**Chapter 9 Tables**

Table 1 Percent of Cross Section of Conduit and Tubing for Conductors and Cables

Number of Conductors and/or Cables Cross-Sectional Area (%)

1 53

2 31

Over 2 40

Informational Note No. 1: Table 1 is based on common conditions of proper cabling and alignment of conductors where the length of the pull and the number of bends are within reasonable limits. It should be recognized that, for certain conditions, a larger size conduit or a lesser conduit fill should be considered.

Informational Note No. 2: When pulling three conductors or cables into a raceway, if the ratio of the raceway (inside diameter) to the conductor or cable (outside diameter) is between 2.8 and 3.2, jamming can occur. While jamming can occur when pulling four or more conductors or cables into a raceway, the probability is very low.

Notes to Tables

See Informative Annex C for the maximum number of conductors and fixture wires, all of the same size (total cross-sectional area including insulation) permitted in trade sizes of the applicable conduit or tubing.

Table 1 applies only to complete conduit or tubing systems and is not intended to apply to sections of conduit or tubing used to protect exposed wiring and cables from physical damage.

Equipment grounding or bonding conductors, where installed, shall be included when calculating conduit or tubing fill. The actual dimensions of the equipment grounding or bonding conductor (insulated or bare) shall be used in the calculation.

Where conduit or tubing nipples having a maximum length not to exceed 600 mm (24 in.) are installed between boxes, cabinets, and similar enclosures, the nipples shall be permitted to be filled to 60 percent of their total cross-sectional area, and 310.15(C)(1) adjustment factors need not apply to this condition.

For conductors not included in Chapter 9, such as multiconductor cables and optical fiber cables, the actual dimensions shall be used.

For combinations of conductors of different sizes, use actual dimensions or Table 5 and Table 5A for dimensions of conductors and Table 4 for the applicable conduit or tubing dimensions.

When calculating the maximum number of conductors or cables permitted in a conduit or tubing, all of the same size (total cross-sectional area including insulation), the next higher whole number shall be used to determine the maximum number of conductors permitted when the calculation results in a decimal greater than or equal to 0.8. When calculating the size for conduit or tubing permitted for a single conductor, one conductor shall be permitted when the calculation results in a decimal greater than or equal to 0.8.

Where bare conductors are permitted by other sections of this Code, the dimensions for bare conductors in Table 8 shall be permitted.

A multiconductor cable, optical fiber cable, or flexible cord of two or more conductors shall be treated as a single conductor for calculating percentage conduit or tubing fill area. For cables that have elliptical cross sections, the cross-sectional area calculation shall be based on using the major diameter of the ellipse as a circle diameter. Assemblies of single insulated conductors without an overall covering shall not be considered a cable when determining conduit or tubing fill area. The conduit or tubing fill for the assemblies shall be calculated based upon the individual conductors.

The values for approximate conductor diameter and area shown in Table 5 are based on worst-case scenario and indicate round concentric-lay-stranded conductors. Solid and round concentric-lay-stranded conductor values are grouped together for the purpose of Table 5. Round compact-stranded conductor values are shown in Table 5A. If the actual values of the conductor diameter and area are known, they shall be permitted to be used.

Table 2 Radius of Conduit and Tubing Bends

Conduit or Tubing Size One Shot and Full Shoe Benders Other Bends

Metric Designator Trade Size mm in. mm in.

16 1/2 101.6 4 101.6 4

21 3/4 114.3 41/2 127 5

27 1 146.05 53/4 152.4 6

35 11/4 184.15 71/4 203.2 8

41 11/2 209.55 81/4 254 10

53 2 241.3 91/2 304.8 12

63 21/2 266.7 101/2 381 15

78 3 330.2 13 457.2 18

91 31/2 381 15 533.4 21

103 4 406.4 16 609.6 24

129 5 609.6 24 762 30

155 6 762 30 914.4 36

Table 4 Dimensions and Percent Area of Conduit and Tubing (Areas of Conduit or Tubing for the Combinations of Wires Permitted in Table 1, Chapter 9)

Article 358 — Electrical Metallic Tubing (EMT)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

16 1/2 78 0.122 118 0.182 104 0.161 61 0.094 15.8 0.622 196 0.304

21 3/4 137 0.213 206 0.320 182 0.283 106 0.165 20.9 0.824 343 0.533

27 1 222 0.346 333 0.519 295 0.458 172 0.268 26.6 1.049 556 0.864

35 11/4 387 0.598 581 0.897 513 0.793 300 0.464 35.1 1.380 968 1.496

41 11/2 526 0.814 788 1.221 696 1.079 407 0.631 40.9 1.610 1314 2.036

53 2 866 1.342 1299 2.013 1147 1.778 671 1.040 52.5 2.067 2165 3.356

63 21/2 1513 2.343 2270 3.515 2005 3.105 1173 1.816 69.4 2.731 3783 5.858

78 3 2280 3.538 3421 5.307 3022 4.688 1767 2.742 85.2 3.356 5701 8.846

91 31/2 2980 4.618 4471 6.927 3949 6.119 2310 3.579 97.4 3.834 7451 11.545

103 4 3808 5.901 5712 8.852 5046 7.819 2951 4.573 110.1 4.334 9521 14.753

Article 362 — Electrical Nonmetallic Tubing (ENT)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

16 1/2 73 0.114 110 0.171 97 0.151 57 0.088 15.3 0.602 184 0.285

21 3/4 131 0.203 197 0.305 174 0.269 102 0.157 20.4 0.804 328 0.508

27 1 215 0.333 322 0.499 284 0.441 166 0.258 26.1 1.029 537 0.832

35 11/4 375 0.581 562 0.872 497 0.770 291 0.450 34.5 1.36 937 1.453

41 11/2 512 0.794 769 1.191 679 1.052 397 0.616 40.4 1.59 1281 1.986

53 2 849 1.316 1274 1.975 1125 1.744 658 1.020 52 2.047 2123 3.291

63 21/2 — — — — — — — — — — — —

78 3 — — — — — — — — — — — —

91 31/2 — — — — — — — — — — — —

Article 348 — Flexible Metal Conduit (FMC)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

12 3/8 30 0.046 44 0.069 39 0.061 23 0.036 9.7 0.384 74 0.116

16 1/2 81 0.127 122 0.190 108 0.168 63 0.098 16.1 0.635 204 0.317

21 3/4 137 0.213 206 0.320 182 0.283 106 0.165 20.9 0.824 343 0.533

27 1 211 0.327 316 0.490 279 0.433 163 0.253 25.9 1.020 527 0.817

35 11/4 330 0.511 495 0.766 437 0.677 256 0.396 32.4 1.275 824 1.277

41 11/2 480 0.743 720 1.115 636 0.985 372 0.576 39.1 1.538 1201 1.858

53 2 843 1.307 1264 1.961 1117 1.732 653 1.013 51.8 2.040 2107 3.269

63 21/2 1267 1.963 1900 2.945 1678 2.602 982 1.522 63.5 2.500 3167 4.909

78 3 1824 2.827 2736 4.241 2417 3.746 1414 2.191 76.2 3.000 4560 7.069

91 31/2 2483 3.848 3724 5.773 3290 5.099 1924 2.983 88.9 3.500 6207 9.621

103 4 3243 5.027 4864 7.540 4297 6.660 2513 3.896 101.6 4.000 8107 12.566

Article 342 — Intermediate Metal Conduit (IMC)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

12 3/8 — — — — — — — — — — — —

16 1/2 89 0.137 133 0.205 117 0.181 69 0.106 16.8 0.660 222 0.342

21 3/4 151 0.235 226 0.352 200 0.311 117 0.182 21.9 0.864 377 0.586

27 1 248 0.384 372 0.575 329 0.508 192 0.297 28.1 1.105 620 0.959

35 11/4 425 0.659 638 0.988 564 0.873 330 0.510 36.8 1.448 1064 1.647

41 11/2 573 0.890 859 1.335 759 1.179 444 0.690 42.7 1.683 1432 2.225

53 2 937 1.452 1405 2.178 1241 1.924 726 1.125 54.6 2.150 2341 3.630

63 21/2 1323 2.054 1985 3.081 1753 2.722 1026 1.592 64.9 2.557 3308 5.135

78 3 2046 3.169 3069 4.753 2711 4.199 1586 2.456 80.7 3.176 5115 7.922

91 31/2 2729 4.234 4093 6.351 3616 5.610 2115 3.281 93.2 3.671 6822 10.584

103 4 3490 5.452 5235 8.179 4624 7.224 2705 4.226 105.4 4.166 8725 13.631

Article 356 — Liquidtight Flexible Nonmetallic Conduit (LFNC-A\*)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

12 3/8 50 0.077 75 0.115 66 0.102 39 0.060 12.6 0.495 125 0.192

16 1/2 80 0.125 121 0.187 107 0.165 62 0.097 16.0 0.630 201 0.312

21 3/4 139 0.214 208 0.321 184 0.283 107 0.166 21.0 0.825 346 0.535

27 1 221 0.342 331 0.513 292 0.453 171 0.265 26.5 1.043 552 0.854

35 11/4 387 0.601 581 0.901 513 0.796 300 0.466 35.1 1.383 968 1.502

41 11/2 520 0.807 781 1.211 690 1.070 403 0.626 40.7 1.603 1301 2.018

53 2 863 1.337 1294 2.006 1143 1.772 669 1.036 52.4 2.063 2157 3.343

\*Corresponds to 356.2(1).

Article 356 — Liquidtight Flexible Nonmetallic Conduit (LFNC-B\*)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

12 3/8 49 0.077 74 0.115 65 0.102 38 0.059 12.5 0.494 123 0.192

16 1/2 81 0.125 122 0.188 108 0.166 63 0.097 16.1 0.632 204 0.314

21 3/4 140 0.216 210 0.325 185 0.287 108 0.168 21.1 0.830 350 0.541

27 1 226 0.349 338 0.524 299 0.462 175 0.270 26.8 1.054 564 0.873

35 11/4 394 0.611 591 0.917 522 0.810 305 0.474 35.4 1.395 984 1.528

41 11/2 510 0.792 765 1.188 676 1.050 395 0.614 40.3 1.588 1276 1.981

53 2 836 1.298 1255 1.948 1108 1.720 648 1.006 51.6 2.033 2091 3.246

\*Corresponds to 356.2(2).

Article 356 — Liquidtight Flexible Nonmetallic Conduit (LFNC-C\*)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

12 3/8 47.7 0.074 71.5 0.111 63.2 0.098 36.9 0.057 12.3 0.485 119.19 0.185

16 1/2 77.9 0.121 116.9 0.181 103.2 0.160 60.4 0.094 15.7 0.620 194.778 0.302

21 3/4 134.6 0.209 201.9 0.313 178.4 0.276 104.3 0.162 20.7 0.815 336.568 0.522

27 1 215.0 0.333 322.5 0.500 284.9 0.442 166.6 0.258 26.2 1.030 537.566 0.833

35 11/4 380.4 0.590 570.6 0.884 504.1 0.781 294.8 0.457 34.8 1.370 951.039 1.474

41 11/2 509.2 0.789 763.8 1.184 674.7 1.046 394.6 0.612 40.3 1.585 1272.963 1.973

53 2 847.6 1.314 1271.4 1.971 1123.1 1.741 656.9 1.018 51.9 2.045 2119.063 3.285

\*Corresponds to 356.2(3).

Article 350 — Liquidtight Flexible Metal Conduit (LFMC)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

12 3/8 49 0.077 74 0.115 65 0.102 38 0.059 12.5 0.494 123 0.192

16 1/2 81 0.125 122 0.188 108 0.166 63 0.097 16.1 0.632 204 0.314

21 3/4 140 0.216 210 0.325 185 0.287 108 0.168 21.1 0.830 350 0.541

27 1 226 0.349 338 0.524 299 0.462 175 0.270 26.8 1.054 564 0.873

35 11/4 394 0.611 591 0.917 522 0.810 305 0.474 35.4 1.395 984 1.528

41 11/2 510 0.792 765 1.188 676 1.050 395 0.614 40.3 1.588 1276 1.981

53 2 836 1.298 1255 1.948 1108 1.720 648 1.006 51.6 2.033 2091 3.246

63 21/2 1259 1.953 1888 2.929 1668 2.587 976 1.513 63.3 2.493 3147 4.881

78 3 1931 2.990 2896 4.485 2559 3.962 1497 2.317 78.4 3.085 4827 7.475

91 31/2 2511 3.893 3766 5.839 3327 5.158 1946 3.017 89.4 3.520 6277 9.731

103 4 3275 5.077 4912 7.615 4339 6.727 2538 3.935 102.1 4.020 8187 12.692

129 5 — — — — — — — — — — — —

155 6 — — — — — — — — — — — —

Article 344 — Rigid Metal Conduit (RMC)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

12 3/8 — — — — — — — — — — — —

16 1/2 81 0.125 122 0.188 108 0.166 63 0.097 16.1 0.632 204 0.314

21 3/4 141 0.220 212 0.329 187 0.291 109 0.170 21.2 0.836 353 0.549

27 1 229 0.355 344 0.532 303 0.470 177 0.275 27.0 1.063 573 0.887

35 11/4 394 0.610 591 0.916 522 0.809 305 0.473 35.4 1.394 984 1.526

41 11/2 533 0.829 800 1.243 707 1.098 413 0.642 41.2 1.624 1333 2.071

53 2 879 1.363 1319 2.045 1165 1.806 681 1.056 52.9 2.083 2198 3.408

63 21/2 1255 1.946 1882 2.919 1663 2.579 972 1.508 63.2 2.489 3137 4.866

78 3 1936 3.000 2904 4.499 2565 3.974 1500 2.325 78.5 3.090 4840 7.499

91 31/2 2584 4.004 3877 6.006 3424 5.305 2003 3.103 90.7 3.570 6461 10.010

103 4 3326 5.153 4990 7.729 4408 6.828 2578 3.994 102.9 4.050 8316 12.882

129 5 5220 8.085 7830 12.127 6916 10.713 4045 6.266 128.9 5.073 13050 20.212

155 6 7528 11.663 11292 17.495 9975 15.454 5834 9.039 154.8 6.093 18821 29.158

Article 352 — Rigid PVC Conduit (PVC), Schedule 80

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

12 3/8 — — — — — — — — — — — —

16 1/2 56 0.087 85 0.130 75 0.115 44 0.067 13.4 0.526 141 0.217

21 3/4 105 0.164 158 0.246 139 0.217 82 0.127 18.3 0.722 263 0.409

27 1 178 0.275 267 0.413 236 0.365 138 0.213 23.8 0.936 445 0.688

35 11/4 320 0.495 480 0.742 424 0.656 248 0.383 31.9 1.255 799 1.237

41 11/2 442 0.684 663 1.027 585 0.907 342 0.530 37.5 1.476 1104 1.711

53 2 742 1.150 1113 1.725 983 1.523 575 0.891 48.6 1.913 1855 2.874

63 21/2 1064 1.647 1596 2.471 1410 2.183 825 1.277 58.2 2.290 2660 4.119

78 3 1660 2.577 2491 3.865 2200 3.414 1287 1.997 72.7 2.864 4151 6.442

91 31/2 2243 3.475 3365 5.213 2972 4.605 1738 2.693 84.5 3.326 5608 8.688

103 4 2907 4.503 4361 6.755 3852 5.967 2253 3.490 96.2 3.786 7268 11.258

129 5 4607 7.142 6911 10.713 6105 9.463 3571 5.535 121.1 4.768 11518 17.855

155 6 6605 10.239 9908 15.359 8752 13.567 5119 7.935 145.0 5.709 16513 25.598

Articles 352 and 353 — Rigid PVC Conduit (PVC), Schedule 40, and HDPE Conduit (HDPE)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

12 3/8 — — — — — — — — — — — —

16 1/2 74 0.114 110 0.171 97 0.151 57 0.088 15.3 0.602 184 0.285

21 3/4 131 0.203 196 0.305 173 0.269 101 0.157 20.4 0.804 327 0.508

27 1 214 0.333 321 0.499 284 0.441 166 0.258 26.1 1.029 535 0.832

35 11/4 374 0.581 561 0.872 495 0.770 290 0.450 34.5 1.360 935 1.453

41 11/2 513 0.794 769 1.191 679 1.052 397 0.616 40.4 1.590 1282 1.986

53 2 849 1.316 1274 1.975 1126 1.744 658 1.020 52.0 2.047 2124 3.291

63 21/2 1212 1.878 1817 2.817 1605 2.488 939 1.455 62.1 2.445 3029 4.695

78 3 1877 2.907 2816 4.361 2487 3.852 1455 2.253 77.3 3.042 4693 7.268

91 31/2 2511 3.895 3766 5.842 3327 5.161 1946 3.018 89.4 3.521 6277 9.737

103 4 3237 5.022 4855 7.532 4288 6.654 2508 3.892 101.5 3.998 8091 12.554

129 5 5099 7.904 7649 11.856 6756 10.473 3952 6.126 127.4 5.016 12748 19.761

155 6 7373 11.427 11060 17.140 9770 15.141 5714 8.856 153.2 6.031 18433 28.567

Article 352 — Type A, Rigid PVC Conduit (PVC)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

16 1/2 100 0.154 149 0.231 132 0.204 77 0.119 17.8 0.700 249 0.385

21 3/4 168 0.260 251 0.390 222 0.345 130 0.202 23.1 0.910 419 0.650

27 1 279 0.434 418 0.651 370 0.575 216 0.336 29.8 1.175 697 1.084

35 11/4 456 0.707 684 1.060 604 0.937 353 0.548 38.1 1.500 1140 1.767

41 11/2 600 0.929 900 1.394 795 1.231 465 0.720 43.7 1.720 1500 2.324

53 2 940 1.459 1410 2.188 1245 1.933 728 1.131 54.7 2.155 2350 3.647

63 21/2 1406 2.181 2109 3.272 1863 2.890 1090 1.690 66.9 2.635 3515 5.453

78 3 2112 3.278 3169 4.916 2799 4.343 1637 2.540 82.0 3.230 5281 8.194

91 31/2 2758 4.278 4137 6.416 3655 5.668 2138 3.315 93.7 3.690 6896 10.694

103 4 3543 5.489 5315 8.234 4695 7.273 2746 4.254 106.2 4.180 8858 13.723

129 5 — — — — — — — — — — — —

155 6 — — — — — — — — — — — —

Article 352 — Type EB, Rigid PVC Conduit (PVC)

Metric Designator Trade Size Over 2 Wires 40% 60% 1 Wire 53% 2 Wires 31% Nominal Internal Diameter Total Area 100%

mm2 in.2 mm2 in.2 mm2 in.2 mm2 in.2 mm in. mm2 in.2

16 1/2 — — — — — — — — — — — —

21 3/4 — — — — — — — — — — — —

27 1 — — — — — — — — — — — —

35 11/4 — — — — — — — — — — — —

41 11/2 — — — — — — — — — — — —

53 2 999 1.550 1499 2.325 1324 2.053 774 1.201 56.4 2.221 2498 3.874

63 21/2 — — — — — — — — — — — —

78 3 2248 3.484 3373 5.226 2979 4.616 1743 2.700 84.6 3.330 5621 8.709

91 31/2 2932 4.546 4397 6.819 3884 6.023 2272 3.523 96.6 3.804 7329 11.365

103 4 3726 5.779 5589 8.669 4937 7.657 2887 4.479 108.9 4.289 9314 14.448

129 5 5726 8.878 8588 13.317 7586 11.763 4437 6.881 135.0 5.316 14314 22.195

155 6 8133 12.612 12200 18.918 10776 16.711 6303 9.774 160.9 6.336 20333 31.530

Table 5 Dimensions of Insulated Conductors and Fixture Wires

Type Size (AWG or kcmil) Approximate Area Approximate Diameter

mm2 in.2 mm in.

Type: FFH-2, RFH-1, RFH-2, RFHH-2, RHH\*, RHW\*, RHW-2\*, RHH, RHW, RHW-2, SF-1, SF-2, SFF-1, SFF-2, TF, TFF, THHW, THW, THW-2, TW, XF, XFF

RFH-2, FFH-2, RFHH-2 18 9.355 0.0145 3.454 0.136

16 11.10 0.0172 3.759 0.148

RHH, RHW, RHW-2 14 18.90 0.0293 4.902 0.193

12 22.77 0.0353 5.385 0.212

10 28.19 0.0437 5.994 0.236

8 53.87 0.0835 8.280 0.326

6 67.16 0.1041 9.246 0.364

4 86.00 0.1333 10.46 0.412

3 98.13 0.1521 11.18 0.440

2 112.9 0.1750 11.99 0.472

1 171.6 0.2660 14.78 0.582

1/0 196.1 0.3039 15.80 0.622

2/0 226.1 0.3505 16.97 0.668

3/0 262.7 0.4072 18.29 0.720

4/0 306.7 0.4754 19.76 0.778

250 405.9 0.6291 22.73 0.895

300 457.3 0.7088 24.13 0.950

350 507.7 0.7870 25.43 1.001

400 556.5 0.8626 26.62 1.048

500 650.5 1.0082 28.78 1.133

600 782.9 1.2135 31.57 1.243

700 874.9 1.3561 33.38 1.314

750 920.8 1.4272 34.24 1.348

800 965.0 1.4957 35.05 1.380

900 1057 1.6377 36.68 1.444

1000 1143 1.7719 38.15 1.502

1250 1515 2.3479 43.92 1.729

1500 1738 2.6938 47.04 1.852

1750 1959 3.0357 49.94 1.966

2000 2175 3.3719 52.63 2.072

SF-2, SFF-2 18 7.419 0.0115 3.073 0.121

16 8.968 0.0139 3.378 0.133

14 11.10 0.0172 3.759 0.148

SF-1, SFF-1 18 4.194 0.0065 2.311 0.091

RFH-1,TF, TFF, XF, XFF 18 5.161 0.0088 2.692 0.106

TF, TFF, XF, XFF 16 7.032 0.0109 2.997 0.118

TW, XF, XFF, THHW, THW, THW-2 14 8.968 0.0139 3.378 0.133

TW, THHW, THW, THW-2 12 11.68 0.0181 3.861 0.152

10 15.68 0.0243 4.470 0.176

8 28.19 0.0437 5.994 0.236

RHH\*, RHW\*, RHW-2\* 14 13.48 0.0209 4.140 0.163

RHH\*, RHW\*, RHW-2\*, XF, XFF 12 16.77 0.0260 4.623 0.182

Type: RHH\*, RHW\*, RHW-2\*, THHN, THHW, THW, THW-2, TFN, TFFN, THWN, THWN-2, XF, XFF

RHH,\* RHW,\* RHW-2,\* XF, XFF 10 21.48 0.0333 5.232 0.206

RHH\*, RHW\*, RHW-2\* 8 35.87 0.0556 6.756 0.266

TW, THW, THHW, THW-2, RHH\*, RHW\*, RHW-2\* 6 46.84 0.0726 7.722 0.304

4 62.77 0.0973 8.941 0.352

3 73.16 0.1134 9.652 0.380

2 86.00 0.1333 10.46 0.412

1 122.6 0.1901 12.50 0.492

1/0 143.4 0.2223 13.51 0.532

2/0 169.3 0.2624 14.68 0.578

3/0 201.1 0.3117 16.00 0.630

4/0 239.9 0.3718 17.48 0.688

250 296.5 0.4596 19.43 0.765

300 340.7 0.5281 20.83 0.820

350 384.4 0.5958 22.12 0.871

400 427.0 0.6619 23.32 0.918

500 509.7 0.7901 25.48 1.003

600 627.7 0.9729 28.27 1.113

700 710.3 1.1010 30.07 1.184

750 751.7 1.1652 30.94 1.218

800 791.7 1.2272 31.75 1.250

900 874.9 1.3561 33.38 1.314

1000 953.8 1.4784 34.85 1.372

1250 1200 1.8602 39.09 1.539

1500 1400 2.1695 42.21 1.662

1750 1598 2.4773 45.11 1.776

2000 1795 2.7818 47.80 1.882

TFN, TFFN 18 3.548 0.0055 2.134 0.084

16 4.645 0.0072 2.438 0.096

THHN, THWN, THWN-2 14 6.258 0.0097 2.819 0.111

12 8.581 0.0133 3.302 0.130

10 13.61 0.0211 4.166 0.164

8 23.61 0.0366 5.486 0.216

6 32.71 0.0507 6.452 0.254

4 53.16 0.0824 8.230 0.324

3 62.77 0.0973 8.941 0.352

2 74.71 0.1158 9.754 0.384

1 100.8 0.1562 11.33 0.446

1/0 119.7 0.1855 12.34 0.486

2/0 143.4 0.2223 13.51 0.532

3/0 172.8 0.2679 14.83 0.584

4/0 208.8 0.3237 16.31 0.642

250 256.1 0.3970 18.06 0.711

300 297.3 0.4608 19.46 0.766

Type: FEP, FEPB, PAF, PAFF, PF, PFA, PFAH, PFF, PGF, PGFF, PTF, PTFF, TFE, THHN, THWN, THWN-2, Z, ZF, ZFF, ZHF

THHN, THWN, THWN-2 350 338.2 0.5242 20.75 0.817

400 378.3 0.5863 21.95 0.864

500 456.3 0.7073 24.10 0.949

600 559.7 0.8676 26.70 1.051

700 637.9 0.9887 28.50 1.122

750 677.2 1.0496 29.36 1.156

800 715.2 1.1085 30.18 1.188

900 794.3 1.2311 31.80 1.252

1000 869.5 1.3478 33.27 1.310

PF, PGFF, PGF, PFF, PTF, PAF, PTFF, PAFF 18 3.742 0.0058 2.184 0.086

16 4.839 0.0075 2.489 0.098

PF, PGFF, PGF, PFF, PTF, PAF, PTFF, PAFF, TFE, FEP, PFA, FEPB, PFAH 14 6.452 0.0100 2.870 0.113

TFE, FEP, PFA, FEPB, PFAH 12 8.839 0.0137 3.353 0.132

10 12.32 0.0191 3.962 0.156

8 21.48 0.0333 5.232 0.206

6 30.19 0.0468 6.198 0.244

4 43.23 0.0670 7.417 0.292

3 51.87 0.0804 8.128 0.320

2 62.77 0.0973 8.941 0.352

TFE, PFAH, PFA 1 90.26 0.1399 10.72 0.422

TFE, PFA, PFAH, Z 1/0 108.1 0.1676 11.73 0.462

2/0 130.8 0.2027 12.90 0.508

3/0 158.9 0.2463 14.22 0.560

4/0 193.5 0.3000 15.70 0.618

ZF, ZFF, ZHF 18 2.903 0.0045 1.930 0.076

16 3.935 0.0061 2.235 0.088

Z, ZF, ZFF, ZHF 14 5.355 0.0083 2.616 0.103

Z 12 7.548 0.0117 3.099 0.122

10 12.32 0.0191 3.962 0.156

8 19.48 0.0302 4.978 0.196

6 27.74 0.0430 5.944 0.234

4 40.32 0.0625 7.163 0.282

3 55.16 0.0855 8.382 0.330

2 66.39 0.1029 9.195 0.362

1 81.87 0.1269 10.21 0.402

Type: KF-1, KF-2, KFF-1, KFF-2, XHH, XHHW, XHHW-2, ZW

XHHW, ZW, XHHW-2, XHH 14 8.968 0.0139 3.378 0.133

12 11.68 0.0181 3.861 0.152

10 15.68 0.0243 4.470 0.176

8 28.19 0.0437 5.994 0.236

6 38.06 0.0590 6.960 0.274

4 52.52 0.0814 8.179 0.322

3 62.06 0.0962 8.890 0.350

2 73.94 0.1146 9.703 0.382

XHHW, XHHW-2, XHH 1 98.97 0.1534 11.23 0.442

1/0 117.7 0.1825 12.24 0.482

2/0 141.3 0.2190 13.41 0.528

3/0 170.5 0.2642 14.73 0.58

4/0 206.3 0.3197 16.21 0.638

250 251.9 0.3904 17.91 0.705

300 292.6 0.4536 19.30 0.76

350 333.3 0.5166 20.60 0.811

400 373.0 0.5782 21.79 0.858

500 450.6 0.6984 23.95 0.943

600 561.9 0.8709 26.75 1.053

700 640.2 0.9923 28.55 1.124

750 679.5 1.0532 29.41 1.158

800 717.5 1.1122 30.23 1.190

900 796.8 1.2351 31.85 1.254

1000 872.2 1.3519 33.32 1.312

1250 1108 1.7180 37.57 1.479

1500 1300 2.0156 40.69 1.602

1750 1492 2.3127 43.59 1.716

2000 1682 2.6073 46.28 1.822

KF-2, KFF-2 18 2.000 0.003 1.575 0.062

16 2.839 0.0043 1.88 0.074

14 4.129 0.0064 2.286 0.090

12 6.000 0.0092 2.743 0.108

10 8.968 0.0139 3.378 0.133

KF-1, KFF-1 18 1.677 0.0026 1.448 0.057

16 2.387 0.0037 1.753 0.069

14 3.548 0.0055 2.134 0.084

12 5.355 0.0083 2.616 0.103

10 8.194 0.0127 3.226 0.127

\*Types RHH, RHW, and RHW-2 without outer covering.

Table 5A Compact Copper and Aluminum Building Wire Nominal Dimensions\*\* and Areas

Size (AWG or kcmil) Bare Conductor Types RHH\* Types THW and THHW Type THHN Type XHHW Size (AWG or kcmil)

Diameter Approximate Diameter Approximate Area Approximate Diameter Approximate Area Approximate Diameter Approximate Area Approximate Diameter Approximate Area

mm in. mm in. mm2 in.2 mm in. mm2 in.2 mm in. mm2 in.2 mm in. mm2 in.2

8 3.404 0.134 6.604 0.260 34.25 0.0531 6.477 0.255 32.90 0.0510 — — — — 5.690 0.224 25.42 0.0394 8

6 4.293 0.169 7.493 0.295 44.10 0.0683 7.366 0.290 42.58 0.0660 6.096 0.240 29.16 0.0452 6.604 0.260 34.19 0.0530 6

4 5.410 0.213 8.509 0.335 56.84 0.0881 8.509 0.335 56.84 0.0881 7.747 0.305 47.10 0.0730 7.747 0.305 47.10 0.0730 4

2 6.807 0.268 9.906 0.390 77.03 0.1194 9.906 0.390 77.03 0.1194 9.144 0.360 65.61 0.1017 9.144 0.360 65.61 0.1017 2

1 7.595 0.299 11.81 0.465 109.5 0.1698 11.81 0.465 109.5 0.1698 10.54 0.415 87.23 0.1352 10.54 0.415 87.23 0.1352 1

1/0 8.534 0.336 12.70 0.500 126.6 0.1963 12.70 0.500 126.6 0.1963 11.43 0.450 102.6 0.1590 11.43 0.450 102.6 0.1590 1/0

2/0 9.550 0.376 13.72 0.540 147.8 0.2290 13.84 0.545 150.5 0.2332 12.57 0.495 124.1 0.1924 12.45 0.490 121.6 0.1885 2/0

3/0 10.74 0.423 14.99 0.590 176.3 0.2733 14.99 0.590 176.3 0.2733 13.72 0.540 147.7 0.2290 13.72 0.540 147.7 0.2290 3/0

4/0 12.07 0.475 16.26 0.640 207.6 0.3217 16.38 0.645 210.8 0.3267 15.11 0.595 179.4 0.2780 14.99 0.590 176.3 0.2733 4/0

250 13.21 0.520 18.16 0.715 259.0 0.4015 18.42 0.725 266.3 0.4128 17.02 0.670 227.4 0.3525 16.76 0.660 220.7 0.3421 250

300 14.48 0.570 19.43 0.765 296.5 0.4596 19.69 0.775 304.3 0.4717 18.29 0.720 262.6 0.4071 18.16 0.715 259.0 0.4015 300

350 15.65 0.616 20.57 0.810 332.3 0.5153 20.83 0.820 340.7 0.5281 19.56 0.770 300.4 0.4656 19.30 0.760 292.6 0.4536 350

400 16.74 0.659 21.72 0.855 370.5 0.5741 21.97 0.865 379.1 0.5876 20.70 0.815 336.5 0.5216 20.32 0.800 324.3 0.5026 400

500 18.69 0.736 23.62 0.930 438.2 0.6793 23.88 0.940 447.7 0.6939 22.48 0.885 396.8 0.6151 22.35 0.880 392.4 0.6082 500

600 20.65 0.813 26.29 1.035 542.8 0.8413 26.67 1.050 558.6 0.8659 25.02 0.985 491.6 0.7620 24.89 0.980 486.6 0.7542 600

700 22.28 0.877 27.94 1.100 613.1 0.9503 28.19 1.110 624.3 0.9676 26.67 1.050 558.6 0.8659 26.67 1.050 558.6 0.8659 700

750 23.06 0.908 28.83 1.135 652.8 1.0118 29.21 1.150 670.1 1.0386 27.31 1.075 585.5 0.9076 27.69 1.090 602.0 0.9331 750

900 25.37 0.999 31.50 1.240 779.3 1.2076 31.09 1.224 759.1 1.1766 30.33 1.194 722.5 1.1196 29.69 1.169 692.3 1.0733 900

1000 26.92 1.060 32.64 1.285 836.6 1.2968 32.64 1.285 836.6 1.2968 31.88 1.255 798.1 1.2370 31.24 1.230 766.6 1.1882 1000

\*Types RHH and RHW without outer coverings.

\*\*Dimensions are from industry sources.

Table 8 Conductor Properties

Size (AWG or kcmil) Area Conductors Direct-Current Resistance at 75°C (167°F)

Stranding Overall Copper

Diameter Diameter Area Uncoated Coated Aluminum

mm2 Circular mils Quantity mm in. mm in. mm2 in.2 ohm/km ohm/kFT ohm/km ohm/kFT ohm/km ohm/kFT

18 0.823 1620 1 — — 1.02 0.040 0.823 0.001 25.5 7.77 26.5 8.08 42.0 12.8

18 0.823 1620 7 0.39 0.015 1.16 0.046 1.06 0.002 26.1 7.95 27.7 8.45 42.8 13.1

16 1.31 2580 1 — — 1.29 0.051 1.31 0.002 16.0 4.89 16.7 5.08 26.4 8.05

16 1.31 2580 7 0.49 0.019 1.46 0.058 1.68 0.003 16.4 4.99 17.3 5.29 26.9 8.21

14 2.08 4110 1 — — 1.63 0.064 2.08 0.003 10.1 3.07 10.4 3.19 16.6 5.06

14 2.08 4110 7 0.62 0.024 1.85 0.073 2.68 0.004 10.3 3.14 10.7 3.26 16.9 5.17

12 3.31 6530 1 — — 2.05 0.081 3.31 0.005 6.34 1.93 6.57 2.01 10.45 3.18

12 3.31 6530 7 0.78 0.030 2.32 0.092 4.25 0.006 6.50 1.98 6.73 2.05 10.69 3.25

10 5.261 10380 1 — — 2.588 0.102 5.26 0.008 3.984 1.21 4.148 1.26 6.561 2.00

10 5.261 10380 7 0.98 0.038 2.95 0.116 6.76 0.011 4.070 1.24 4.226 1.29 6.679 2.04

8 8.367 16510 1 — — 3.264 0.128 8.37 0.013 2.506 0.764 2.579 0.786 4.125 1.26

8 8.367 16510 7 1.23 0.049 3.71 0.146 10.76 0.017 2.551 0.778 2.653 0.809 4.204 1.28

6 13.30 26240 7 1.56 0.061 4.67 0.184 17.09 0.027 1.608 0.491 1.671 0.510 2.652 0.808

4 21.15 41740 7 1.96 0.077 5.89 0.232 27.19 0.042 1.010 0.308 1.053 0.321 1.666 0.508

3 26.67 52620 7 2.20 0.087 6.60 0.260 34.28 0.053 0.802 0.245 0.833 0.254 1.320 0.403

2 33.62 66360 7 2.47 0.097 7.42 0.292 43.23 0.067 0.634 0.194 0.661 0.201 1.045 0.319

1 42.41 83690 19 1.69 0.066 8.43 0.332 55.80 0.087 0.505 0.154 0.524 0.160 0.829 0.253

1/0

53.49 105600 19 1.89 0.074 9.45 0.372 70.41 0.109 0.399 0.122 0.415 0.127 0.660 0.201

2/0

67.43 133100 19 2.13 0.084 10.62 0.418 88.74 0.137 0.3170 0.0967 0.329 0.101 0.523 0.159

3/0

85.01 167800 19 2.39 0.094 11.94 0.470 111.9 0.173 0.2512 0.0766 0.2610 0.0797 0.413 0.126

4/0

107.2 211600 19 2.68 0.106 13.41 0.528 141.1 0.219 0.1996 0.0608 0.2050 0.0626 0.328 0.100

250 127 — 37 2.09 0.082 14.61 0.575 168 0.260 0.1687 0.0515 0.1753 0.0535 0.2778 0.0847

300 152 — 37 2.29 0.090 16.00 0.630 201 0.312 0.1409 0.0429 0.1463 0.0446 0.2318 0.0707

350 177 — 37 2.47 0.097 17.30 0.681 235 0.364 0.1205 0.0367 0.1252 0.0382 0.1984 0.0605

400 203 — 37 2.64 0.104 18.49 0.728 268 0.416 0.1053 0.0321 0.1084 0.0331 0.1737 0.0529

500 253 — 37 2.95 0.116 20.65 0.813 336 0.519 0.0845 0.0258 0.0869 0.0265 0.1391 0.0424

600 304 — 61 2.52 0.099 22.68 0.893 404 0.626 0.0704 0.0214 0.0732 0.0223 0.1159 0.0353

700 355 — 61 2.72 0.107 24.49 0.964 471 0.730 0.0603 0.0184 0.0622 0.0189 0.0994 0.0303

750 380 — 61 2.82 0.111 25.35 0.998 505 0.782 0.0563 0.0171 0.0579 0.0176 0.0927 0.0282

800 405 — 61 2.91 0.114 26.16 1.030 538 0.834 0.0528 0.0161 0.0544 0.0166 0.0868 0.0265

900 456 — 61 3.09 0.122 27.79 1.094 606 0.940 0.0470 0.0143 0.0481 0.0147 0.0770 0.0235

1000 507 — 61 3.25 0.128 29.26 1.152 673 1.042 0.0423 0.0129 0.0434 0.0132 0.0695 0.0212

1250 633 — 91 2.98 0.117 32.74 1.289 842 1.305 0.0338 0.0103 0.0347 0.0106 0.0554 0.0169

1500 760 — 91 3.26 0.128 35.86 1.412 1011 1.566 0.02814 0.00858 0.02814 0.00883 0.0464 0.0141

1750 887 — 127 2.98 0.117 38.76 1.526 1180 1.829 0.02410 0.00735 0.02410 0.00756 0.0397 0.0121

2000 1013 — 127 3.19 0.126 41.45 1.632 1349 2.092 0.02109 0.00643 0.02109 0.00662 0.0348 0.0106

Notes:

1. These resistance values are valid only for the parameters as given. Using conductors having coated strands, different stranding type, and, especially, other temperatures changes the resistance.

2. Equation for temperature change: R2 = R1 [1 + a (T2—75)], where αcu = 0.00323, αAL = 0.00330 at 75°C.

3. Conductors with compact and compressed stranding have about 9 percent and 3 percent, respectively, smaller bare conductor diameters than those shown. See Table 5A for actual compact cable dimensions.

4. The IACS conductivities used: bare copper = 100%, aluminum = 61%.

5. Class B stranding is listed as well as solid for some sizes. Its overall diameter and area are those of its circumscribing circle.

Informational Note: The construction information is in accordance with NEMA WC/70-2009 or ANSI/UL 1581-2017.

The resistance is calculated in accordance with National Bureau of Standards Handbook 100, dated 1966, and Handbook 109, dated 1972.

Table 9 Alternating-Current Resistance and Reactance for 600-Volt Cables, 3-Phase, 60 Hz, 75°C (167°F) — Three Single Conductors in Conduit

Size (AWG or kcmil) Ohms to Neutral per Kilometer

Ohms to Neutral per 1000 Feet Size (AWG or kcmil)

XL (Reactance) for All Wires Alternating-Current Resistance for Uncoated Copper Wires Alternating-Current Resistance for Aluminum Wires Effective Z at 0.85 PF for Uncoated Copper Wires Effective Z at 0.85 PF for Aluminum Wires

PVC, Aluminum Conduits Steel Conduit PVC Conduit Aluminum Conduit Steel Conduit PVC Conduit Aluminum Conduit Steel Conduit PVC Conduit Aluminum Conduit Steel Conduit PVC Conduit Aluminum Conduit Steel Conduit

14 0.190 0.240 10.2 10.2 10.2 — — — 8.9 8.9 8.9 — — — 14

0.058 0.073 3.1 3.1 3.1 — — — 2.7 2.7 2.7 — — —

12 0.177 0.223 6.6 6.6 6.6 10.5 10.5 10.5 5.6 5.6 5.6 9.2 9.2 9.2 12

0.054 0.068 2.0 2.0 2.0 3.2 3.2 3.2 1.7 1.7 1.7 2.8 2.8 2.8

10 0.164 0.207 3.9 3.9 3.9 6.6 6.6 6.6 3.6 3.6 3.6 5.9 5.9 5.9 10

0.050 0.063 1.2 1.2 1.2 2.0 2.0 2.0 1.1 1.1 1.1 1.8 1.8 1.8

8 0.171 0.213 2.56 2.56 2.56 4.3 4.3 4.3 2.26 2.26 2.30 3.6 3.6 3.6 8

0.052 0.065 0.78 0.78 0.78 1.3 1.3 1.3 0.69 0.69 0.70 1.1 1.1 1.1

6 0.167 0.210 1.61 1.61 1.61 2.66 2.66 2.66 1.44 1.48 1.48 2.33 2.36 2.36 6

0.051 0.064 0.49 0.49 0.49 0.81 0.81 0.81 0.44 0.45 0.45 0.71 0.72 0.72

4 0.157 0.197 1.02 1.02 1.02 1.67 1.67 1.67 0.95 0.95 0.98 1.51 1.51 1.51 4

0.048 0.060 0.31 0.31 0.31 0.51 0.51 0.51 0.29 0.29 0.30 0.46 0.46 0.46

3 0.154 0.194 0.82 0.82 0.82 1.31 1.35 1.31 0.75 0.79 0.79 1.21 1.21 1.21 3

0.047 0.059 0.25 0.25 0.25 0.40 0.41 0.40 0.23 0.24 0.24 0.37 0.37 0.37

2 0.148 0.187 0.62 0.66 0.66 1.05 1.05 1.05 0.62 0.62 0.66 0.98 0.98 0.98 2

0.045 0.057 0.19 0.20 0.20 0.32 0.32 0.32 0.19 0.19 0.20 0.30 0.30 0.30

1 0.151 0.187 0.49 0.52 0.52 0.82 0.85 0.82 0.52 0.52 0.52 0.79 0.79 0.82 1

0.046 0.057 0.15 0.16 0.16 0.25 0.26 0.25 0.16 0.16 0.16 0.24 0.24 0.25

1/0 0.144 0.180 0.39 0.43 0.39 0.66 0.69 0.66 0.43 0.43 0.43 0.62 0.66 0.66 1/0

0.044 0.055 0.12 0.13 0.12 0.20 0.21 0.20 0.13 0.13 0.13 0.19 0.20 0.20

2/0 0.141 0.177 0.33 0.33 0.33 0.52 0.52 0.52 0.36 0.36 0.36 0.52 0.52 0.52 2/0

0.043 0.054 0.10 0.10 0.10 0.16 0.16 0.16 0.11 0.11 0.11 0.16 0.16 0.16

3/0 0.138 0.171 0.253 0.269 0.259 0.43 0.43 0.43 0.289 0.302 0.308 0.43 0.43 0.46 3/0

0.042 0.052 0.077 0.082 0.079 0.13 0.13 0.13 0.088 0.092 0.094 0.13 0.13 0.14

4/0 0.135 0.167 0.203 0.220 0.207 0.33 0.36 0.33 0.243 0.256 0.262 0.36 0.36 0.36 4/0

0.041 0.051 0.062 0.067 0.063 0.10 0.11 0.10 0.074 0.078 0.080 0.11 0.11 0.11

250 0.135 0.171 0.171 0.187 0.177 0.279 0.295 0.282 0.217 0.230 0.240 0.308 0.322 0.33 250

0.041 0.052 0.052 0.057 0.054 0.085 0.090 0.086 0.066 0.070 0.073 0.094 0.098 0.10

300 0.135 0.167 0.144 0.161 0.148 0.233 0.249 0.236 0.194 0.207 0.213 0.269 0.282 0.289 300

0.041 0.051 0.044 0.049 0.045 0.071 0.076 0.072 0.059 0.063 0.065 0.082 0.086 0.088

350 0.131 0.164 0.125 0.141 0.128 0.200 0.217 0.207 0.174 0.190 0.197 0.240 0.253 0.262 350

0.040 0.050 0.038 0.043 0.039 0.061 0.066 0.063 0.053 0.058 0.060 0.073 0.077 0.080

400 0.131 0.161 0.108 0.125 0.115 0.177 0.194 0.180 0.161 0.174 0.184 0.217 0.233 0.240 400

0.040 0.049 0.033 0.038 0.035 0.054 0.059 0.055 0.049 0.053 0.056 0.066 0.071 0.073

500 0.128 0.157 0.089 0.105 0.095 0.141 0.157 0.148 0.141 0.157 0.164 0.187 0.200 0.210 500

0.039 0.048 0.027 0.032 0.029 0.043 0.048 0.045 0.043 0.048 0.050 0.057 0.061 0.064

600 0.128 0.157 0.075 0.092 0.082 0.118 0.135 0.125 0.131 0.144 0.154 0.167 0.180 0.190 600

0.039 0.048 0.023 0.028 0.025 0.036 0.041 0.038 0.040 0.044 0.047 0.051 0.055 0.058

750 0.125 0.157 0.062 0.079 0.069 0.095 0.112 0.102 0.118 0.131 0.141 0.148 0.161 0.171 750

0.038 0.048 0.019 0.024 0.021 0.029 0.034 0.031 0.036 0.040 0.043 0.045 0.049 0.052

1000 0.121 0.151 0.049 0.062 0.059 0.075 0.089 0.082 0.105 0.118 0.131 0.128 0.138 0.151 1000

0.037 0.046 0.015 0.019 0.018 0.023 0.027 0.025 0.032 0.036 0.040 0.039 0.042 0.046

Notes:

1. These values are based on the following constants: UL-Type RHH wires with Class B stranding, in cradled configuration. Wire conductivities are 100 percent IACS copper and 61 percent IACS aluminum, and aluminum conduit is 45 percent IACS. Capacitive reactance is ignored, since it is negligible at these voltages. These resistance values are valid only at 75°C (167°F) and for the parameters as given, but are representative for 600-volt wire types operating at 60 Hz.

2. Effective Z is defined as R cos(θ) + X sin(θ), where θ is the power factor angle of the circuit. Multiplying current by effective impedance gives a good approximation for line-to-neutral voltage drop. Effective impedance values shown in this table are valid only at 0.85 power factor. For another circuit power factor (PF), effective impedance (Ze) can be calculated from R and XL values given in this table as follows: Ze = R × PF + XLsin[arccos(PF)].

Table 10 Conductor Stranding

Conductor Size Number of Strands

Copper Aluminum

AWG or kcmil mm2 Class Ba Class C Class Ba

24—30 0.20—0.05 b — —

22 0.32 7 — —

20 0.52 10 — —

18 0.82 16 — —

16 1.3 26 — —

14—2 2.1—33.6 7 19 7c

1—4/0 42.4—107 19 37 19

250—500 127—253 37 61 37

600—1000 304—508 61 91 61

1250—1500 635—759 91 127 91

1750—2000 886—1016 127 271 127

aConductors with a lesser number of strands shall be permitted based on an evaluation for connectability and bending.

bNumber of strands vary.

cAluminum 14 AWG (2.1 mm2) is not available.

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Table 11(A) and Table 11(B)

For listing purposes, Table 11(A) and Table 11(B) provide the required power source limitations for Class 2 and Class 3 power sources. Table 11 (A) applies for alternating-current sources, and Table 11(B) applies for direct-current sources.

The power for Class 2 and Class 3 circuits shall be either (1) inherently limited, requiring no overcurrent protection, or (2) not inherently limited, requiring a combination of power source and overcurrent protection. Power sources designed for interconnection shall be listed for the purpose.

As part of the listing, the Class 2 or Class 3 power source shall be durably marked where plainly visible to indicate the class of supply and its electrical rating. A Class 2 power source not suitable for wet location use shall be so marked.

Exception: Limited power circuits used by listed information technology equipment.

Overcurrent devices, where required, shall be located at the point where the conductor to be protected receives its supply and shall not be interchangeable with devices of higher ratings. The overcurrent device shall be permitted as an integral part of the power source.

Table 11(A) Class 2 and Class 3 Alternating-Current Power Source Limitations

Power Source Inherently Limited Power Source (Overcurrent Protection Not Required) Not Inherently Limited Power Source (Overcurrent Protection Required)

Class 2 Class 3 Class 2 Class 3

Source voltage Vmax (volts)

(see Note 1) 0 through 20\* Over 20 and through 30\* Over 30 and through 150 Over 30 and through 100 0 through 20\* Over 20 and through 30\* Over 30 and through 100 Over 100 and through 150

Power limitations VAmax (volt-amperes)

(see Note 1) — — — — 250 (see Note 3) 250 250 N.A.

Current limitations Imax (amperes)

(see Note 1) 8.0 8.0 0.005 150/Vmax 1000/Vmax 1000/Vmax 1000/Vmax 1.0

Maximum overcurrent protection (amperes) — — — — 5.0 100/Vmax 100/Vmax 1.0

Power source maximum nameplate rating VA (volt-amperes) 5.0 × Vmax 100 0.005 × Vmax 100 5.0 × Vmax 100 100 100

Current (amperes) 5.0 100/Vmax 0.005 100/Vmax 5.0 100/Vmax 100/Vmax 100/Vmax

Note: Notes for this table can be found following Table 11(B).

\*Voltage ranges shown are for sinusoidal ac in indoor locations or where wet contact is not likely to occur.

For nonsinusoidal or wet contact conditions, see Note 2.

Table 11(B) Class 2 and Class 3 Direct-Current Power Source Limitations

Power Source Inherently Limited Power Source

(Overcurrent Protection Not Required) Not Inherently Limited Power Source

(Overcurrent Protection Required)

Class 2 Class 3 Class 2 Class 3

Source voltage Vmax (volts)

(see Note 1) 0 through 20\* Over 20 and through 30\* Over 30 and through 60\* Over 60 and through 150 Over 60 and through 100 0 through 20\* Over 20 and through 60\* Over 60 and through 100 Over 100 and through 150

Power limitations VA max (volt-amperes)(see Note 1) — — — — — 250 (see Note 3) 250 250 N.A.

Current limitations Imax (amperes)

(see Note 1) 8.0 8.0 150/Vmax 0.005 150/Vmax 1000/Vmax 1000/Vmax 1000/Vmax 1.0

Maximum overcurrent protection (amperes) — — — — — 5.0 100/Vmax 100/Vmax 1.0

Power source maximum nameplate rating VA (volt-amperes) 5.0 × Vmax 100 100 0.005 × Vmax 100 5.0 × Vmax 100 100 100

Current (amperes) 5.0 100/Vmax 100/Vmax 0.005 100/Vmax 5.0 100/Vmax 100/Vmax 100/Vmax

\*Voltage ranges shown are for continuous dc in indoor locations or where wet contact is not likely to occur.

For interrupted dc or wet contact conditions, see Note 4.

Notes for Table 11(A) and Table 11(B)

1. Vmax, Imax, and VAmax are determined with the current-limiting impedance in the circuit (not bypassed) as follows:

Vmax: Maximum output voltage regardless of load with rated input applied.

Imax: Maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed if used. Where a transformer limits the output current, Imax limits apply after 1 minute of operation. Where a current-limiting impedance, listed for the purpose, or as part of a listed product, is used in combination with a non—power-limited transformer or a stored energy source, e.g., storage battery, to limit the output current, Imax limits apply after 5 seconds.

VAmax: Maximum volt-ampere output after 1 minute of operation regardless of load and overcurrent protection bypassed if used.

2. For nonsinusoidal ac, Vmax shall not be greater than 42.4 volts peak. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used or Vmax shall not be greater than 15 volts for sinusoidal ac and 21.2 volts peak for nonsinusoidal ac.

3. If the power source is a transformer, VAmax is 350 or less when Vmax is 15 or less.

4. For dc interrupted at a rate of 10 to 200 Hz, Vmax shall not be greater than 24.8 volts peak. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used, or Vmax shall not be greater than 30 volts for continuous dc; 12.4 volts peak for dc that is interrupted at a rate of 10 to 200 Hz.

Table 12(A) and Table 12(B)

For listing purposes, Table 12(A) and Table 12(B) provide the required power source limitations for power-limited fire alarm sources. Table 12(A) applies for alternating-current sources, and Table 12(B) applies for direct-current sources. The power for power-limited fire alarm circuits shall be either (1) inherently limited, requiring no overcurrent protection, or (2) not inherently limited, requiring the power to be limited by a combination of power source and overcurrent protection.

As part of the listing, the PLFA power source shall be durably marked where plainly visible to indicate that it is a power-limited fire alarm power source. The overcurrent device, where required, shall be located at the point where the conductor to be protected receives its supply and shall not be interchangeable with devices of higher ratings. The overcurrent device shall be permitted as an integral part of the power source.

Table 12(A) PLFA Alternating-Current Power Source Limitations

Power Source Inherently Limited Power Source

(Overcurrent Protection Not Required) Not Inherently Limited Power Source

(Overcurrent Protection Required)

Circuit voltage Vmax (volts)

(see Note 1) 0 through 20 Over 20 and through 30 Over 30 and through 100 0 through 20 Over 20 and through 100 Over 100 and through 150

Power limitations VAmax(volt-amperes)

(see Note 1) — — — 250 (see Note 2) 250 N.A.

Current limitations Imax (amperes)

(see Note 1) 8.0 8.0 150/Vmax 1000/Vmax 1000/Vmax 1.0

Maximum overcurrent protection

(amperes) — — — 5.0 100/Vmax 1.0

Power source maximum nameplate ratings VA (volt-amperes) 5.0 × Vmax 100 100 5.0 × Vmax 100 100

Current (amperes) 5.0 100/Vmax 100/Vmax 5.0 100/Vmax 100/Vmax

Note: Notes for this table can be found following Table 12(B).

Table 12(B) PLFA Direct-Current Power Source Limitations

Power Source Inherently Limited Power Source

(Overcurrent Protection Not Required) Not Inherently Limited Power Source

(Overcurrent Protection Required)

Circuit voltage Vmax (volts)

(see Note 1) 0 through 20 Over 20 and through 30 Over 30 and through 100 0 through 20 Over 20 and through 100 Over 100 and through 150

Power limitations VAmax (volt-amperes)

(see Note 1) — — — 250 (see Note 2) 250 N.A.

Current limitations I max (amperes)

(see Note 1) 8.0 8.0 150/Vmax 1000/Vmax 1000/Vmax 1.0

Maximum overcurrent protection

(amperes) — — — 5.0 100/Vmax 1.0

Power source maximum nameplate ratings VA (volt- amperes) 5.0 × Vmax 100 100 5.0 × Vmax 100 100

Current (amperes) 5.0 100/Vmax 100/Vmax 5.0 100/Vmax 100/Vmax

Notes for Table 12(A) and Table 12(B)

1. V max, I max, and VA max are determined as follows:

V max: Maximum output voltage regardless of load with rated input applied.

I max: Maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed if used. Where a transformer limits the output current, Imax limits apply after 1 minute of operation. Where a current-limiting impedance, listed for the purpose, is used in combination with a nonpower-limited transformer or a stored energy source, e.g., storage battery, to limit the output current, Imax limits apply after 5 seconds.

VA max: Maximum volt-ampere output after 1 minute of operation regardless of load and overcurrent protection bypassed if used. Current limiting impedance shall not be bypassed when determining Imax and VAmax.

2. If the power source is a transformer, VAmax is 350 or less when Vmax is 15 or less.