



Designation: B 48 – 00

# Standard Specification for Soft Rectangular and Square Bare Copper Wire for Electrical Conductors<sup>1</sup>

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<sup>2</sup>

B 193 Test Method for Resistivity of Electrical Conductor Materials<sup>3</sup>

B 279 Test Method for Stiffness of Bare Soft Square and Rectangular Copper and Aluminum Wire for Magnet Wire Fabrication<sup>3</sup>

E 8 Test Methods for Tension Testing of Metallic Materials<sup>4</sup>

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>5</sup>

### 2.2 Other Document:

NBS Handbook 100—Copper Wire Tables<sup>6</sup>

<sup>1</sup> 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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<sup>2</sup> Annual Book of ASTM Standards, Vol 02.01.

<sup>3</sup> Annual Book of ASTM Standards, Vol 02.03.

<sup>4</sup> Annual Book of ASTM Standards, Vol 03.01.

<sup>5</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>6</sup> Available from National Institute of Standards and Technology, (NIST), Gaithersburg, MD 20899.

## 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

**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) |       |     |       |
|                     |          |                |          | Permissible Variation in Thickness, max, plus and minus |     |  |       |     |                           |       |     |       |
| in.                 |          | mm             |          | 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.                            |            |
| 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 <sup>A</sup>         |               | 0.03 <sup>B</sup>              | 0.80 <sup>B</sup>        | 0.026                          | 0.67       |
| 0.098 <sup>C</sup>  | 0.063    | 2.15 <sup>C</sup> | 1.60     | rounded edge <sup>A</sup>         |               | 0.03 <sup>B</sup>              | 0.80 <sup>B</sup>        | 0.020                          | 0.50       |
| 0.063 <sup>D</sup>  | ...      | 1.60 <sup>D</sup> | ...      | rounded edge <sup>A</sup>         |               | full rounded edge <sup>E</sup> |                          | full rounded edge <sup>E</sup> |            |

<sup>A</sup>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).

<sup>B</sup>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).

<sup>C</sup>Square wire 0.072 in. (1.83 mm) and under shall have a corner radius of 0.016 in. (0.41 mm) ± 25 %.

<sup>D</sup>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 %.

<sup>E</sup>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 %.

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) 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:

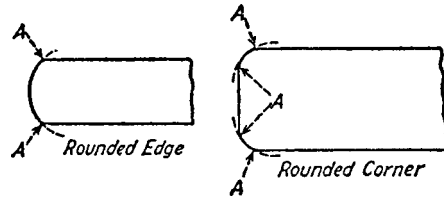
7.1.1 Type A wire shall conform to the requirements for elongation given in **Table 4**.

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



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 <sup>A</sup> | 50.8 |

<sup>A</sup>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   |

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 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:

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

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

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