INTERNATIONAL

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Standard Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors[1]

This standard is issued under the fixed designation B 258; 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 prescribes standard nominal diameters and cross-sectional areas of American Wire Gage (AWG) sizes of solid round wires, used as electrical conductors, and gives equations and rules for the calculation of standard nominal mass and lengths, resistances, and breaking strengths of such wires (Explanatory Note 1).

1.2 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 of the two systems may result in nonconformance with the specification. For conductor sizes designated by AWG or kcmil sizes, the requirements in SI units have been numerically converted from the 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.

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

2. Referenced Documents

2.1 *ASTM Standards:*

A 111 Specification for Zinc-Coated (Galvanized) "Iron" Telephone and Telegraph Line Wire[2]

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[1] This specification is under the jurisdiction of ASTM Committee B01 on Electrical Conductors and is the direct responsibility of Subcommittee B01.02 on Methods of Test and Sampling Procedure.

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A 326 Specification for Zinc-Coated (Galvanized) High Tensile Steel Telephone and Telegraph Line Wire[3]
B 1 Specification for Hard-Drawn Copper Wire[4]
B 2 Specification for Medium-Hard-Drawn Copper Wire[4]
B 3 Specification for Soft or Annealed Copper Wire[4]
B 9 Specification for Bronze Trolley Wire[4]
B 33 Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes[4]
B 47 Specification for Copper Trolley Wire[4]
B 105 Specification for Hard-Drawn Copper Alloy Wires for Electrical Conductors[4]
B 189 Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes[4]
B 193 Test Method for Resistivity of Electrical Conductor Materials
B 227 Specification for Hard-Drawn Copper-Clad Steel Wire[4]
B 230/B 230M Specification for Aluminum 1350-H19 Wire for Electrical Purposes[4]
B 314 Specification for Aluminum 1350 Wire for Communication Cable[5]
B 396 Specification for Aluminum-Alloy 5005-H19 Wire for Electrical Purposes[4]
B 398/B 398M Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes[4]
B 415 Specification for Hard-Drawn Aluminum-Clad Steel Wire[4]
B 609/B 609M Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes[4]
B 800 Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes—Annealed and Intermediate Tempers[4]
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[6]
F 205 Test Method for Measuring Diameter of Fine Wire by Weighing[7]

3. Standard Reference Temperature

3.1 For the purpose of this specification, all wire dimensions and properties shall be considered as occurring at the internationally standardized reference temperature of 20°C (68°F).

4. Standard Rules for Rounding

4.1 All calculations for the standard nominal dimensions and properties of solid round wires shall be rounded in the *final* value only, in accordance with rounding method of Practice E 29.

5. Standard Nominal Diameters

5.1 Standard nominal diameters of AWG sizes of solid round wires shall be calculated in accordance with the conventional mathematical law of the American Wire Gage (see Explanatory Note 1) and in accordance with Section 4.

5.2 For wire sizes 4/0 to 44 AWG, inclusive, nominal diameters shall be expressed in no more than four significant figures but in no case closer than the nearest 0.1 mil (0.0001 in.).

5.3 For wire sizes 45 to 56 AWG, inclusive, nominal diameters shall be expressed to the nearest 0.01 mil (0.00001 in.).

5.4 The standard nominal diameters expressed in mils have been calculated in accordance with these rules and are given in Table 1 for convenient reference (Explanatory Note 2).

6. Standard Nominal Cross-Sectional Areas

6.1 Standard nominal cross-sectional areas in circular mils and square ~~inches~~ millimetres shall be calculated in accordance with the following equations and shall be rounded in accordance with Section 4 to the same number of significant figures as used in expressing the standard diameters, but in no case to less than three significant figures:

$$\text{Area, cmil} = d^2$$

$$\cancel{\text{Area, in.}^2 = d^2 \times 0.7854 \times 10^{-6}}$$

$$\text{Area, mm}^2 = d^2 \times 5.067 \times 10^{-4}$$

where:
d = diameter of the wire in mils as given in Table 1.

Standard nominal cross-sectional areas in circular mils and square ~~inches~~ millimetres have been calculated in accordance with the foregoing rules and are given in Table 1 for convenient reference.

7. Rules for Calculations Involving Mass and Length

7.1 Standard nominal mass and lengths shall be calculated from the standard wire diameters specified in Table 1, in accordance

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[2] *Annual Book of ASTM Standards*, Vol 01.06.
[3] Discontinued, see *1990 Annual Book of ASTM Standards*, Vol 01.06.
[4] *Annual Book of ASTM Standards*, Vol 02.03.
[5] Discontinued, see *1994 Annual Book of ASTM Standards*, Vol 02.03.
[6] *Annual Book of ASTM Standards*, Vol 14.02.
[7] *Annual Book of ASTM Standards*, Vol 10.04.

TABLE 1 Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires at 20°C

Size	Diameter		Cross-Sectional Area			Size	Diameter		Cross-Sectional Area	
AWG	mils	mm	cmils	~~in²~~	mm²	AWG	mils	mm	cmils	~~in²~~
4/0	460.0	11.684	211 600	~~0.1662~~	107.2	29	11.3	0.287	128	~~0.000100~~
3/0	409.6	10.404	167 800	~~0.1318~~	85.0	30	10.0	0.254	100	~~0.0000785~~
2/0	364.8	9.26	133 100	~~0.1045~~	67.4	31	8.9	0.226	79.2	~~0.0000622~~
1/0	324.9	8.25	105 600	~~0.08291~~	53.5	32	8.0	0.203	64.0	~~0.0000503~~
1	289.3	7.35	83 690	~~0.06573~~	42.4	33	7.1	0.180	50.4	~~0.0000396~~
2	257.6	6.54	66 360	~~0.05212~~	33.6	34	6.3	0.160	39.7	~~0.0000312~~
3	229.4	5.82	52 620	~~0.04133~~	26.7	35	5.6	0.142	31.4	~~0.0000246~~
4	204.3	5.19	41 740	~~0.03278~~	21.1	36	5.0	0.127	25.0	~~0.0000196~~
5	181.9	4.62	33 090	~~0.02599~~	16.8	37	4.5	0.114	20.2	~~0.0000159~~
6	162.0	4.11	26 240	~~0.02061~~	13.3	38	4.0	0.102	16.0	~~0.0000126~~
7	144.3	3.67	20 820	~~0.01635~~	10.6	39	3.5	0.0890	12.2	~~0.00000962~~
8	128.5	3.26	16 510	~~0.01297~~	8.37	40	3.1	0.0787	9.61	~~0.00000755~~
9	114.4	2.91	13 090	~~0.01028~~	6.63	41	2.8	0.0711	7.84	~~0.00000616~~
10	101.9	2.59	10 380	~~0.008155~~	5.26	42	2.5	0.0635	6.25	~~0.00000491~~
11	90.7	2.30	8 230	~~0.00646~~	4.17	43	2.2	0.0559	4.84	~~0.00000380~~
12	80.8	2.05	6 530	~~0.00513~~	3.31	44	2.0	0.0508	4.00	~~0.00000314~~
13	72.0	1.83	5 180	~~0.00407~~	2.63	45	1.76	0.0447	3.10	~~0.00000243~~
14	64.1	1.63	4 110	~~0.00323~~	2.08	46	1.57	0.0399	2.46	~~0.00000194~~
15	57.1	1.45	3 260	~~0.00256~~	1.65	47	1.40	0.0356	1.96	~~0.00000154~~
16	50.8	1.29	2 580	~~0.00203~~	1.31	48	1.24	0.0315	1.54	~~0.00000121~~
17	45.3	1.15	2 050	~~0.00161~~	1.04	49	1.11	0.0282	1.23	~~9.68E-07~~
18	40.3	1.02	1 620	~~0.00128~~	0.823	50	0.99	0.0252	0.980	~~7.70 E-07~~
19	35.9	0.904	1 290	~~0.00101~~	0.653	51	0.88	0.0224	0.774	~~6.08E-07~~
20	32.0	0.813	1 020	~~0.000804~~	0.519	52	0.78	0.0198	0.608	~~4.78E-07~~
21	28.5	0.724	812	~~0.000638~~	0.412	53	0.70	0.0178	0.490	~~3.85E-07~~
22	25.3	0.643	640	~~0.000503~~	0.324	54	0.62	0.0158	0.384	~~3.02E-07~~
23	22.6	0.574	511	~~0.000401~~	0.259	55	0.55	0.0140	0.302	~~2.38E-07~~
24	20.1	0.511	404	~~0.000317~~	0.205	56	0.49	0.0125	0.240	~~1.89E-07~~
25	17.9	0.455	320	~~0.000252~~	0.162					
26	15.9	0.404	253	~~0.000199~~	0.128					
27	14.2	0.361	202	~~0.000158~~	0.102					
28	12.6	0.320	159	~~0.000125~~	0.0804					

with the following equations. They shall be rounded in the *final* value only, in accordance with Section 4, to the same number of significant figures as used in expressing the standard diameters, but in no case to less than three significant figures:

$$W = d^2 \times \delta \times 0.34049 \times 10^{-3}$$

$$L = (1/d^2) \times (1/\delta) \times 2.9369 \times 10^6$$

where:
W = mass, lb/1000 ft,
d = diameter of the wire in mils as given in Table 1,
δ = density of the wire material at 20°C in g/cm³ as given in Table 2, and
L = length, ft/lb.

8. Rules for Calculations Involving Resistivity

8.1 Standard nominal resistances and other values derived from the resistivity units shall be calculated from the standard wire diameters specified in Table 1 in accordance with the following equations. All values so derived shall be rounded in the *final* value only, in accordance with Section 4, to the same number of significant figures as used in expressing the standard diameters, but in no case to less than three significant figures:

$$\text{D}-\text{c resistance at 20°C, }\Omega/1000\text{ ft} = [\rho/(d^2 \times \delta)] \times 105.35$$

$$\cancel{\text{D}-\text{c resistance at 20°C, }\Omega/\text{lb} = [\rho/(\delta^2 \times d^4)] \times 0.30940 \times 10^{-6}}$$

$$\text{D}-\text{c resistance at 20°C, }\Omega/\text{lb} = [\rho/(\delta^2 \times d^4)] \times 0.30940 \times 10^{6}$$

$$\text{Length at 20°C, ft}/\Omega = [(d^2 \times \delta)/\rho] \times 9.4924$$

$$\text{Mass at 20°C, lb}/\Omega = [(\delta^2 \times d^4)/\rho] \times 3.2321 \times 10^{-6}$$

where:
d = diameter of the wire in mils as given in Table 1,
ρ = resistivity of the wire material at 20°C in Ω·lb/mile² as given in Table 2 (Explanatory Note 3), and
δ = density of the wire material at 20°C in g/cm³ as given in Table 2.

TABLE 2 Density and Resistivity of Electrical Conductor Materials

Material	Density, δ, at 20°C, g/cm^3	Resistivity[A], ρ, at 20°C, Ω· lb/mile^2	Material	Density,δ, at 20°C, g/cm^3	Resistivity, ρ, at 20°C Ω· lb/mile^2
Copper (Specifications B 1, B 2, B 3, B 33, B 47 and B 189), Volume Conductivity, % IACS:			Aluminum-Clad Steel (Specification B 415)	6.59	3191
			Copper-Clad Steel (Specification B 227):		
100	8.89	875.20			
97.66	8.89	896.15	Grade 30 HS	8.15	2728
97.16	8.89	900.77	Grade 30 EHS	8.15	2728
96.66	8.89	905.44	Grade 40	8.15	2045
96.16	8.89	910.15	Grade 40 EHS	8.15	2045
94.16	8.89	929.52	Galvanized Steel (Telephone and Telegraph) (Specification A 111):		
93.15	8.89	939.51			
Bronze (Specification B 9):					
Class A	8.89	2188	Class A Coating:		
Class B	8.89	1346	Grade EBB (Non-Copper Bearing)	7.78	5000
Class C	8.89	1094			
Copper Alloys (Specification B 105[B]):			Grade BB (Copper Bearing)	7.78	5800
			Grade BB (Non-Copper Bearing)	7.78	5600
Grade 8.5	8.78	10 169			
Grade 13	8.78	6649	Class B Coating:		
Grade 15	8.54	5605	Grade EBB (Non-Copper Bearing)	7.78	4900
Grade 20	8.89	4376			
Grade 30	8.89	2917	Grade BB (Copper Bearing)	7.78	5600
Grade 40	8.89	2188	Grade BB (Non-Copper Bearing)	7.78	5450
Grade 55	8.89	1591			
Grade 65	8.89	1346	Class C Coating:		
Grade 74	8.89	1183	Grade EBB (Non-Copper Bearing)	7.78	4800
Grade 80	8.89	1094			
Grade 85	8.89	1030	Grade BB (Copper Bearing)	7.78	5400
Aluminum, 1350 (Specifications B 230/B 230M, B 314, and B 609/B 609M), Volume Conductivity, % IACS:			Grade BB (Non-Copper Bearing)	7.78	5300
			Galvanized Steel (Telephone and Telegraph) (Specification A 326):		
61.8	2.705	430.91			
61.2	2.705	435.13			
61.0	2.705	436.56	Class A Coating:		
Aluminum Alloys (Specifications B 396 and B 398/B 398M)			Grade 85	7.83	5800
			Class B Coating:		
Alloy 5005–H19	2.70	496.84	Grade 135	7.83	6500
Alloy 6201–T81	2.69	504.43	Grade 85	7.80	5600
Aluminum Alloy 8000 Series (Specification B 800) Volume Conductivity, % IACS:			Grade 135	7.80	6300
			Class C Coating:		
			Grade 85	7.77	5400
61.0	2.71	437.36	Grade 135	7.77	6100

[A] To convert from Ω·lb/mile^2 to Ω·g/m^2 multiply by 5710.0. See Table ~~4~~ 1 in Test Method B 193.
[B] Various compositions are permitted for some of the grades in Specification B 105 and the density value may not apply to all materials supplied to this specification. In case of doubt, the density value should be determined or obtained from the manufacturer.

9. Rules for Calculating Rated Strength

9.1 Standard rated strengths shall be calculated from the standard wire diameters specified in Table 1 in accordance with the following equation and shall be rounded in the *final* value only, in accordance with Section 4, to the same number of significant figures as used in expressing the standard diameters, but in no case to less than three significant figures:

$$\text{Rated strength, lb} = d^2 \times T \times 0.7854 \times 10^{-6}$$

where:
d = diameter of the wire in mils as given in Table 1, and
T = tensile strength, psi, applicable to the wire material, temper, and size, for which reference should be made to the specifications which cover the material.

10. Tolerances

10.1 The standard dimensions given in Table 1 and the calculated values for mass, resistances, and rated strengths obtained by the use of the formulas included in this specification are all *nominal* values. This specification is not concerned with quantitative values of tolerances per se, but it is contemplated that the standard nominal wire dimensions specified in Table 1, and the properties derived therefrom, shall be made subject to tolerances as indicated in either the individual specifications applicable to the wires of various materials and tempers or as may be mutually agreed by the manufacturer and the purchaser.

TABLE 3 American Wire Gage Series

Ascending Wire Sizes:											
Step No.	1	2	3	4	5	. . .	37	38	39	40	
AWG No.	36	35	34	33	32	. . .	1/0	2/0	3/0	4/0	
Wire diameter, mils	5	$5r$	$5r^2$	$5r^3$	$5r^4$	. . .	$5r^{36}$	$5r^{37}$	$5r^{38}$	$5r^{39}$	= 460
Descending Wire Sizes:											
Step No.	1	2	3	4	5	. . .	37	38	39	40	
AWG No.	4/0	3/0	2/0	1/0	1	. . .	33	34	35	36	
Wire diameter, mils	460	$460/r$	$460/r^2$	$460/r^3$	$460/r^4$	. . .	$\frac{460}{r^{36}}$	$\frac{460}{r^{37}}$	$\frac{460}{r^{38}}$	$\frac{460}{r^{39}}$	= 5

Since the last wire diameter term of both the ascending and descending series indicates that r^{39} = 460/5 = 92, the value for r is $92^{1/39}$ = 1.1229322, and the value of $1/r$ is 0.89052571.

EXPLANATORY NOTES

NOTE 1—Except for certain classes of wire products, the American Wire Gage (formerly known as the Brown & Sharpe Gage) has been almost universally employed in the United States for many years for the designation of wire sizes. This gage is based upon fixed diameters for two wire sizes (4/0 and 36 AWG, respectively), and the simple mathematical law that the thirty-eight intermediate gage designations vary in size in geometric progress. The extent of the American Wire Gage is not, however, limited to the forty gage numbers from 4/0 to 36 AWG, inclusive, both larger and smaller sizes being determined by extrapolation in accordance with the geometric progression mentioned. Like many other wire gages, the American Wire Gage is an inverse gage, that is, a higher size number denotes a wire of smaller size.

The specified diameters for sizes 4/0 AWG and 36 AWG are 460 mils and 5 mils, respectively (1 mil is equal to 0.001 in.). Designating the ratio between ascending adjacent wire sizes by r, and the ratio between descending adjacent wire sizes by $1/r$, the law of the American Wire Gage is indicated explicitly by an ascending and descending series, expressed in tabular form as shown in Table 3.

It is implicit in these series that the diameters of the various AWG wire sizes may be calculated either by ascending from d = 5 for size 36 AWG, or descending from d = 460 for 4/0 AWG, for intermediate sizes, as well as descending from = 5 for size 36 AWG, for sizes 37 AWG and smaller. It is further implicit in these series that the diameter of any AWG size of wire may be derived directly from any other AWG size whose diameter is known by multiplying the known diameter by r^n or $1/r^n$, as the case may be, where n is the number of steps between the two gage numbers. For example, size 18 AWG is eighteen gage numbers apart from 36 AWG, and twenty-one gage numbers apart from size 4/0 AWG. The diameter of size 18 AWG is, then,

$$d_{18} = d_{36} \times r^{18} = 5 \times 1.1229322^{18} = 5 \times 8.060653 = 40.30 \text{ mils}$$

or:

$$d_{18} = d_{4/0}/r^{21} = 460 \times 0.89052571^{21}$$
$$= 460 \times 0.0876144 = 40.30 \text{ mils}$$

Similarly, size 45 AWG is nine gage numbers removed from size 36 AWG, from which the diameter of size 45 AWG is:

$$d_{45} = d_{36}/r^{9} = 5 \times 0.89052571^{9} = 5 \times 0.352223 = 1.761 \text{ mils}$$

Since areas and mass vary directly as the square of wire diameter, it can be shown similarly that the mathematical law of the American Wire Gage holds rigorously for these quantities when the ratio of r^2(1.2609767) or $1/r^2$(0.79303605), as the case may be (depending upon the quantity involved and whether the calculation is an ascending or descending one), is assigned to the properties of adjacent gage sizes. Thus, for size 18 AWG, the circular-mil area is given by the expression:

$$A_{18} = A_{36}r^{36} = 25 \times 1.2609767^{18} = 25 \times 64.9721 = 1624 \text{ cmils}$$

or:

$$A_{18} = A_{4/0}/r^{42} = 211{,}600 \times 0.79303605^{21} = 211{,}600 \times 0.00767629 = 1624 \text{ cmils}$$

Similar calculations can be made for mass where these quantities are known for size 36 AWG or size 4/0 AWG.

NOTE 2—AWG numbers appearing in Columns 1 and 5 of Table 1 are given only to facilitate conversion from AWG numbers to the wire size in mils. It is emphasized that this is not intended to be an endorsement of the use of AWG numbers to designate wire sizes. Wire diameters should be specified in mils as shown in Table 1, Columns 2 and 6.

Micrometer calipers calibrated to measure 0.1 mil (0.0001 in.) should be considered satisfactory for measuring the diameters of 4/0 to 44 AWG (0.4600 to 0.0020 in.) inclusive.

For greater accuracy in obtaining the mean diameter of ultrafine wire size 45 to 56 AWG (0.00176 to 0.00049 in.) inclusive, Test Method F 205 should be considered satisfactory. The density values in Table 2 shall be used in determining constants C and K.

NOTE 3—The value of 875.20Ω·lb/mile^2 at 20°C (68°F) is the mass resistivity equivalent to the International Annealed Copper Standard (IACS) for 100 % conductivity. This term means that a wire one mile in length, with a mass of 1 lb, would have a resistance of 875.20 Ω. This is equivalent to a resistivity value of 0.15328 Ω·g/m^2 which signifies the resistance of a wire 1 m in length with a mass of 1 g. It is also equivalent for example to a volume resistivity of 1.7241 μΩ/cm of length of a bar 1 cm^2 in cross section. A complete discussion of this subject is contained in *NBS Handbook 100* of the National Institute of Standards and Technology.[8] Conversion of the various units of mass resistivity, volume resistivity, and conductivity may be facilitated by employing the formulas and factors shown in Table ~~4.~~ 1 of Test Method B 193. The factors given therein are applicable to all metallic electrical

[8] *NBS Handbook 100,* Nat. Institute of Standards and Technology, , is sold by the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

conductor material. Table 2 lists values of δ for the common electrical conductor materials.