Designation: B 48 – 00

Standard Specification for Soft Rectangular and Square Bare Copper Wire for Electrical Conductors[1]

This standard is issued under the fixed designation B 48; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers soft or annealed bare copper wire, rectangular or square in shape with rounded corners (Explanatory Note 1).

1.2 For the purpose of this specification, the wire is classified as follows:

1.2.1 *Type A*—For all applications except those involving edgewise bending.

1.2.2 *Type B*—For applications involving edgewise bending. Type B wire of thickness less than 0.020 in. (0.51 mm) or with a ratio of width to thickness greater than 30 to 1 is not contemplated in this specification.

1.3 Unless otherwise specified by the purchaser, Type A material shall be furnished.

1.4 For referee purposes, inch-pound units shall be used throughout this specification, except for Sections 12 and 13.

2. Referenced Documents

2.1 *ASTM Standards:*

B 49 Specification for Copper Redraw Rod for Electrical Purposes[2]

B 193 Test Method for Resistivity of Electrical Conductor Materials[3]

B 279 Test Method for Stiffness of Bare Soft Square and Rectangular Copper and Aluminum Wire for Magnet Wire Fabrication[3]

E 8 Test Methods for Tension Testing of Metallic Materials[4]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[5]

2.2 *Other Document:*

NBS Handbook 100— Copper Wire Tables[6]

3. Ordering Information

3.1 Orders for material to this specification shall include the following information:

3.1.1 Quantity of each size,

3.1.2 Type of wire (see 1.1, 1.2, and 1.3),

3.1.3 Wire size: thickness and width, in inches or millimetres (see 6.1),

3.1.4 Type of copper, if special (see Section 4),

3.1.5 Package size (see 16.1),

3.1.6 Special package marking, if required, and

3.1.7 Place of inspection. (see Section 15).

4. Material

4.1 The material shall be copper of such quality and purity that the finished product shall have the properties and characteristics prescribed in this specification.

4.2 Specification B 49 defines the materials suitable for use.

5. Manufacture

5.1 The wire shall be annealed after the last drawing or rolling to size and shape, and shall be so processed as to produce a uniformly soft product with a clean surface.

5.2 The finished wire shall not contain joints except such as have passed through drawing dies. Necessary joints in the wire and rods prior to final drawing shall be made in accordance with good commercial practice.

6. Dimensions and Permissible Variations

6.1 The dimensions shall be expressed in decimal fractions of an inch or in millimetres. Unless otherwise specified, it will be assumed that the dimensions are in inches. (Explanatory Note 6, Explanatory Note 7, and Explanatory Note 8.)

6.2 The thickness shall not vary from that specified by more than the amounts prescribed in Table 1.

6.3 The width shall not vary from that specified by more than the amounts prescribed in Table 2.

6.4 The wire shall have rounded corners or rounded edges as specified in Table 3 and as shown in Fig. 1. Where rounded corners are required, the corners of the wire shall be rounded within the limits of radii, 25 % under and 25 % over (as determined by a radius gage) those radii values specified in Table 3.

6.5 From each shipping unit, approximately 12 ft (3.66 m)

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[1] This specification is under the jurisdiction of ASTM Committee B-1 on Electrical Conductors and is the direct responsibility of Subcommittee B01.04 on Conductors of Copper and Copper Alloys.

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[2] *Annual Book of ASTM Standards*, Vol 02.01.

[3] *Annual Book of ASTM Standards*, Vol 02.03.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] Available from National Institute of Standards and Technology, (NIST), Gaithersburg, MD 20899.

TABLE 1 Variation in Thickness

Specified Thickness				Width								
				Over 1,000 in. (25.4 mm)			1.000 in. (25.4 mm) to 0.492 in. (12.5 mm)			Under 0.492 in. (12.5 mm)		
in.		mm		Permissible Variation in Thickness, max, plus and minus								
				in	%	mm	in.	%	mm	in.	%	mm
0.501 and over		12.73 and over		...	1	...	...	1	...	...	...	...
under	to, incl	under	to, incl									
0.501	0.280	12.73	7.11	...	1	...	...	1	...	0.003	...	0.076
0.280	0.201	7.11	5.11	0.003	...	0.08	...	1	...	...	1	...
0.201	0.098	5.11	2.49	0.0025	...	0.064	...	1	...	...	1	...
0.098	0.051	2.49	1.30	0.002	...	0.051	0.001	...	0.03	0.001	...	0.03
0.051	...	1.30	...	0.0015	...	0.038	0.001	...	0.03	0.001	...	0.03

TABLE 2 Variation in Width

Specified Width		Permissible Variation in Width, max, plus and minus
In.	mm	
0.492 and over	12.5 and over	1 % but not to exceed 0.016 in. (0.406 mm)
Under 0.492 to 0.315, incl	under 12.5 to 8.00, incl	0.003 in. (0.076 mm)
Under 0.315 to 0.098, incl	under 8.00 to 2.49, incl	1 %
Under 0.098	under 2.49	0.001 in. (0.025 mm)

TABLE 3 Requirements for Rounded Corners and Rounded Edges

Specified Thickness				Corner Radius for Specified Width					
				in.	mm	in.	mm	in.	mm
in.		mm		0.748 and over	19.0 and over	under 0.748 to 0.187, incl	under 19.0 to 4.75, incl	under 0.187	under 4.75
0.689 and over		17.50 and over		0.188	4.78	0.188	4.78	...	...
under	to, incl	under	to, incl						
0.689	0.439	17.50	11.15	0.125	3.18	0.094	2.39	...	...
0.439	0.280	11.15	7.10	0.094	2.39	0.039	1.00	...	...
0.280	0.177	7.10	4.50	0.063	1.60	0.039	1.00	0.039	1.00
0.177	0.124	4.50	3.15	0.063	1.60	0.03	0.80	0.03	0.80
0.124	0.098	3.15	2.15	rounded edge[A]		0.03[B]	0.80[B]	0.026	0.67
0.098[C]	0.063	2.15[C]	1.60	rounded edge[A]		0.03[B]	0.80[B]	0.020	0.50
0.063[D]	...	1.60[D]	...	rounded edge[A]		full rounded edge[E]		full rounded edge[E]	

[A] A rounded edge is an edge produced by (1) rolling wire to the size specified either with or without edging rolls or (2) drawing through a die (see Fig. 1).

[B] Rectangular wire with a thickness under 0.124 in. (3.15 mm) to 0.063 in. (1.60 mm) and a width under 0.751 in. (19.08 mm) to 0.189 in. (4.80 mm) may be manufactured with the corner radius specified for the same thickness and a width under 0.189 in. (4.80 mm).

[C] Square wire 0.072 in. (1.83 mm) and under shall have a corner radius of 0.016 in. (0.41 mm) ± 25 %.

[D] Rectangular wire with a thickness under 0.063 in. (1.60 mm) to 0.03 in. (0.80 mm) may be manufactured with a corner radius of 0.016 in. (0.41 mm) ± 25 %.

[E] Except as permitted by Footnote *B*, rectangular wire less than 0.751 in. (19.08 mm) wide with full rounded edge shall have a radius half the thickness of the wire, ± 25 %.

shall be unwound and the wire gaged at six places between points 12 in. (30.5 cm) and 12 ft (3.66 m) from the end. The shipping unit shall be rejected if the average of the measurements obtained is not within the limits specified in 6.2 and 6.3.

7. Physical Requirements

7.1 *Elongation*:

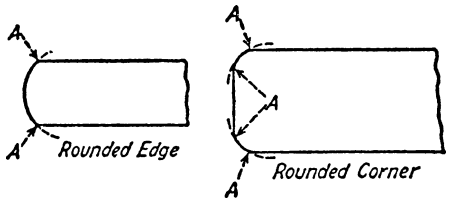
7.1.1 Type A wire shall conform to the requirements for elongation given in Table 4.

7.1.2 For Type B wire elongation tests shall not be required.

7.1.3 Elongation tests shall be made in accordance with Test Methods E 8 on representative samples. The elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between gage marks placed originally 10 in. (250 mm) apart upon the test specimen (Explanatory Note 2). The fracture shall be in between gage marks and not closer than 1 in. (25 mm) to either gage mark.

7.2 *Bending*:

7.2.1 Both edges of Type B wire shall withstand bending edgewise through 180° around the mandrel indicated without cracking. The mandrel shall be one of the sizes shown in Table 5 and shall be the size that is equal to or next larger than the figure obtained by multiplying the width of the wire by the factor in Table 6, corresponding to the ratio of the width to the thickness of the wire. In cases where the mandrel diameter desired is less than 0.156 in. (3.96 mm) or the thickness is less than 0.020 in. (0.51 mm) or the ratio of the width to thickness of the wire is greater than 30 to 1, the scope of Type B wire is exceeded and the edgewise bending properties shall be as



NOTE 1—The arc is not necessarily tangent to the flats at points *A*. However, the wire shall be commercially free of sharp, rough, or projecting edges.

FIG. 1 Sections of Wire with Rounded Edges and Rounded Corners

TABLE 4 Requirements for Elongation

Specified Thickness		Elongation in 10 in. (250 mm); min, %
in.	mm	
0.290 and over	7.37 and over	35
Under 0.290 to 0.051, incl	under 7.37 to 1.30, incl	32
Under 0.051 to 0.021, incl	under 1.30 to 0.53, incl	32
Under 0.021 to 0.011, incl	under 0.53 to 0.28, incl	25
Under 0.011	under 0.28	20

TABLE 5 Standard Mandrel Sizes for Edgewise Bend Test

Mandrel Diameters			
in.	mm	in.	mm
0.156	3.96	0.625	15.9
0.188	4.78	0.750	19.0
0.220	5.59	0.875	22.2
0.250	6.35	1.000	25.4
0.312	7.98	1.250	31.8
0.375	9.52	1.500	38.1
0.438	11.1	1.750	44.4
0.500	12.7	2.000[A]	50.8

[A]The maximum mandrel diameter of 2 in. (50.8 mm) is based on the suggested maximum width of strap, made from round copper wire, of 1.250 in. (31.8 mm), established by the Copper Development Association.

TABLE 6 Factor for Determining Mandrel Size for Edgewise Bend Test

Width to Thickness Ratio	Multiplying Factor to Determine Mandrel Size
30 to 20, incl	1.50
Under 20 to 10, incl	1.25
Under 10 to 5, incl	1.00
Under 5 to 2.5, incl	0.75
Under 2.5	0.50

agreed upon between the purchaser and the manufacturer (Explanatory Note 3 and Explanatory Note 4).

7.2.2 For Type A wire the bend test shall not be required.

7.3 *Low Stress Elongation (LSE)*:

7.3.1 Types A and B wire shall have a minimum LSE value of 1 % determined in accordance with Test Method B 279. (Explanatory Note 5).

7.4 *Retests*:

7.4.1 If upon testing a sample from any coil or reel of wire, the results do not conform to the respective requirements of 7.1, 7.2 and 7.3, two additional samples shall be tested, each of which shall conform to the prescribed requirements.

8. Standard Reference Temperature

8.1 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.

9. Standard Rules for Rounding Off

9.1 All calculations for the standard nominal dimensions and properties of rectangular and square wires shall be rounded off in the final value only, in accordance with the rounding-off method of Practice E 29.

10. Nominal Cross-Sectional Areas

10.1 Nominal cross-sectional areas in square mils or square millimetres shall be calculated by subtracting the area reductions due to rounded corners or rounded edges (see Table 7 and Table 8) from the product of the specified nominal thickness and width dimensions in mils (0.001 in.) or millimetres as applicable. Values so derived shall be rounded off in accordance with Section 9 to the same number of significant figures as used in expressing the nominal dimensions, but in no case to less than three significant figures.

11. Nominal Mass/Unit Length and Length

11.1 Nominal mass/unit length and lengths shall be calculated from the nominal wire dimensions in accordance with the following equations and shall be rounded off in the *final* value only, in accordance with Section 9, to the same number of significant figures as used in expressing the nominal dimensions, but in no case to less than three significant figures:

$$\text{Mass/Unit Length, lb/1000 ft} = 3.8540 \times A \times 10^{-3}$$

$$\text{kg/km} = 8.89 \times A_1$$

$$\text{Length, ft/lb} = (2.5947 \times 10^{5})/A$$

$$\text{m/kg} = 112.486/A_1$$

where:

A = nominal cross-sectional area in square mils, obtained in accordance with Section 10, and

A_1 = nominal cross-sectional area in square millimetres obtained in accordance with Section 10.

TABLE 7 Areas of Square Copper Wire

Nominal Size		Calculated Area of Perfect Square		Nominal Corner Radius		Calculated Departure[A]		Nominal Area		Nominal Area Working Value	
in.	mm	mil^2	mm^2	in.	mm	mils^2	mm^2	mils^2	mm^2	mils^2	mm^2
1	2	3	4	5	6	7	8	9	10	11	12
0.0508	1.290	2580.64	1.66493	0.016	0.41	219.75	0.14177	2360.89	1.52315	2.36×10^3	1.52
0.0571	1.450	3260.41	2.10349	0.016	0.41	219.75	0.14177	3040.66	1.96171	3.04	1.96
0.0641	1.628	4108.81	2.65038	0.016	0.41	219.75	0.14177	3889.06	2.50907	3.89	2.51
0.0720	1.829	5184.00	3.34451	0.016	0.41	219.75	0.14177	4964.25	3.20274	4.96	3.20
0.0808	2.052	6528.64	4.21202	0.020	0.51	343.36	0.22151	6185.28	3.99050	6.19	3.99
0.0907	2.304	8226.49	5.30740	0.020	0.51	343.36	0.22151	7883.13	5.08588	7.88	5.09
0.1019	2.588	10383.61	6.69909	0.026	0.66	580.28	0.37437	9803.33	6.32472	9.80	6.32
0.1144	2.906	13087.36	8.44344	0.026	0.66	580.28	0.37437	12507.08	8.06907	12.51	8.07
0.1285	3.264	16512.25	10.65304	0.032	0.81	879.00	0.56710	15633.25	10.08595	15.63	10.09
0.1443	3.665	20822.49	13.43384	0.032	0.81	879.00	0.56710	19943.49	12.86674	19.94	12.87
0.1620	4.115	26244.00	16.93158	0.032	0.81	879.00	0.56710	25365.00	16.36448	25.36†	16.36
0.1819	4.620	33087.61	21.34680	0.040	1.02	1373.44	0.88609	31714.17	20.46071	31.71	20.46
0.2043	5.189	41738.49	26.92800	0.040	1.02	1373.44	0.88609	40365.05	26.04192	40.37	26.04
0.2294	5.827	52624.36	33.95113	0.040	1.02	1373.44	0.88609	51250.92	33.06504	51.25	33.07
0.2576	6.543	66357.76	42.81137	0.040	1.02	1373.44	0.88609	64984.32	41.92528	64.98	41.93
0.2893	7.348	83694.49	53.99634	0.040	1.02	1373.44	0.88609	82321.05	53.11025	82.32	53.11
0.3249	8.252	105560.01	68.10310	0.040	1.02	1373.44	0.88609	104186.57	67.21701	104.2	67.22
0.3648	9.266	133097.04	85.86889	0.040	1.02	1373.44	0.88609	131723.60	84.98280	131.7	84.98
0.4096	10.404	167772.16	108.23989	0.040	1.02	1373.44	0.88609	166398.72	107.35380	166.4	107.4
0.4600	11.684	211600.00	136.51586	0.094	2.39	7584.82	4.89342	204015.18	131.62243	204.0	131.6

[A]The reduction in area due to rounding the corners.

TABLE 8 Calculated Reduction in Area Due to Rounding of Corners of Rectangular Wire

Specified Thickness				Specified Width					
				in.	mm	in.	mm	in.	mm
				0.751 and over	19.08 and over	under 0.751 to 0.189, incl	under 19.08 to 4.80, incl	under 0.189	under 4.80
in.		mm		Calculated Reduction					
				mils^2	mm^2	mils^2	mm^2	mils^2	mm^2
0.689 and over		17.50 and over		30339.29	19.5732	30339.29	19.5737	...	...
under	to, incl	under	to, incl						
0.689	0.439	17.50	11.15	13412.50	8.65321	7584.82	4.89342	...	...
0.439	0.226	11.15	5.74	7584.82	4.89342	1373.44	0.88609	...	...
0.226	0.166	5.24	4.22	3406.90	2.19805	1373.44	0.88609	1373.44	0.88609
0.166	0.126	4.22	3.20	3406.00	2.19805	879.00	0.56710	879.00	0.56710
0.126	0.096	3.20	2.44	[A]	[A]	879.00	0.56710	580.28	0.37437
0.096	0.061	2.44	1.55	[A]	[A]	879.00	0.56710	343.36	0.22152
0.061	...	1.55	...	[A]	[A]	[A]	[A]	[A]	[A]

[A]For wire with rounded edges, the calculated reduction in area in square mils is equivalent to 214600 T^2, where T is the thickness of the wire in inches, and the calculated reduction in area in square mm is equivalent to $0.2146 T_1^2$, where T_1 is the thickness of the wire in millimetres. For square wire, see Table 7.

12. Resistivity

12.1 Electrical resistivity shall be determined on representative samples by resistance measurements (Explanatory Note 9). At a temperature of 20°C, the resistivity shall not exceed $0.017241 \Omega \cdot \text{mm}^2/\text{m}$.

12.2 Tests to determine conformance to electrical resistance requirements shall be made on the uninsulated conductor in accordance with Test Method B 193.

12.3 Nominal resistances and other values derived from the resistivity units shall be calculated from the nominal wire dimensions in accordance with the following equations and all values so derived shall be rounded off in the *final* value only, in accordance with Section 9, to the same number of significant figures as used in expressing the nominal dimensions, but in no case to less than three significant figures:

$$\text{D-c resistance at 20°C, } \Omega/1000 \text{ ft} = (8.1458 \times 10^3)/A$$

$$\text{D-c resistance at 20°C, } \Omega/\text{km} = 17.241/A_1$$

$$\text{D-c resistance at 20°C, } \Omega/\text{lb} = (2.1135 \times 10^6)/A^2$$

$$\text{D-c resistance at 20°C, } \Omega/\text{kg} = 1.9394/A_1^2$$

$$\text{Length at 20°C ft}/\Omega = 0.12277 \times A$$

$$\text{Length at 20°C, m}/\Omega = 58{,}000 \times A_1$$

$$\text{Mass at 20°C, lb}/\Omega = 0.47315 \times A^2 \times 10^{-6}$$

$$\text{Mass at 20°C, g}/\Omega = 515.62 \times A_1^2$$

where:

A = the nominal cross-sectional area of the wire in square mils, obtained in accordance with Section 10,

A_1 = the nominal cross-sectional area of the wire in square mm, obtained in accordance with Section 10.

13. Density

13.1 For the purpose of calculating mass, cross sections, etc., the density of the copper shall be taken as 8.89 g/cm^3(0.32117 lb/in.^{3}) at 20°C (Explanatory Note 10).

14. Finish

14.1 The wire shall be free of all imperfections not consistent with good commercial practice.

15. Inspection

15.1 All tests and inspection shall be made at the place of manufacture unless otherwise especially agreed upon between the manufacturer and purchaser at the time of purchase. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification.

16. Packaging and Shipping

16.1 Package sizes shall be agreed upon by the manufacturer and the purchaser in the placing of individual orders (Explanatory Note 11).

16.2 The wire shall be protected against damage in ordinary handling and shipping.

16.3 Unless otherwise agreed upon, the wire shall be shipped in continuous lengths of not less than the weights shown in Table 9.

17. Precision and Bias

17.1 *Precision*—This specification has been in use for many years. No statement of precision has been made and no work has been planned to develop such a statement.

17.2 *Bias*—This specification has no bias because the value for cross-sectional area is determined solely in terms of this specification.

18. Keywords

18.1 copper bare electrical conductor; copper wire; soft square and rectangular copper wire

TABLE 9 Minimum Mass

Nominal Area		Minimum Mass	
mil^2	mm^2	lb	kg
5001 and over	3.23 and over	135	61.2
Under 5001 to 2000, incl	under 3.23 to 1.29, incl	65	29.5
Under 2000	under 1.29	30	13.6

EXPLANATORY NOTES

NOTE 1—Soft or annealed copper wire is wire that has been drawn or rolled to size by customary operations and then annealed. When necessary, it is finished by cleaning to remove scale or oxide. It is not limited in size by the Copper Development Association definition of flat wire, namely 0.188 in. (4.77 mm) maximum thickness by 1¼in. (31.8 mm) maximum width. The wire is soft and ductile, easily marred, and even stretched by careless handling. It is therefore necessary that the requirements of this specification relating to elongation properties and resistivity refer to the wire as it is put up by the manufacturer, and before being put through processes incident to its use by the purchaser.

NOTE 2—In general, tested values of elongation are reduced with increase in speed of the moving head of the testing machine in the tension testing of copper wire. In the case of tests on soft or annealed copper wire, however, the effects of speed of testing are not pronounced. Tests of soft wire made at speeds of moving head, which under no-load conditions are not greater than 12 in. (300 mm)/min, do not alter the final results of elongation determinations to any practical extent.

NOTE 3—Edgewise bend characteristics are affected by small amounts of cold working and by imperfections in the surface or edges of the wire. Care must be taken in selecting the sample to be sure that the wire has not been damaged where the edgewise bend test is to be applied. The edgewise bend test equipment should make provision to hold the sample flat while the bend is being made. When samples under 0.050 in. (1.27 mm) are being tested, it is recommended that a number of samples be bent at the same time to give an effective thickness of not less than 0.060 in. (1.52 mm).

NOTE 4—In considering the results of the edgewise bend test, slight surface roughness or the so-called "Orange Peel Effect" is not considered cause for rejection. If minute fissues are visible, either on the edge or the corners, when the sample is viewed with normal near vision corrected if necessary with spectacles, the sample is considered to have failed the edgewise bend test.

NOTE 5—LSE test results are affected by small amounts of cold working. The specified 1 % minimum LSE value applies only to bare wire before further processing.

NOTE 6—It is urged that gage numbers be avoided entirely in connection with rectangular wire. Not only are there several systems of gage numbers, but confusion is likely to result even if the identity of the particular gage is known since it may not be clear whether the gage number refers to the thickness dimension or to the area of a round wire having a diameter equal to that gage number. Definite dimensions of thickness and width in decimal fractions of an inch or in millimetres are much preferred.

Square wire sizes sometimes are expressed in terms of AWG sizes, as" No. 8 AWG Square." This terminology is confusing and its use is not recommended. However, when a square wire size is expressed in this manner, it refers to a square circumscribing a circle whose diameter is that of a round wire of the specified AWG size.

NOTE 7—Table 7 gives data on the cross sectional area of square wire in sizes 0.0508 in. (1.29 mm) to 0.4600 in. (11.68 mm), incl, allowance having been made for reduction of the theoretical area of a perfect square wire due to the rounding of its four corners as shown in Table 3 of this specification. These areas are for the nominal dimensions shown in Columns 1 and 2 of Table 7 and do not take into account the variation in the dimensions permitted by the tolerances given in the specification. The significance of these nominal working area values should not extend beyond the significance of the values in Columns 1 and 2 and it is for this reason that the nominal working area values have been rounded off as shown in Columns 11 and 12. Attention is also called to the fact that the values obtained by the equations of 12.3 are for wire of nominal dimensions and do not take into account probable increase or decrease of the values due to the variations of the dimensions of an actual wire within the limits of the specified tolerances. Square mils and square millimetres are terms used to express cross-sectional area of square and rectangular sections. A square mil is the area of a square, 1 mil on each side. A square millimetre is the area of a square, 1 mm on each side. Thus, if dimensions

of a rectangular section are expressed in mils or millimetres, the area of that section in square mils or square millimetres, respectively, is the product of thickness times width. The relationship between circular mils and square mils is that of a circle to its circumscribing square. Thus, 1 cmil = 0.7854 mil^2.

NOTE 8—Table 8 gives the calculated area in square mils or square millimetres to be deducted, because of the rounding of the four corners of the rectangular wire from the area of a circumscribing rectangle having the same thickness and width, in order to obtain the working net area of the wire. The areas to be deducted are based on the radii specified in Table 3 of this specification, and do not take into account probable increase or decrease of the area of an actual wire due to the variation in its dimensions within the limits of the tolerances given in this specification. As in the case of square wire, working net areas of rectangular wire should not extend to a number of significant figures greater than that employed in specifying its thickness and width. This is also true of any other derived values such as circular-mil area, weight or electrical resistance.

NOTE 9—"Resistivity" is used in place of "percentage conductivity" and the resistivity units are based on the International Annealed Copper Standard adopted by IEC in 1913, which is ⅟58 $\Omega \cdot mm^2/m$. The value of 0.017241 $\Omega \cdot mm^2/m$ and the value of 0.15328 $\Omega \cdot g/m$ at 20°C are respectively the international standard of volume and mass resistivity of annealed copper equal to 100 % conductivity. This term means that a wire 1 m in length and weighing 1 g would have a resistance of 0.15328 Ω. This is equivalent to a resistivity value of 875.20 $\Omega \cdot lb/mile^2$, which signifies the resistance of a wire 1 mile in length weighing 1 lb. It is also equivalent, for example, to 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. Relationships which may be useful in connection with the values of resistivity prescribed in this specification are as follows:

Conductivity at 20°C, %	100.00
$\Omega \cdot lb/mile^2$	875.20
$\Omega \cdot g/m^2$	0.15328
$\Omega \cdot cmil/ft$	10.371
$\Omega \cdot mm^2/m$	0.017241
μΩ·in.	0.67879
μΩ·cm	1.7241

The use of five significant figures in expressing resistivity does not imply the need for greater accuracy of measurement than that specified in Test Method B 193. The use of five significant figures is required for complete reversible conversion from one set of resistivity units to another.

NOTE 10—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^3 (0.32150 $lb/in.^3$). The subject of density is discussed at length in *NBS Handbook 100*.

NOTE 11—Attention is called to the desirability for agreement between the manufacturer and purchaser on package sizes, which will be sufficiently large and yet not so heavy or bulky that the wire may likely be damaged in handling.