Designation: B 283 – 99a

Standard Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed)[1]

This standard is issued under the fixed designation B 283; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This specification establishes the requirements for copper and copper alloy die forgings produced by the hot pressing method. The following copper and copper alloys are included:

Copper or Copper Alloy UNS No.	Name
C11000	copper
C14500	copper-tellurium
C14700	copper-sulfur
C36500	leaded Muntz metal
C37700	forging brass
C46400	naval brass
C48200	medium leaded naval brass
C48500	leaded naval brass
C61900	aluminum bronze
C62300	aluminum bronze, 9 %
C63000	aluminum-nickel bronze
C63200	aluminum-nickel bronze
C64200	aluminum-silicon bronze
C64210	aluminum-silicon bronze, 6.7 %
C65500	high-silicon bronze (A)
C67500	manganese bronze (A)
C67600	. . .
C70620	copper-nickel 90-10
C71520	copper-nickel 70-30
C77400	nickel silver, 45-10

1.2 The values stated in inch-pound units are the standard. The SI values in parentheses are for information only.

1.3 The following safety caveat pertains only to Section 10 of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—Nominal composition and relative forgeability ratings are given in Appendix X1. Copper-nickel alloys C70620 and C71520 are intended for welded applications with seawater exposure.

2. Referenced Documents

2.1 *ASTM Standards:*

B 249 Specification for General Requirements for Wrought Copper and Copper Alloy Rod, Bar, Shapes and Forgings[2]

B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast[2]

B 846 Terminology for Copper and Copper Alloys[2]

E 8 Test Methods for Tension Testing of Metallic Materials[3]

E 54 Test Methods for Chemical Analysis of Special Brasses and Bronzes[4]

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Method)[4]

E 75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys[4]

E 478 Test Methods for Chemical Analysis of Copper Alloys[4]

2.2 *ISO Standard:*

7602 Determination of Tellurium Content (High Content)—Flame Atomic Absorption Spectrometric Method[5]

2.3 *Military Standards:*

MIL-STD-792 Identification Marking Requirements for Special Purpose Components[6]

NAVSEA T9074-AS-GIB-010/271 Requirements for Nondestructive Testing Method[6]

3. General Requirements

3.1 The following sections of Specification B 249 constitute a part of this specification:

3.1.1 Terminology,
3.1.2 Materials and Manufacture,
3.1.3 Workmanship, Finish and Appearance,
3.1.4 Sampling,
3.1.5 Number of Tests and Retests,
3.1.6 Specimen Preparation,
3.1.7 Test Methods,
3.1.8 Significance of Numerical Limits,
3.1.9 Inspection,
3.1.10 Rejection and Rehearing,
3.1.11 Certification,

[1] This specification is under the jurisdiction of ASTM Committee B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.02 on Rod, Bar, Wire, Shapes, and Forgings.

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

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

[4] *Annual Book of ASTM Standards*, Vol 03.05.

[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[6] Available from DODSSP, Bldg. 4/Sec. D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

***A Summary of Changes section appears at the end of this standard.**

3.1.12 Test Reports,
3.1.13 Packaging and Package Marking, and
3.1.14 Supplementary Requirements.
3.1.15 In addition, when a section with a title identical to one of those referenced in 3.1 appears in this specification, it contains additional requirements that supplement those appearing in Specification B 249.

4. Terminology

4.1 *Definitions:*
4.1.1 For definitions of terms used in this specification, refer to Terminology B 846.
4.2 *Definition of Term Specific to This Standard:*
4.2.1 *hot pressed forging, n*—a product made by pressing a heated blank or section of wrought copper or copper alloy in a closed impression die.

5. Ordering Information

5.1 Orders for product produced to this specification shall include the following information:
5.1.1 ASTM designation and year of issue,
5.1.2 Copper or Copper Alloy UNS No. designation (Section 1.1),
5.1.3 Drawing showing the shape dimensions and tolerances (Section 11),
5.1.4 Temper (Section 8),
5.1.5 Quantity: total weight or number of pieces for each form, temper, and copper or copper alloy,
5.1.6 When product is purchased for agencies of the U.S. Government (Section 12), and
5.1.7 When product must adhere to the requirements of ASME Boiler and Pressure Vessel Code (Section 9).
5.2 The following requirements are optional and shall be specified in the contract or purchase order.
5.2.1 Certification (Section 14 and Supplementary Requirements),
5.2.2 Mill test report (Specification B 249), and
5.2.3 Ultrasonic inspection report (Supplementary Requirements).

6. Material and Manufacture

6.1 *Materials*:
6.1.1 The starting material shall be rods, billets, or blanks cut from cast or wrought material of one of the copper or copper alloys listed in 1.1 of this specification.
6.1.2 In the event heat identification or traceability is required, the purchaser shall specify the details desired.

NOTE 2—Because of the discontinuous nature of the processing of castings into wrought products, it is not always practical to identify specific casting analysis with a specific quantity of finished material.

6.2 *Manufacture*:
6.2.1 The product shall be manufactured by hot pressing material between the upper and lower sections of a set of dies conforming to the configuration defined by the purchaser's submitted drawings.
6.2.2 Product of Copper Alloy UNS No. C63200 shall be heat treated (Section 10).

7. Chemical Composition

7.1 The materials shall conform to the requirements specified in Table 1 for the Copper or Copper Alloy UNS No. designated in the ordering information.
7.2 These composition limits do not preclude the presence of other elements. When limits for unnamed elements are required, they shall be established by agreement between manufacturer or supplier and the purchaser.
7.2.1 For copper alloys in which zinc is specified as a remainder, either copper or zinc is permitted to be taken as the difference between the sum of results for all the elements analyzed and 100 %. When copper is so determined, that difference value shall conform to the requirements given in Table 1.
7.2.2 For copper alloys for which copper is specified as the remainder, copper may be taken as the difference between the sum of all the elements analyzed and 100 %.
7.3 When all the elements in Table 1 are determined for the individual alloy, the sum of results shall be 99.6 % min for Copper Alloy UNS No. C36500, C46400, C48200, C48500 and 99.5 % for all others.

8. Temper

8.1 Tempers, as defined in Practice B 601, available under this specification are M10 (as hot forged-air cooled), M11 (as forged-quenched), TQ50 (quench hardened and temper annealed), and O20 (hot forged and annealed).
8.2 Alloys C70620 and C71520 shall be furnished in the M10 temper unless the O20 temper is specified.

9. Mechanical Property Requirements

9.1 Mechanical property requirements are subject to agreement between the manufacturer and the purchaser.
9.2 Alloys C70620 and C71520 and product specified to meet the requirements of the *ASME Boiler and Pressure Vessel Code* shall have tensile properties as prescribed in Table 2 when tested in accordance with Test Methods E 8.

10. Heat Treatment

10.1 Product produced from Copper Alloy UNS No. C63200 shall be heat treated as follows:
10.1.1 Heat to 1550°F (843°C) minimum for 1 h minimum and quench in water or other suitable medium.
10.1.2 Temper at 1300+ and −25°F (704+ and −14°C) for 3 to 9 h as required to meet mechanical properties.

11. Special Government Requirements

11.1 Product purchased for agencies of the U.S. Government shall conform to the additional requirements prescribed in the Supplementary Requirements section of this specification.

12. Dimensions and Permissible Variations

12.1 The dimensions and tolerances for forgings shall be those agreed upon between the manufacturer and the purchaser, and such dimensions and tolerances shall be specified on the drawings which form a part of the contract or purchase order.

NOTE 3—Typical tolerances commonly used for forgings are shown in Table X2.1.

TABLE 1 Chemical Requirements

Copper or Copper Alloy UNS No.	Composition, %												
	Copper	Lead	Tin	Iron	Nickel (incl Co)	Aluminum	Silicon	Manganese	Zinc	Sulfur	Tellurium	Phosphorus	Arsenic
C11000	99.90[A] min	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
C14500[B]	99.90[C] min	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.40–0.7	0.004–0.012[D]	. . .
C14700[B]	99.90[E] min	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.20–0.50	. . .	0.002–0.005[D]	. . .
C36500	58.0–61.0	0.25–0.7	0.25 max	0.15 max	. . .	. . .	. . .	. . .	remainder	. . .	. . .	. . .	. . .
C37700	58.0–61.0	1.5–2.5	. . .	0.30 max	. . .	. . .	. . .	. . .	remainder	. . .	. . .	. . .	. . .
C46400	59.0–62.0	0.20 max	0.50–1.0	0.10 max	. . .	. . .	. . .	. . .	remainder	. . .	. . .	. . .	. . .
C48200	59.0–62.0	0.40–1.0	0.50–1.0	0.10 max	. . .	. . .	. . .	. . .	remainder	. . .	. . .	. . .	. . .
C48500	59.0–62.0	1.3–2.2	0.50–1.0	0.10 max	. . .	. . .	. . .	. . .	remainder	. . .	. . .	. . .	. . .
C61900	remainder	0.02 max	0.6 max	3.0–4.5[F]	. . .	8.5–10.00	. . .	. . .	0.8 max	. . .	. . .	. . .	. . .
C62300	remainder	. . .	0.6 max	2.0–4.0	1.0 max	8.5–10.0	0.25 max	0.50 max	. . .	. . .	. . .	. . .	. . .
C63000	remainder	. . .	0.20 max	2.0–4.0	4.0–5.5	9.0–11.0	0.25 max	1.5 max	0.30 max	. . .	. . .	. . .	. . .
C63200	remainder	0.02 max	. . .	3.5–4.3[G]	4.0–4.8	8.7–9.5	0.10 max	1.2–2.0	. . .	. . .	. . .	. . .	. . .
C64200	remainder	0.05 max	0.20 max	0.30 max	0.25 max	6.3–7.6	1.5–2.2	0.10 max	0.50 max	. . .	. . .	. . .	0.15 max
C64210	remainder	0.05 max	0.20 max	0.30 max	0.25 max	6.3–7.0	1.50–2.0	0.10 max	0.50 max	. . .	. . .	. . .	0.15 max
C65500	remainder	0.05 max	. . .	0.8 max	0.6 max	. . .	2.8–3.8	0.50–1.3	1.5 max	. . .	. . .	. . .	. . .
C67500	57.0–60.0	0.20 max	0.50–1.5	0.8–2.0	. . .	0.25 max	. . .	0.05–0.50	remainder	. . .	. . .	. . .	. . .
C67600	57.0–60.0	0.50–1.0	0.50–1.0	0.40–1.3	. . .	. . .	. . .	0.05–0.50	remainder	. . .	. . .	. . .	. . .
C70620[H]	86.5[A] min	0.02 max	. . .	1.0–1.8	9.0–11.0	. . .	. . .	1.0 max	0.50 max	0.02 max	. . .	0.02 max	. . .
C71520[H]	65.0[A] min	0.02 max	. . .	0.40–1.0	29.0–33.0	. . .	. . .	1.0 max	0.50 max	0.02 max	. . .	0.02 max	. . .
C77400	43.0–47.0	0.20 max	. . .	. . .	9.0–11.0	. . .	. . .	. . .	remainder	. . .	. . .	. . .	. . .

[A] Silver counting as copper.
[B] Includes oxygen-free or deoxidized grades with deoxidizers (such as phosphorus, boron, lithium, or others) in amount agreed upon.
[C] This includes copper plus silver plus tellurium.
[D] Other deoxidizers may be used as agreed upon, in which case phosphorus need not be present.
[E] This includes copper plus silver plus sulfur plus phosphorus.
[F] For boiler code application maximum iron content shall be 4.0 %.
[G] Iron content shall not exceed nickel content.
[H] Carbon shall be 0.05 % max.

TABLE 2 Tensile Requirements

Diameter or Section Thickness, in. (mm)		Tensile Strength, min		Yield Strength at 0.5 % Extension Under Load, min		Elongation in 4 × Diameter or Thickness of Specimen, min, %
		ksi	MPa[A]	ksi	MPa[A]	
Copper Alloy UNS No. C37700						
Up to 1½ (38.1), incl		50	345	18	124	25
Over 1½ (38.1)		46	317	15	103	30
Copper Alloy UNS No. C64200						
Up to 1½ (38.1), incl		70	483	25	172	30
Over 1½ (38.1)		68	469	23	156	35
Copper Alloy UNS Nos. C46400, C48200 and C48500						
All sizes		52	358	22	152	25
Copper Alloy UNS No. C70620						
Up to 6 (152.3), incl	M10 temper	45	310	18	124	30
Over 6 (152.3)	M10 temper	40	276	15	103	30
All sizes	O20 temper	40	276	15	103	30
Copper Alloy UNS No. C71520						
Up to 6 (152.3), incl	M10 temper	50	345	20	138	30
Over 6 (152.3)	M10 temper	45	310	18	124	30
All sizes	O20 temper	45	310	18	124	30

[A] See Appendix X3.

13. Test Methods

13.1 *Chemical Analysis*:

13.1.1 Chemical composition shall, in case of disagreement, be determined as follows:

Element		ASTM Test Method
Aluminum		E 478
Arsenic		E 62
Copper		E 478
Iron	<1.3 %	E 478, E 75 for CuNi
	>1.3 %	E 54, E 75 for CuNi
Lead		E 478 (AA)
Manganese		E 62, E 75 for CuNi
Nickel	<5 %	E 478 (photometric)
	>5 %	E 478 (gravimetric)
Phosphorus		E 62
Silicon		E 54 (perchloric acid)
Tin	<1.3 %	E 478
	>1.3 %	E 54
Zinc	<2 %	E 478 (AA)
	>2 %	E 478 (titrimetric)
Tellurium		ISO Test Method 7602

NOTE—< = less than: > = greater than

13.1.2 Test method(s) to be followed for the determination of element(s) required by contractual or purchase order agreement shall be as agreed upon between the supplier and the purchaser.

Property	Rounded Unit for Observed or Calculated Value
Chemical composition	nearest unit in the last right-hand place of figures
Tensile strength, Yield strength	nearest ksi, nearest 5 MPa for over 10 to 100 ksi, incl
Elongation	nearest 1 %

14. Certification

14.1 Certification to this specification is mandatory for product purchased for *ASME Boiler and Pressure Vessel* applications.

15. Keywords

15.1 copper and copper alloy die forgings (hot pressed); die forgings (hot pressed)

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract or order, for agencies of the U.S. Government.

S1. Supplementary Requirements S1, S2, and S4 of ASTM B 249 shall apply.

S2. **Identification Marking**—Individual forgings shall be marked with the producer's name or trademark, this ASTM specification number, the UNS number, and the heat number or serial number. The method and location of marking shall be in accordance with MIL-STD-792. If approved by the purchaser, the forgings may be bundled or boxed and each bundle or box provided with a metal or oil-proof tag showing the above information.

S3. **Sampling**—The lot size, portion size, and selection of sample pieces shall be as follows:

S3.1 *Lot Size*—For forgings weighing 250 lbs (114 kg) or less, a lot shall be 2000 lbs (909 kg) or less, and shall consist of forgings of the same design and alloy forged from the same material heat and heat treated at the same time. For forgings exceeding 250 lbs (114 kg), each individual forging shall constitute a lot.

S3.2 *Portion Size*—For forgings less than 250 lbs (114 kg), two forgings per lot shall be selected for tensile testing. Tensile tests shall be performed on each forging over 250 lbs (114 kg).

S3.3 *Chemical Analysis*—If heat identification is required, one sample for chemical analysis shall be taken for each heat at the time of pouring or from semifinished or finished product.

S3.4 *Tensile Testing*—The tensile specimens shall be taken from integral forging prolongations or shall be removed from the forgings by trepanning. Alternatively, samples may be taken from separately forged test bars of the same heat as the forgings in the lot provided the wall thickness and amount of working for the test bar are equivalent to those for the forgings. The axis of the tensile specimen shall be located at any point midway between the center and the surface of solid forgings and at any point midway between the inner and outer surfaces of the wall of hollow forgings, and shall be parallel to the direction of greatest grain flow to the greatest extent possible.

S4. **Liquid Penetrant Inspection**—When specified by the purchaser, each piece of each lot shall be inspected in accordance with NAVSEA T9074-AS-GIB-101/271.

S5. **Ultrasonic Inspection**—When specified by the purchaser, each piece of each lot shall be inspected.

S5.1 *General Requirements*—Ultrasonic testing shall be performed in accordance with NAVSEA T9074-AS-GIB-101/271. Acoustic compatibility between the production material and the calibration standard material shall be within 75 %. If the acoustic compatibility is within 25 %, no gain compensation is required for the examination. If acoustic compatibility difference is between 25 and 75 %, a change in the gain or dB controls shall be accomplished to compensate for the differences in acoustic compatibility. This method cannot be used if the ultrasonic noise level exceeds 50 % of the rejection value.

S5.2 *Calibration:*

S5.2.1 *Shear Wave*—The shear wave test shall be calibrated on two notches, one notch cut into the inside and one into the outside surface. The notches shall be cut axially and shall have a depth of 5 % of the material thickness or ¼ in. (6.4 mm), whichever is less. Notch length shall not exceed 1 in. (25.4 mm). Notches shall be made either in the piece to be examined or in a separate defect-free specimen of the same size (within ±⅛in. (3.18 mm), shape, material, and condition, or acoustically similar material. The position and amplitude of the response from each notch shall be marked on the instrument screen or a transparent overlay, and these marks shall be used as the evaluation reference. Indications that appear between these points shall be evaluated on the basis of a straight line joining the two peak amplitudes.

S5.2.2 *Longitudinal Wave*—The longitudinal wave test shall be calibrated on a flat-bottomed reference hole of a given diameter in accordance with Table S5.1 for specified material thickness drilled either into the piece to be tested or into a separate defect-free specimen of the same size (within ±⅛ in. (3.18 mm)), shape, material, and condition or acoustically similar material. Holes are to be drilled to midsection and the bottom of the hole shall be parallel to the entrant surface. The ultrasonic test instrument shall be adjusted so that the response from the reference hole shall not be less than 25 % and not more than 75 % of screen height.

S5.2.3 *Recalibration*—During quality conformance inspection, any realignment of the search unit that will cause a decrease in the calibrated sensitivity and resolution, or both, or any change in search unit, couplant, instrument settings, or scanning speed from that used for calibration shall require recalibration. Recalibration shall be performed at least once per 8-h shift.

S5.3 *Procedure:*

S5.3.1 *Ring and Hollow Round Products*—Rings and other hollow cylindrical products shall be tested using the shear wave method by the contact or immersion technique. The shear wave entrant angle shall be such to ensure reflection from the notch or notches used in calibration. For contact testing, the search unit shall be fitted with a wedge or shoe machined to fit the curvature of the piece being inspected. The product also shall be inspected with a longitudinal wave test from the external circumferential and end surfaces.

TABLE S5.1 Ultrasonic Testing Reference Hole for Rod, Bar, Disk Pancake Forgings, and Forgings

Material Thickness, in. (mm)	Hole Diameter, in. (mm)
Up to and including 6 (152)	⅛ (3.18)
Over 6 (152) and including 16 (406)	¼ (6.4)
Over 16 (406)	As agreed upon

S5.3.2 *Disk or Pancake Forgings*—Disk or pancake forgings shall be inspected with a longitudinal wave technique from both parallel surfaces.

S5.4 *Acceptance Criteria:*

S5.4.1 *Shear Wave*—Any material that produces indications equal to or larger than the response from the reference notch or higher than the straight line joining the two peak amplitudes shall be rejected.

S5.4.2 *Longitudinal Wave*—Any material that produces indications equal to or larger than the response from the reference hole or that produces a complete loss of back reflection shall be rejected. Material shall be tested using a square, rectangular, or circular transducer having an effective area of 1 $in.^2$ or less, but no dimension shall be smaller than the diameter of the reference hole. In the event of disagreement on the degree of back reflection loss, it shall be determined by the contact method using a 1- to 1⅛-in. (25.4- to 28.6-mm) diameter transducer or one whose area falls within this range.

S5.4.3 *Reference Notch Removal*—If reference notches or flat-bottomed holes are made in the material to be tested, they shall be so located that their subsequent removal will not impair the suitability of the material for its intended use.

APPENDIXES

(Nonmandatory Information)

X1. NOMINAL COMPOSITION AND RELATIVE FORGEABILITY RATINGS

X1.1 The nominal composition of the various forging materials are shown in Table X1.1.

TABLE X1.1 Nominal Compositions and Forgeability Ratings

Copper or Copper Alloy UNS No.	Nominal Composition, %											Forgeability Rating[A]
	Copper	Lead	Tin	Iron	Nickel	Aluminum	Silicon	Manganese	Zinc	Sulfur	Tellurium	
C11000	100	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	65
C14500	99.45	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.55	65
C14700	99.5	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.35	. . .	65
C36500	60	0.6	. . .	. . .	. . .	. . .	. . .	. . .	39.4	. . .	. . .	. . .
C37700	60	2	. . .	. . .	. . .	. . .	. . .	. . .	38	. . .	. . .	100
C46400	60	. . .	0.8	. . .	. . .	. . .	. . .	. . .	39.2	. . .	. . .	90
C48200	60	0.7	0.8	. . .	. . .	. . .	. . .	. . .	38.5	. . .	. . .	. . .
C48500	60	1.8	0.8	. . .	. . .	. . .	. . .	. . .	37.4	. . .	. . .	90
C61900	87.5	. . .	. . .	3.5	. . .	9	. . .	. . .	. . .	. . .	. . .	75
C62300	88	. . .	. . .	3	. . .	9	. . .	. . .	. . .	. . .	. . .	75
C63000	81	. . .	. . .	3	5	10	. . .	1	. . .	. . .	. . .	75
C63200	81	. . .	. . .	4	4.5	9	. . .	1.5	. . .	. . .	. . .	75
C64200	91	. . .	. . .	. . .	. . .	7	2	. . .	. . .	. . .	. . .	75
C64210	91.3	. . .	. . .	. . .	. . .	6.7	2	. . .	. . .	. . .	. . .	75
C65500	96	. . .	. . .	[B]	. . .	. . .	3	[B]	[B]	. . .	. . .	40
C67500	58.5	. . .	1	1	. . .	. . .	. . .	0.10	39.4	. . .	. . .	80
C67600	58.5	0.75	1	0.8	. . .	. . .	. . .	0.10	39.6	. . .	. . .	80
C70620	86.5	. . .	. . .	1.4	10.0	. . .	. . .	1	. . .	. . .	. . .	75
C71520	65.0	. . .	. . .	0.7	31.0	. . .	. . .	1	. . .	. . .	. . .	40
C77400	45	. . .	. . .	. . .	10	. . .	. . .	. . .	45	. . .	. . .	85

[A] Relative forgeability rating takes into consideration such variable factors as pressure, die wear, and plasticity (hot). Since it is impracticable to reduce these variables to common units, calibration in terms of a percentage of the most generally used alloy, forging brass (100 %), is considered the most practical basis for such ratings. The values shown represent the general opinion and are intended for information to enable the designer to better understand the forging characteristics of these various alloys. Intricate parts are more likely to be available in alloys having a high rating.

[B] One or more of these elements may be present as specified in Table 2.

X2. DIMENSIONAL TOLERANCES

X2.1 The data in Table X2.1 do not constitute a part of this specification. They are given merely to indicate to the purchaser the various forging types and some dimensional tolerances used on commercially designed hot-pressed forgings up to 2 lbs (0.91 kg) in weight. For tolerances applicable to heavier forgings, the manufacturers should be consulted.

TABLE X2.1 Dimensional Tolerances

	Tolerances, Plus and Minus, in. (mm) Except as Indicated[A]			
	Copper or Copper Alloy UNS Nos.			
Forging types:	C11000 C14500 C14700 C61900 C62300 C64200 C64210	C36500 C37700 C46400 C48200 C48500 C67500 C67600	C77400	C63000 C63200 C65500 C70620 C71520
Solid	0.010 (0.25)	0.008 (0.20)	0.008 (0.20)	0.012 (0.30)
Solid, with symmetrical cavity	0.010 (0.25)	0.008 (0.20)	0.008 (0.20)	0.012 (0.30)
Solid, with eccentric cavity	0.012 (0.30)	0.008 (0.20)	0.008 (0.20)	0.012 (0.30)
Solid, deep extrusion	0.012 (0.30)	0.010 (0.25)	0.010 (0.25)	0.014 (0.36)
Hollow, deep extrusion	0.012 (0.30)	0.010 (0.25)	0.010 (0.25)	0.014 (0.36)
Thin section, short (up to 6 in. (152 mm) incl.)	0.012 (0.30)	0.010 (0.25)	0.010 (0.25)	0.014 (0.36)
Thin section, long (over 6 in. (152 mm) to 14 in. (356 mm) incl.)	0.015 (0.38)	0.015 (0.38)	0.015 (0.38)	0.020 (0.51)
Thin section, round	0.012 (0.30)	0.010 (0.25)	0.010 (0.25)	0.014 (0.36)
Draft angles, outside and inside 1 to 5°	½°	½°	½°	½°
Machining allowance (on one surface)	1/32 (0.79)	1/32 (0.79)	1/32 (0.79)	1/32 (0.79)
Flatness (maximum deviation per inch)	0.005 (0.13)	0.005 (0.13)	0.005 (0.13)	0.005 (0.13)
Concentricity (total indicator reading)	0.030 (0.76)	0.020 (0.51)	0.030 (0.76)	0.030 (0.76)
Nominal web thickness:	5/32 (4.0)	⅛ (3.2)	⅛ (3.2)	3/16 (4.8)
Tolerance	1/64 (0.40)	1/64 (0.40)	1/64 (0.40)	1/64 (0.40)
Nominal fillet and radius:	3/32 (2.4)	1/16 (1.6)	1/16 (1.6)	⅛ (3.2)
Tolerance	1/64 (0.40)	1/64 (0.40)	1/64 (0.40)	1/64 (0.40)
Approximate flash thickness	1/16 (1.6)	3/64 (1.2)	3/64 (1.2)	5/64 (2.0)

[A] If tolerances all plus or all minus are desired, double the values given.

X3. TYPICAL MECHANICAL PROPERTIES

X3.1 Mechanical properties of any forging are influenced by shape and size. Unless otherwise specified in the purchase order or specifically guaranteed by the manufacturer, acceptance of forgings under this specification shall not depend on the mechanical properties determined by tension or hardness tests. (Frequently, the design of forgings will not permit adequate test sections.) Therefore, the data in Table X3.1 do not constitute a part of this specification, and are given for general information only. They are typical of forgings up to 2 lbs (0.91 kg) in weight.\

TABLE X3.1 Typical Mechanical Properties of Forgings as Hot Pressed, Temper M10, M11, or TQ50[A]

Copper or Copper Alloy UNS No.	0.505-in. (128-mm) Diameter Test Section					Rockwell Hardness (Filed Surface, ⅛-in. (3.18-mm) Chord, min)	
	Tensile Strength		Yield Strength (0.5 % Extension Under Load)		Elongation in 4 × Diameter, %	F Scale	B Scale
	ksi[B]	MPa[C]	ksi[B]	MPa[C]			
C11000	33	230	11	75	40	37	. . .
C14500	34	235	12	85	35	40	. . .
C14700	34	235	12	85	35	40	. . .
C36500	58	400	23	160	40	. . .	45
C37700	58	400	23	160	40	. . .	45
C46400	64	440	26	180	40	. . .	55
C48200	64	440	26	180	40	. . .	55
C48500	62	425	24	165	40	. . .	55
C61900	82	565	37	255	32	. . .	82
C62300	82	565	37	255	32	. . .	82
C63000	95	655	48	330	15	. . .	90
C63200	92	635	45	310	18	. . .	88
C64200	83	570	41	285	35	. . .	77
C64210	83	570	41	285	35	. . .	77
C65500	52	360	18	125	70	. . .	62
C67500	72	495	34	235	33	. . .	69
C67600	72	495	34	235	33	. . .	69
C71520	55	380	20	138	45	. . .	35
C77400	83	570	36	250	25	. . .	73

[A] For Copper Alloy UNS Nos. C63000 and C63200.
[B] ksi = 1000 psi.
[C] See Appendix X4.

X4. METRIC EQUIVALENTS

X4.1 The SI unit for strength properties now shown is in accordance with the International System of Units (SI). The derived SI unit for force is the newton (N), which is defined as that force which when applied to a body having a mass of one kilogram gives it an acceleration of one metre per second squared ($N = kg \cdot m/s^2$). The derived SI unit for pressure or stress is the newton per square metre (N/m^2), which has been named the pascal (Pa) by the General Conference on Weights and Measures. Since 1 ksi = 6 894 757 Pa, the metric equivalents are expressed as megapascal (MPa), which is the same as MN/m^2 and N/mm^2.

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this specification since the last issue (B 283 – 99) that may impact the use of this standard.

(*1*) Changed the iron content in C46400 from 0.15 max to 0.10 max.
(*2*) Changed the iron content in C48200 from 0.15 max to 0.10 max.
(*3*) Changed the iron content in C48500 from 0.15 max to 0.10 max.
(*4*) Changed the aluminum content in C62300 from 8.5–11 to 8.5–10.0.