note 9, and

$k_a$  = is the increment of mass or electrical resistance, in percent, due to twisting the concentric-stranded members into the completed conductor, calculated as described in Specification B8, Note 9, with each member considered as an individual wire.

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