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

This standard is issued under the fixed designation B283; 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
C27450	plumbing brass
C36500	leaded Muntz metal
C37000	free-cutting Muntz metal
C37700	forging brass
C46400	naval brass
C48200	medium leaded naval brass
C48500	leaded naval brass
C49260	copper-zinc-bismuth alloy
C49300	copper-zinc-tin-bismuth alloy
C49340	copper-zinc-tin-bismuth alloy
C49350	copper-zinc-tin-bismuth alloy
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	. . .
C69300	copper-zinc-silicon
C70620	copper-nickel 90-10
C71520	copper-nickel 70-30
C77400	nickel silver, 45-10

1.2 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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.

NOTE 2—Wrought product intended for hot forging is described in Specification B124/B124M.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B124/B124M Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes

[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] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

B249/B249M Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings
B846 Terminology for Copper and Copper Alloys
E8 Test Methods for Tension Testing of Metallic Materials
E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)
E75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys
E478 Test Methods for Chemical Analysis of Copper Alloys

2.2 *Other Standards:*
ISO 7602 Determination of Tellurium Content (High Content)—Flame Atomic Absorption Spectrometric Method[3]
JIS H 1068:2005 Method for Determination of Bismuth in Copper and Copper Alloys[4] (Japanese Industrial Standards)

2.3 *Military Standards:*
MIL-STD-792 Identification Marking Requirements for Special Purpose Components[5]
NAVSEA T9074-AS-GIB-010/271 Requirements for Nondestructive Testing Method[5]

3. General Requirements

3.1 The following sections of Specification B249/B249M 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,
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, above, appears in this specification, it contains additional requirements that supplement those appearing in Specification B249/B249M.

4. Terminology

4.1 *Definitions:*
4.1.1 For definitions of terms related to copper and copper alloys, refer to Terminology B846.
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 or cast copper or copper alloy in a closed impression die.

5. Ordering Information

5.1 Include the following information when placing orders for products to this specification, as applicable:
5.1.1 ASTM designation and year of issue,
5.1.2 Copper or Copper Alloy UNS No. designation (Scope),
5.1.3 Drawing showing the shape dimensions and tolerances (Dimensions and Permissible Variations),
5.1.4 Temper (as specified herein),
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 (as specified herein), and
5.1.7 When product must adhere to the requirements of ASME Boiler and Pressure Vessel Code (Mechanical Property Requirements).
5.2 The following requirements are optional and shall be specified in the contract or purchase order.
5.2.1 Certification (as specified herein and Supplementary Requirements),
5.2.2 Mill test report (as specified in B249/B249M), and
5.2.3 Ultrasonic inspection report (Supplementary Requirements).

6. Material and Manufacture

6.1 *Materials*:

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[4] Available from Japanese Industrial Standards, http://www.JIS.or.jp/
[5] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

6.1.1 The material of manufacture shall be a form of rods, billets, or blanks cut from cast or wrought material of one of the copper or copper alloys listed in the Scope of this specification and of purity and soundness as to be suitable for processing in to the products prescribed herein.

6.1.2 In the event heat identification or traceability is required, the purchaser shall specify the details desired.

NOTE 3—Due to 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. C63000 and C63200 shall be heat treated (as specified herein).

7. Chemical Composition

7.1 The material shall conform to the chemical composition requirements in Table 1 for the Copper or Copper Alloy UNS No. designation specified in the ordering information.

7.2 These composition limits do not preclude the presence of other elements. By agreement between manufacturer and purchaser, limits may be established and analysis required for unnamed elements.

7.2.1 For alloys in which zinc is listed as a remainder, zinc is the difference between the sum of results for all elements determined and 100 %.

7.2.2 For alloys in which copper is listed as the remainder, copper is the difference between the sum of results of all elements determined and 100 %.

7.3 When all elements in Table 1 are determined for Copper Alloy UNS No. C36500, C37000, C46400, C48200, C48500 , the sum of results shall be 99.6 % min, for all other alloys the sum of results shall be 99.5 % min.

8. Temper

8.1 The standard tempers for products described in this specification are as follows:

8.1.1 As hot forged-air cooled M10,

8.1.2 As forged-quenched M11,

8.1.3 Hot forged and annealed O20.

8.2 UNS Alloy Nos. C63000 and C63200 shall be furnished as:

8.2.1 Quench hardened and temper annealed, TQ50.

8.3 Alloys C70620 and C71520 shall be furnished in the following tempers:

8.3.1 As hot forged-air cooled M10, unless,

8.3.2 Hot forged and annealed O20 is specified.

8.4 Other tempers, shall be subjected to agreement between the manufacturer and the purchaser.

9. Mechanical Property Requirements

9.1 Mechanical property requirements are subject to agreement between the manufacturer and the purchaser.

9.2 Product furnished to this specification for UNS Alloy No. C70620 and C71520 and specified to meet the requirements of the *ASME Boiler and Pressure Vessel Code* shall conform to the tensile requirements prescribed in Table 2, when tested in accordance with Test Methods E8.

9.2.1 Acceptance or rejection based upon mechanical properties for UNS Alloy No. C70620 and C71520 shall depend only on tensile strength.

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 Anneal at 1300 ± 25°F (704 ± 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 4—Typical tolerances commonly used for forgings are shown in Table X2.1.

13. Test Methods

13.1 *Chemical Analysis*:

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	Bismuth
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]	. . .	
C27450	60.0–65.0	0.25 max	. . .	0.35 max	. . .	. . .	. . .	. . .	remainder	. . .	. . .	. . .	. . .	
C36500	58.0–61.0	0.25–0.7	0.25 max	0.15 max	. . .	. . .	. . .	. . .	remainder	. . .	. . .	. . .	. . .	
C37000	59.0–62.0	0.8–1.5	. . .	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	. . .	. . .	. . .	. . .	
C49260[F]	58.0-63.0	0.09 max	0.50 max	0.50 max	. . .	. . .	0.10 max	...	remainder	...	...	0.05-0.15	...	0.50-1.8
~~C49300[G]~~	~~58.0-62.0~~	~~0.01 max~~	~~1.3-1.8~~	~~0.10 max~~	~~1.5 max~~	~~0.50 max~~	~~0.10 max~~	~~0.03 max~~	~~remainder~~	~~...~~	~~...~~	~~0.20 max~~	~~...~~	~~0.50-2.0~~
C49300[G]	58.0-62.0	0.01 max	1.0-1.8	0.10 max	1.5 max	0.50 max	0.10 max	0.03 max	remainder	...	...	0.20 max	...	0.50-2.0
C49340[H]	60.0-63.0	0.09 max	0.50-1.5	0.12 max	...	...	0.10 max	...	remainder	...	...	0.05-0.15	...	0.50-2.0
C49350[I]	61.0-63.0	0.09 max	1.5-3.0	0.12 max	...	...	0.30 max	...	remainder	...	...	0.04-0.15	...	0.50-2.5
C61900	remainder	0.02 max	0.6 max	3.0–4.5[J]	. . .	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[K]	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	. . .	. . .	. . .	0.09 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	. . .	. . .	. . .	0.09 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	0.50–1.5	0.40–1.3	. . .	. . .	. . .	0.05–0.50	remainder	. . .	. . .	. . .	. . .	
C69300	73.0–77.0	0.09 max	0.20 max	0.10 max	0.10 max	. . .	2.7–3.4	0.10 max	remainder	. . .	. . .	0.04–0.15	. . .	
C70620[L]	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[L]	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	0.09 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 plus phosphorus.
[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] Includes cadmium 0.001 % max.
[G] Includes antimony 0.50 % max, and selenium 0.20 % max.
[H] Includes cadmium 0.001 % max.
[I] Includes antimony 0.02-0.10 %.
[J] For boiler code application maximum iron content shall be 4.0 %.
[K] Iron content shall not exceed nickel content.
[L] Carbon shall be 0.05 % max.

TABLE 2 Tensile Requirements

Diameter or Section Thickness, in. (mm)	Temper Designation Standard Former	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. C27450						
All Sizes	M10 As Hot Forged–Air Cooled	50	(345)	18	(124)	25
Copper Alloy UNS No. C37700						
Up to 1½ (38.1), incl	M10 As Hot Forged–Air Cooled	50	(345)	18	(124)	25
Over 1½ (38.1)	M10 As Hot Forged–Air Cooled	46	(317)	15	(103)	30
Copper Alloy UNS No. C64200						
Up to 1½ (38.1), incl	M10 As Hot Forged–Air Cooled	70	(483)	25	(172)	30
Over 1½ (38.1)	M10 As Hot Forged–Air Cooled	68	(469)	23	(156)	35
Copper Alloy UNS Nos. C46400, C48200, C48500, C49260 and C49300						
All sizes	M10 As Hot Forged–Air Cooled	52	(358)	22	(152)	25
Copper Alloy UNS Nos. C49340 and C49350						
All sizes	M10 As Hot Forged-Air Cooled	50	(345)	20	(140)	20
Copper Alloy UNS No. C69300						
All sizes	M10 As Hot Forged-Air Cooled	65	(450)	26	(180)	15
Copper Alloy UNS No. C70620						
Up to 6 (152.3), incl	M10 As Hot Forged–Air Cooled	45	(310)	18	(124)	30
Over 6 (152.3)	M10 As Hot Forged–Air Cooled	40	(276)	15	(103)	30
All sizes	O20 Hot Forged and Annealed	40	(276)	15	(103)	30
Copper Alloy UNS No. C71520						
Up to 6 (152.3), incl	M10 As Hot Forged – Air Cooled	50	(345)	20	(138)	30
Over 6 (152.3)	M10 As Hot Forged – Air Cooled	45	(310)	18	(124)	30
All sizes	O20 Hot Forged and Annealed	45	(310)	18	(124)	30

[A] See Appendix X4.

13.1.1 In case of disagreement, determine the composition using the following methods:

Element		ASTM Test Method
Aluminum		E478
Arsenic		E62
Bismuth		JIS H 1068:2005
Copper		E478
Iron	<1.3 %	E478, E75 for CuNi
	>1.3 %	E478, E75 for CuNi
Lead		E478 (AA)
Manganese		E62, E75 for CuNi
Nickel	<5 %	E478 (photometric)
	>5 %	E478 (gravimetric)
Phosphorus		E62
Silicon		E62 (perchloric acid)
Tin	<1.3 %	E478
	>1.3 %	E478
Zinc	<2 %	E478 (AA)
	>2 %	E478 (titrimetric)
		ISO Test Method 7602
Tellurium		

NOTE— < = less than: > = greater than

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

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); UNS No. C11000; UNS No. C14500; UNS No. C14700; UNS No. C27450; UNS No. C36500; UNS No. C37000; UNS No. C37700; UNS No. C46400; UNS No. C48200;

UNS No. C48500; UNS No. C49260; UNS No. C49300; UNS No. C49340; UNS No. C49350; UNS No. C61900; UNS No. C62300; UNS No. C63000; UNS No. C63200; UNS No. C64200; UNS No. C64210; UNS No. C65500; UNS No. C67500; UNS No. C67600; UNS No. C69300; UNS No. C70620; UNS No. C71520; UNS No. C77400

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 B249/B249M 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 ±⅛ in. (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.

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