

QQ-C-533B  
March 20, 1972  
SUPERSEDING  
Fed. Spec. QQ-C-533A  
June 3, 1964

## FEDERAL SPECIFICATION

### COPPER-BERYLLIUM ALLOY STRIP (COPPER ALLOY NUMBERS 170 AND 172)

This specification was approved by the Commissioner, Federal Supply Service, General Services Administration, for the use of all Federal agencies.

#### 1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers two alloys of copper-beryllium strip (see 1.2.1).

#### 1.2 Classification.

1.2.1 Alloys. Strip furnished under this specification shall be of one of the following alloys:

Copper alloy number 170 - Incl. 1.60 to 1.79 percent beryllium.

Copper alloy number 172 - Incl. 1.80 to 2.00 percent beryllium.

1.2.2 Tempers. Copper alloy numbers 170 and 172 strip shall be furnished in the tempers listed below, as specified. "T" following the temper designation denotes material after a precipitation hardening treatment.

A - Cold-rolled and solution heat treated

1/4 H - Hot or cold-rolled, solution heat treated, and cold-rolled quarter hard.

1/2 H - Hot or cold-rolled, solution heat treated, and cold-rolled half hard.

H - Hot or cold-rolled, solution heat treated, and cold-rolled hard.

#### 2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issues in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

FSC 9535

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Federal Standards:

- Fed. Std. No. 123 - Marking for Domestic Shipment (Civilian Agencies).
- Fed. Std. No. 146 - Tolerances for Copper and Copper Base Alloy Mill Products.
- Fed. Std. No. 185 - Identification Marking of Copper and Copper Base Alloy Mill Products.
- Fed. Test Method Std. No. 151 - Metals; Test Methods

(Activities outside the Federal Government may obtain copies of Federal Specifications, Standards, and Handbooks as outlined under General Information in the Index of Federal Specifications and Standards and at the prices indicated in the Index. The Index, which includes cumulative monthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402.

(Single copies of this specification and other Federal Specifications required by activities outside the Federal Government for bidding purposes are available without charge from Business Service Centers at the General Services Administration Regional Offices in Boston, New York, Washington, DC Atlanta, Chicago, Kansas City, MO, Fort Worth, Denver, San Francisco, Los Angeles, and Seattle, WA.

(Federal Government activities may obtain copies of Federal Specifications, Standards, and Handbooks and the Index of Federal Specifications and Standards from established distribution points in their agencies.)

Military Specification:

- MIL-C-3993 - Copper and Copper Base Alloy Mill Products; Packaging of.

Military Standards:

- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
- MIL-STD-129 - Marking for Shipment and Storage.

(Copies of Military Specifications and Standards required by suppliers in connection with specification procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless a specific issue is identified, the issue in effect on date of invitation for bids or request for proposal shall apply.

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American Society for Testing and Materials (ASTM) Standards:

- E 8 - Tension Testing of Metallic Materials.
- E 18 - Test for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials.
- E 112 - Estimating the Average Grain Size of Metals.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

### 3. REQUIREMENTS

3.1 Chemical composition. The material shall conform to the chemical requirements specified in table I.

TABLE I.—Chemical composition

Alloy	Beryllium percent	Other additive elements to produce special properties		Copper plus beryllium plus additive elements, min., percent
		Cobalt, nickel or both, percent	Nickel plus cobalt plus iron, max., percent	
170	1.60 to 1.79	0.20 min.	0.6	99.5
172	1.80 to 2.00	0.20 min.	0.6	99.5

3.1.1 Analysis shall be made regularly only for the elements specifically mentioned in table I. If, however, the presence of other elements is suspected or indicated in the course of routine analysis, further analysis shall be made to determine that the total of other elements is not in excess of the limits specified.

### 3.2 Mechanical properties.

3.2.1 As-supplied. As-supplied material shall conform to the mechanical properties shown in table II for the respective alloys and tempers.

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TABLE II.—*Mechanical properties, as-supplied, alloy numbers 170 and 172*

Temper	Tensile strength, psi	Elongation in 2 in., min., percent <sup>1</sup>	Rockwell hardness <sup>2 3</sup>	
			B scale <sup>4</sup>	30T scale <sup>5</sup>
A	60,000—78,000	35	45—78	46—67
1/4 H	75,000—88,000	10	68—90	62—75
1/2 H	85,000—100,000	5	88—96	74—79
H	100,000—120,000	2	96—102	79—83

<sup>1</sup> Applicable only to material 0.004 inch and over.

<sup>2</sup> Hardness requirements apply only under the conditions stated in 3.2.3.

<sup>3</sup> Hardness values shown apply only to direct determinations, not converted values.

<sup>4</sup> Applicable to material 0.032-inch thick and over.

<sup>5</sup> Applicable to material 0.020 to 0.032 inch incl.

3.2.2 After precipitation hardening. Samples of as-supplied material shall be heat-treated in accordance with table III and shall conform to the tensile property requirements of table IV applicable to the corresponding precipitation-hardened temper.

TABLE III.—*Precipitation-hardening treatment, alloy numbers 170 and 172*

Temper	Number of hours at 600°—625°F <sup>1 2</sup>
A	3
1/4 H	2
1/2 H	2
H	2

<sup>1</sup> All parts of the charge shall be up to the specified temperature before beginning the time record. No distinction shall be made for time at heat between liquid bath or air-furnace type of heat treatment.

<sup>2</sup> Applicable to testing of strip under this specification. See 6.4 for heat treatment of finished parts.

TABLE IV.—*Mechanical properties after precipitation hardening, alloy numbers 170 and 172<sup>1</sup>*

Alloy	Temper	Tensile strength, p.s.i. <sup>2</sup>	Yield strength, 0.2% offset minimum, p.s.i.	Elongation in 2 inches minimum percent <sup>3</sup>	Rockwell hardness <sup>4 5</sup> minimum	
					C scale <sup>6</sup>	30N scale <sup>7</sup>
170	AT	150,000 - 180,000	130,000	3	33	53
	1/4 HT	160,000 - 185,000	135,000	2.5	35	55
	1/2 HT	170,000 - 195,000	145,000	1	37	56
	HT	180,000 - 200,000	155,000	1	39	59
172	AT	165,000—190,000	140,000	3	36	56
	1/4 HT	175,000—200,000	150,000	2.5	38	58
	1/2 HT	185,000—210,000	160,000	1	39	59
	HT	190,000—215,000	165,000	1	40	60

<sup>1</sup> These properties apply to the acceptance of strip under this specification. Special requirements of end products may require other properties. Specific test requirements should be agreed upon by the manufacturer and consumer of the end product.

<sup>2</sup> Upper limits of tensile strength apply only to material thicker than 0.020 inch.

<sup>3</sup> Applicable only to material 0.004 inch and over, when specified.

<sup>4</sup> Hardness requirements apply only under the conditions stated in 3.2.3.

<sup>5</sup> Hardness values shown apply only to direct determinations, not converted values.

<sup>6</sup> Applicable to material 0.032-inch thick and over.

<sup>7</sup> Applicable to material 0.020 to 0.032 in. incl.

**3.2.3 Substitution of hardness tests for tensile property tests.** When specified (see 6.2), tension tests shall be waived provided the strip meets the hardness requirements shown in tables II or IV. In cases of dispute, tension tests shall be the basis for acceptance.

**3.2.4 Bend tests.** When specified (see 6.2), the material in any temper, 0.004 to 0.020 inch thick, inclusive, shall conform to the bend test requirements shown in table V.

TABLE V.—*Bend test requirements after precipitation-hardening treatment*

Temper	Test radius <sup>1</sup>
AT	5t
1/4 HT	6t
1/2 HT	9t
HT	15t

<sup>1</sup> "t" refers to the measured average stock thickness to be tested.

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3.3 Grain size. When specified (see 6.2) the average grain size of strip over 0.010 inch in thickness, solution heat treated temper, determined in plane perpendicular to the surface and parallel to the direction of rolling, shall not exceed the limits shown in table VI.

TABLE VI.—Maximum grain size  
A temper

Thickness, inch	Maximum average grain size, mm
Over 0.010 to 0.030, incl . . . . .	0.035
Over .030 to .090, incl . . . . .	.045
Over .090 to .188, incl . . . . .	.060

3.4 Grain count. When specified (see 6.2), the grain count of strip over 0.004 to 0.010 inch in thickness, inclusive, any temper determined in a plane perpendicular to the surface and parallel to the direction of rolling, shall be not less than the limits shown in table VII.

TABLE VII.—Minimum grain count  
all tempers

Thickness, inch	Minimum number of grains
Over 0.004 to 0.006, incl . . . . .	6
Over .006 to .008, incl . . . . .	7
Over .008 to .010, incl . . . . .	8

3.5 Dimensional tolerances. The following references of Fed. Std. No. 146 shall apply:

<u>Dimension</u>	<u>Reference</u>
Thickness	1b(1)
Width	1b(2)
Length	1b(3), 1b(4)
Straightness	1b(5)

3.6 Identification marking. When specified product identification marking shall be in accordance with Fed. Std. No. 185 (see 6.2 and 6.3).

3.7 Workmanship. The copper-beryllium alloy strip shall be uniform in quality and temper; and shall be sound, clean, and smooth; and free from injurious defects including foreign material, pipes, slivers, laps, cracks, seams, scale, burrs, buckles, and damaged ends, corners, or edges, which due to their nature, degree, or extent detrimentally affect the suitability of the material for the purpose intended. A superficial film of residual light lubricant is normally present and is permissible unless otherwise specified.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Lot. Unless otherwise specified (see 6.2), a lot shall consist of 10,000 pounds or fraction thereof, of material of the same composition, form, temper, and size, submitted for inspection at one time.

4.3 Sampling. Samples taken for the purpose of the tests prescribed in this specification shall be selected in a manner that will represent correctly the material furnished.

4.3.1 Sampling for chemical analysis. The number of samples specified in table VIII shall be selected from a different piece in each lot. From each sample, not less than 2 ounces of clean millings, drillings, or clippings shall be obtained.

TABLE VIII.—*Sampling for chemical analysis*

Pounds of material in lot	Number of samples
Up to 5,000 .....	2
5,001 to 10,000 .....	4

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#### 4.3.2 Sampling for mechanical properties.

4.3.2.1 Tension test. Unless otherwise specified (see 3.2.3), two tension-test specimens shall be selected from each lot for determination of as-supplied tensile properties. Two additional tension-test specimens shall be selected from each lot for determination of tensile properties after precipitation-hardening to the AT, 1/4 HT, 1/2 HT and HT tempers as applicable. Each specimen shall be selected from a different piece unless the number of pieces in the lot is less than the required number of specimens. In this case, at least one specimen shall be selected for determination of tensile properties after precipitation-hardening (see above), in addition to one for as-supplied properties.

4.3.2.2 Hardness test. When hardness tests are authorized (see 3.2.3), one hardness determination shall be made for each 100 pounds or fraction thereof in each lot, but not less than 5 tests shall represent each lot. For material in coils, hardness shall be taken at both ends of 20 percent of the coils, but not less than 2 coils shall be tested in each lot. In addition two specimens from each lot shall be precipitation-hardened in accordance with 3.2.2 and then tested for compliance with the hardness requirements.

4.3.2.3 Bend test. When required (see 3.2.4), five specimens,  $3/8 \pm 1/16$  inch in width, of any convenient length, with the rolling direction parallel to the 3/8-inch dimension, shall be selected.

4.3.3 Sampling for grain size determination. When required (see 3.3), two samples shall be selected for grain size determination.

4.3.4 Sampling for grain count determination. When required (see 3.4), one sample shall be selected for grain count determination.

4.3.5 Sampling for visual and dimensional examination. If the weight of each piece is more than 150 pounds, every piece shall be examined. If the weight of each piece is not over 150 pounds, sample pieces shall be selected as specified in 4.3.5.1 and 4.3.5.2.

4.3.5.1 Visual examination. From each lot of material with pieces weighing 150 pounds or less, a representative sample of material shall be selected in accordance with MIL-STD-105, inspection level II, acceptable quality level (AQL) 1.5 percent defective, and shall be visually examined in accordance with 4.4.1.

4.3.5.2 Dimensional examination. From each lot of material composed of pieces weighing 150 pounds or less, a representative sample shall be selected in accordance with 4.3.5.1 and shall be measured in accordance with 4.4.2. The samples selected for dimensional examination may be the same as those selected for visual examination.

4.3.5.3 When material is furnished in rolls or on reels or bucks, the sample for examination shall be taken from within 10 feet of the outer end. If the sample is rejected due to handling marks, an additional sample within the next 20 feet shall be selected for examination.

#### 4.4 Examination.

4.4.1 Visual and dimensional. Pieces selected in accordance with 4.3.5 shall be examined to determine compliance with the requirements for identification marking (see 3.6) workmanship (see 3.7), and dimensional (see 3.5) requirements of this specification.

4.4.2 Straightness. Straightness shall be determined by placing the piece on a level surface so that the arc or departure from straightness is horizontal. The maximum depth of arch shall be measured to the nearest 1/32 inch by means of a straightedge and a steel scale.

4.4.3 Preparation for shipment. Examination of the packing and marking for shipment shall be made for conformance to the requirements of section 5.

#### 4.5 Tests.

4.5.1 Tension test specimens. Tension test specimens shall be machined to the form and dimensions of sheet type, 1/2 inch wide (figure 6) of ASTM E 8. The longitudinal axis of the specimen shall be parallel to the direction of rolling.

#### 4.5.2 Test procedures.

4.5.2.1 Chemical analysis. The samples selected in accordance with 4.3.1 shall be analyzed in accordance with method 111 or method 112 of Fed. Test Method Std. No. 151 to determine conformance to 3.1. A single analysis of a composite sample may be made when emission methods are not used. In case of dispute, the analysis by the wet method (method 111) shall be the basis for acceptance.

4.5.2.2 Tension tests. All tension tests shall be conducted in accordance with ASTM E 8.

4.5.2.2.1 Yield strength. The yield strength shall be determined by the offset method (0.2 percent) in accordance with ASTM E 8.

4.5.2.3 Hardness tests. Hardness tests shall be conducted in accordance with ASTM E 18.

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4.5.2.4 Bend tests. Bend test specimens shall be precipitation heat treated in accordance with 3.2.2. Each specimen shall be clamped firmly between a flat jaw and the test radius as shown in figure 1. The test specimen shall be bent approximately 90° around the test radius, using a tangential wiping motion with adequate radial pressure to assure continuous contact between the specimen and the test radius. The test radius shall be within  $\pm 6$  percent of the nominal radius up to 0.010 inch, exclusive, and within  $\pm 4$  percent for radii 0.010 inch and over. At least four specimens out of five must withstand the 90° bend without visible crack or fracture.

4.5.2.5 Grain size determination. Grain size determinations shall be made in accordance with ASTM E 112.

4.5.2.6 Grain count determination. Grain count shall be the number of grains per stock thickness, averaged for five locations one stock thickness apart.

#### 4.6 Rejection.

4.6.1 Examination defects. Any sample unit having one or more defects shall be rejected. If the number of nonconforming sample units in the sample exceeds the acceptance number specified in 4.3.5.1 or 4.3.5.2 for that sample size, the entire lot shall be rejected, subject to the provisions on "Disposition of Nonconforming Product" of MIL-STD-105.

4.6.2 Test failures. A lot shall be rejected for failure to meet any of the test requirements when tested in accordance with 4.5, subject to the resubmission and retest provisions of Fed. Test Method Std. No. 151.

#### 5. PREPARATION FOR DELIVERY.

5.1 Packing. The material shall be packed in accordance with level A, B, or C of MIL-C-3993 as specified (see 6.2).

#### 5.2 Marking.

5.2.1 Civil agencies. In addition to markings required by the contract or order, marking for shipment shall be in accordance with Fed. Std. No. 123.

5.2.2 Military activities. In addition to markings required by the contract or order, marking for shipment shall be in accordance with MIL-STD-129.

## 6. NOTES

6.1 Intended use. The material covered by this specification is intended for use in the manufacture of items such as springs, diaphragms, contacts, etc. where high strength, corrosion resistance, and high electrical conductivity are required.

6.2 Ordering data. Purchasers should select the preferred options permitted herein and include the following information in procurement documents:

- a. Title, number, and date of this specification.
- b. Alloy, size, and temper required (see 1.2).
- c. When hardness tests may be substituted for tensile tests (see 3.2.3).
- d. When elongation requirements apply (see table IV, note 3).
- e. When the bend test is required (see 3.2.4).
- f. When grain size determination is required (see 3.3).
- g. When grain count determination is required (see 3.4).
- h. Lengths, whether specific or stock lengths with or without ends (see 3.5).
- i. When product identification marking in accordance with Fed. Std. No. 185 is required (see 3.6).
- j. Size of lot, if different from 4.2.
- k. Whether material is to be packed by level A, B, or C (see 5.1).
- l. Maximum gross weight of container (see 5.1).
- m. Special marking, if required (see 5.2).

6.3 The requirements for item identification marking (see 3.6) and for packing (see 5.1) and marking for shipment (see 5.2) specified herein apply to direct shipment for Government activities and apply also, when specified, to contracts or orders between the manufacturer and the Government contractor.

6.4 Copper-beryllium alloy strip may be cold-formed and readily machined before precipitation hardening. After forming and machining to the desired dimensions, it may be heat-treated to develop high tensile properties. The precipitation-hardening heat treatment procedures stated in table III are mandatory for use in determining the ability of material procured under this specification to develop suitable properties after heat treatment but do not necessarily apply to the heat treatment of finished parts. In the heat treatment of parts however, individual procedures differing from table III producing different properties from table IV may be employed.

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6.5 Material after precipitation hardening is considered to have more stable and uniform properties than cold-worked material (even though the later may show adequate tensile strength) and the use of cold-worked material without precipitation hardening is, therefore, not recommended.

6.6 The chemical compositions and mechanical properties are similar to ASTM B 194.

6.7 Whenever QQ-C-533 is specified without alloy designation copper alloy number 172 shall be supplied.

6.8 Electrical conductivity. The following electrical conductivity values shown in table IX for information only:

TABLE IX.—*Electrical conductivity, alloy numbers 170 and 172*

Temper	Electrical conductivity IACS, percent minimum
A	17
1/4 H	16
1/2 H, H	15
AT, 1/4 HT, 1/2 HT, HT	22

6.9 Copper alloy number 172 in the form of bar, rod, and wire is covered by QQ-C-530.

**MILITARY CUSTODIANS:**

Army - MR  
Navy - SH  
Air Force - 11

**Review activities:**

Army - MR, MU, WC, MI, AT, EL  
Navy - SH, AS  
Air Force - 84  
DSA - IS

**User activities:**

Army - AV  
Navy - EC

**Preparing activity:**

Army - MR

**CIVIL AGENCIES INTEREST:**

COM  
HEW  
INT  
DC  
GSA

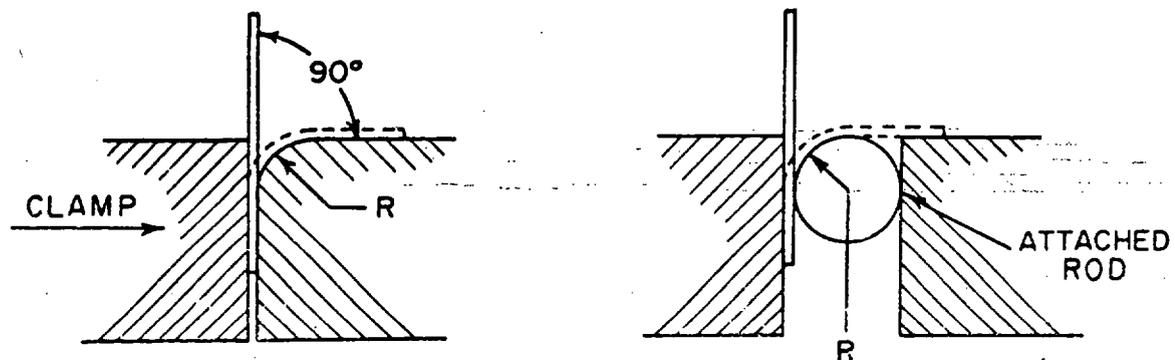


FIGURE 1.—Methods of clamping to radius.

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Orders for this publication are to be placed with the General Services Administration, acting as an agent for the Superintendent of Documents. See section 2 of this specification to obtain extra copies and other documents referenced herein. Price 15 cents each.