Designation: B 564 – 06a

Standard Specification for Nickel Alloy Forgings[1]

This standard is issued under the fixed designation B 564; 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[2] covers forgings of nickel alloy UNS N02200, Ni-Cu alloy UNS N04400, Ni-Cr-Fe alloys UNS N06600, UNS N06603, and UNS N06690, Ni-Cr-Mo-Nb alloy UNS N06625, Ni-Cr-Mo-Si alloy UNS N06219, low-carbon Ni-Mo-Cr alloys UNS N10276 and UNS N06022, Ni-Cr-Mo-W alloy UNS N06110, low-carbon Ni-Cr-Mo-W alloy UNS N06686, Ni-Fe-Cr-Mo-Cu alloy UNS N08825, Fe-Ni-Cr-Mo-N alloy UNS N08367, low-carbon Ni-Cr-Mo alloys UNS N06035, UNS N06058, and UNS N06059, low carbon Ni-Cr-Mo-Cu alloy UNS N06200, Ni-Mo-Cr-Fe alloy UNS N10242, Ni-Mo alloys UNS N10665 and UNS N10675, low-carbon Ni-Fe-Cr-Mo-Cu alloy UNS N08031, Ni-Cr-W-Mo alloy UNS N06230, Ni-Cr-Co-Mo alloy UNS N06617, Ni-Co-Cr-Si alloy UNS N12160, Ni-Fe-Cr alloys, Ni-Mo alloy UNS N10629, Ni-Cr-Fe-Al alloy UNS N06025, Ni-Cr-Fe-Si alloy UNS N06045, Low-Carbon Ni-Mo-Cr-Ta alloy UNS N06210, Ni-Mo-Cr-Fe alloy UNS N10624, and low-carbon Cr-Ni-Fe-N alloy UNS R20033*.

1.1.1 The nickel-iron-chromium alloys are UNS N08120, UNS N08800, UNS N08810, and UNS N08811. Alloy UNS N08800 is normally employed in service temperatures up to and including 1100°F (593°C). Alloys UNS N08810, N08120, and UNS N08811 are normally employed in service temperatures above 1100°F where resistance to creep and rupture is required, and are annealed to develop controlled grain size for optimum properties in this temperature range.

1.2 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.

1.3 *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 become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet (MSDS) for this product/material as provided by the manufacturer, to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [3]

B 880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys

E 8 Test Methods for Tension Testing of Metallic Materials

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

E 76 Test Methods for Chemical Analysis of Nickel-Copper Alloys[4]

E 112 Test Methods for Determining Average Grain Size

E 350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys

2.2 *Military Standards:*[5]

MIL-STD-129 Marking for Shipment and Storage

MIL-STD-271 Nondestructive Testing Requirements for Metals

3. Ordering Information

3.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Examples of such requirements include, but are not limited to, the following:

3.1.1 Alloy (Table 1).

3.1.2 Condition (Table 2).

3.1.3 Quantity (mass or number of pieces).

[1] This specification is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.07 on Refined Nickel and Cobalt and Their Alloys.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SB-564 in Section II of that Code.

* New designations established in accordance with ASTM E 527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

[3] 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.

[4] Withdrawn.

[5] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

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

TABLE 1 Chemical Requirements

Element	Composition, %									
	Nickel-Copper Alloy UNS N04400	Nickel-Chromium-Iron Alloy UNS N06600	Nickel-Chromium-Iron Alloy UNS N06690	Nickel-Iron Chromium Alloy UNS N08120	Nickel-Iron-Chromium Alloy UNS N08800	Nickel-Iron-Chromium Alloy UNS N08810	Nickel-Chromium-Iron-Aluminum Alloy UNS N06603	Nickel-Chromium-Iron-Aluminum Alloy UNS N06025	Nickel-Chromium-Iron-Silicon Alloy UNS N06045	Low-Carbon Nickel-Molybdenum-Chromium-Tantalum Alloy UNS N06210
Nickel	63.0[A] min	72.0[A] min	58.0 min[A]	35.0–39.0	30.0–35.0	30.0–35.0	balance[A]	balance	45 min	remainder[A]
Copper	28.0–34.0	0.5 max	0.5 max	0.50 max	0.75 max	0.75 max	0.5 max	0.10 max	0.3 max	...
Iron	2.5 max	6.0–10.0	7.0–11.0	remainder	39.5 min[A]	39.5 min[A]	8.0–11.0	8.0–11.0	21.0–25.0	1.0 max
Manganese	2.0 max	1.0 max	0.5 max	1.5	1.5 max	1.5 max	0.15 max	0.15	1.0	0.5 max
Carbon	0.3 max	0.15 max	0.05 max	0.02–0.10	0.10 max	0.05–0.10	0.20–0.40	0.15–0.25	0.05–0.12	0.015 max
Silicon	0.5 max	0.5 max	0.5 max	1.0	1.0 max	1.0 max	0.5 max	0.5	2.5–3.0	0.08 max
Sulfur, max	0.024	0.015	0.015	0.03	0.015	0.015	0.010	0.01	0.010	0.02
Chromium	...	14.0–17.0	27.0–31.0	23.0–27.0	19.0–23.0	19.0–23.0	24.0–26.0	24.0–26.0	26.0–29.0	18.0-20.0
Aluminum	...	...	...	0.40 max	0.15–0.60	0.15–0.60	2.4–3.0	1.8–2.4	...	...
Titanium	...	...	...	0.20 max	0.15–0.60	0.15–0.60	0.01–0.25	0.1–0.2	...	...
Columbium (Nb) + tantalum	...	...	...	0.4–0.9	...	...	...	...	...	...
Molybdenum	...	...	...	2.50 max	...	...	...	...	...	18.0-20.0
Phosphorus	...	...	...	0.040 max	...	...	0.02 max	0.02 max	0.02 max	0.02 max
Tungsten	...	...	...	2.50 max	...	...	...	...	...	...
Cobalt, max	...	...	...	3.0	...	...	...	...	...	1.0
Vanadium, max	...	...	...	...	...	...	...	...	...	0.35
Nitrogen	...	...	...	0.15–0.30	...	...	...	...	...	...
Boron	...	...	...	0.010 max	...	...	...	...	...	...
Lanthanum	...	...	...	...	...	...	...	...	...	...
Aluminum + Titanium	...	...	...	...	...	...		...	...	
Nickel + Molybdenum	...	...	...	...	...	...	...	...	...	...
Columbium (Nb) max	...	...	...	...	...	...	...	...	...	...
Tantalum	...	...	...	...	...	...	...	...	...	1.5-2.2
Zirconium, max	...	...	...	...	...	...	0.01–0.10	0.01–0.10	...	...
Cerium	...	...	...	...	...	...	...	...	0.03–0.09	...
Yttrium	...	...	...	...	...	...	0.01–0.15	0.05–0.12	...	...

[A] Element shall be determined arithmetically by difference.

TABLE 1 **Chemical Requirements** *(continued)*

Element	Composition, %								
	Nickel-Iron-Chromium Alloy UNS N08811	Nickel-Chromium-Molybdenum-Columbium Alloy UNS N06625	Nickel-Chromium-Molybdenum-Tungsten Alloy UNS N06110	Nickel-Iron Chromium-Molybdenum-Copper Alloy UNS N08825	Low-Carbon Nickel-Molyb-denum-Chromium Alloy UNS N10276	Low-Carbon Nickel-Molyb-denum-Chro-mium Alloy UNS N06022	Iron-Nickel-Chromium-Molyb-denum-Nitrogen Alloy UNS N08367	Low-Carbon Nickel-Chromium Molyb-denum Alloy UNS N06059	Low-Carbon Nickel-Chromium Molyb-denum Alloy UNS N06058
Nickel	30.0–35.0	58.0 min[A]	51.0 min[A]	38.0–46.0	remainder[A]	remainder[A]	23.50–25.50	balance[A]	balance
Copper	0.75 max	...	0.50 max	1.5–3.0	...	...	0.75 max	0.50 max	0.50 max
Iron	39.5 min[A]	5.0 max	1.0 max	22.0 min[A]	4.0–7.0	2.0–6.0	remainder[A]	1.5 max	1.5 max
Manganese	1.5 max	0.5 max	1.0 max	1.0 max	1.0 max	0.50 max	2.00 max	0.5 max	0.50 max
Carbon	0.06–0.10	0.10 max	0.15 max	0.05 max	0.010 max	0.015 max	0.030 max	0.010 max	0.010 max
Silicon	1.0 max	0.5 max	1.0 max	0.5 max	0.08 max	0.08 max	1.00 max	0.10 max	0.10 max
Sulfur, max	0.015	0.015	0.015	0.03	0.03	0.02	0.030	0.010	0.010
Chromium	19.0–23.0	20.0–23.0	28.0–33.0	19.5–23.5	14.5–16.5	20.0–22.5	20.0–22.0	22.0–24.0	20.0–23.0
Aluminum	0.15–0.60	0.4 max	1.0 max	0.2 max	...	...	...	0.1–0.4	0.40 max
Titanium	0.15–0.60	0.4 max	1.0 max	0.6–1.2	...	...	...	...	...
Columbium (Nb) + tantalum	...	3.15–4.15	1.0 max	...	...	...	...	...	...
Molybdenum	...	8.0–10.0	9.0–12.0	2.5–3.5	15.0–17.0	12.5–14.5	6.00–7.00	15.0–16.5	19.0 - 21.0
Phosphorus	...	0.015 max	0.50 max	...	0.04 max	0.02 max	0.040 max	0.015 max	0.015 max
Tungsten	...	...	1.0-4.0	...	3.0–4.5	2.5–3.5	...	...	0.3 max
Cobalt	...	...	...	...	2.5 max	2.5 max	...	0.3 max	0.3 max
Vanadium, max	...	...	...	...	0.35	0.35	...	...	...
Nitrogen	...	...	...	...	...	...	0.18–0.25	...	0.02 - 0.15
Boron	...	...	...	...	...	...	...	...	...
Lanthanum	...	...	...	...	...	...	...	...	...
Aluminum + Titanium	0.85–1.20	...	...	...	...	...	...	...	...
Nickel + Molybdenum	...	...	...	...	...	...	...	...	...
Columbium (Nb), max	...	...	...	...	...	...	...	...	...
Tantalum	...	...	...	...	...	...	...	...	...
Zirconium, max	...	...	...	...	...	...	...	...	...
Cerium	...	...	...	...	...	...	...	...	...
Yttrium	...	...	...	...	...	...	...	...	...

[A] Element shall be determined arithmetically by difference.

TABLE 1 **Chemical Requirements** *(continued)*

Element	Composition, %							
	Low-Carbon Nickel-Chromium-Molybdenum Alloy UNS N06035	Low-Carbon Nickel-Chromium-Molybdnum-Copper Alloy UNS N06200	Nickel-Chromium-Molybdnum-Silicon Alloy UNS N06219	Low-Carbon Nickel-Iron Chromium-Molybdnum-Copper Alloy UNS N08031	Nickel Chromium-Tungsten-Molybdenum Alloy UNS N06230	Nickel Chromium-Cobalt-Molybdenum Alloy UNS N06617	Nickel-Molybdenum Alloy UNS N10629	Nickel-Molybdenum Alloy UNS N10665
Nickel	remainder[A]	remainder[B]	balance[B]	30.0–32.0	remainder[A]	44.5 min	balance	remainder[A]
Copper	0.30 max	1.3–1.9	0.50 max	1.0–1.4	...	0.5 max	0.5 max	...
Iron	2.00 max	3.0 max	2.0-4.0	balance[B]	3.0 max	3.0 max	1.0–6.0	2.0 max
Manganese	0.50 max	0.50 max	0.50 max	2.0 max	0.30–1.00	1.0 max	1.5	1.0 max
Carbon	0.050 max	0.010 max	0.05 max	0.015 max	0.05–0.15	0.05–0.15	0.010 max	0.02 max
Silicon	0.60 max	0.08 max	0.70-1.10	0.3 max	0.25–0.75	1.0 max	0.05	0.10 max
Sulfur, max	0.015	0.010	0.010	0.010	0.015	0.015	0.01	0.03
Chromium	32.25–34.25	22.0–24.0	18.0-22.0	26.0-28.0	20.0–24.0	20.0–24.0	0.5–1.5	1.0 max
Aluminum	0.40 max	0.50 max	0.50 max	...	0.50 max	0.8–1.5	0.1–0.5	...
Titanium	...	...	0.50 max	...	...	0.6 max	...	...
Columbium (Nb) + tantalum	...	...	...	...	...	...	...	...
Molybdenum	7.60–9.00	15.0–17.0	7.0-9.0	6.0-7.0	1.0–3.0	8.0–10.0	26.0–30.0	26.0–30.0
Phosphorus	0.030 max	0.025 max	0.020 max	0.020 max	0.030 max	...	0.04 max	0.04 max
Tungsten	0.60 max	...	...	...	13.0–15.0	...	...	...
Cobalt	1.00 max	2.0 max	1.0 max	...	5.0 max	10.0 min–15.0 max	2.5	1.00 max
Vanadium, max	0.20	...	...	...	...	...	...	...
Nitrogen	...	...	...	0.15-0.25	...	...	...	...
Boron	...	...	...	...	0.015 max	0.006 max	...	...
Lanthanum	...	...	...	...	0.005–0.050	...	...	...
Aluminum + Titanium					...	...	...	
Nickel + Molybdenum	...	...	...	...	...	...	...	...
Columbium (Nb), max	...	...	...	...	...	...	...	...
Tantalum	...	...	...	...	...	...	...	...
Zirconium, max	...	...	...	...	...	...	...	...
Cerium	...	...	...	...	...	...	...	...
Yttrium	...	...	...	...	...	...	...	...

[B] Element shall be determined arithmetically by difference.

TABLE 1 **Chemical Requirements** *(continued)*

Element	Composition, %						
	Nickel-Molyb-denum Alloy UNS N10675	Nickel-Molyb-denum-Chromium-Iron Alloy UNS N10242	Low-Carbon Nickel-Chro-mium-Molyb-denum-Tungsten Alloy UNS N06686	Nickel-Cobalt-Chro-mium-Silicon Alloy UNS N12160	Nickel Alloy UNS N02200	Nickel-Molyb-denum Chro-mium-Iron Alloy UNS N10624	Chromium-Nickel-Iron-Nitrogen Alloy UNS R20033
Nickel	65.0 min	remainder[A]	remainder	remainder[A]	99.0[A] min	remainder[A]	30.0–33.0
Copper	0.20 max	...	...	...	0.25 max	0.5 max	0.30–1.20
Iron	1.0–3.0	2.0 max	5.0 max	3.5 max	0.40 max	5.0-8.0	balance[A]
Manganese	3.0 max	0.80 max	0.75 max	1.5 max	0.35 max	1.0 max	2.0
Carbon	0.01 max	0.03	0.010 max	0.15 max	0.15 max	0.01 max	0.015 max
Silicon	0.10 max	0.80 max	0.08 max	2.4–3.0	0.35 max	0.10 max	0.50
Sulfur, max	0.010	0.015	0.02	0.015	0.01	0.01 max	0.01
Chromium	1.0–3.0	7.0-9.0	19.0–23.0	26.0–30.0	...	6.0-10.0	31.0–35.0
Aluminum	0.50 max	0.50 max	...	...	...	0.5 max	...
Titanium	0.20 max	...	0.02–0.25	0.20–0.80	...	...	...
Columbium (Nb) + tantalum	...	...	...	...	...	...	...
Molybdenum	27.0–32.0	24.0-26.0	15.0–17.0	1.0 max	...	21.0-25.0	0.50–2.0
Phosphorus	0.030 max	0.030 max	0.04 max	0.030 max	...	0.025 max	0.02 max
Tungsten	3.0 max	...	3.0–4.4	1.0 max	...	...	...
Cobalt	3.0 max†	1.00 max	...	27.0–33.0†	...	1.0 max	...
Vanadium, max	0.20	...	...	...	...	...	...
Nitrogen	...	...	...	...	...	...	0.35–0.60
Boron	...	0.006 max	...	...	...	...	...
Lanthanum	...	...	...	...	...	...	...
Aluminum + Titanium	...	...	...	...	...		...
Nickel + Molybdenum	94.0–98.0	...	...	...	...	...	...
Columbium (Nb), max	0.20	...	...	1.0	...	...	...
Tantalum	0.20 max	...	...	...	...	...	...
Zirconium, max	0.10	...	...	...	...	...	...
Cerium	...	...	...	...	...	...	...
Yttrium	...	...	...	...	...	...	...

[A] Element shall be determined arithmetically by difference.

TABLE 2 Mechanical Property Requirements[A]

Material and Condition	Maximum Section Thickness, in. (mm)	Tensile Strength, min, ksi (MPa)	Yield Strength, 0.2 % Offset, min, ksi (MPa)	Elongation in 2 in. or 50 mm or 4*D*, min, %
Nickel alloy UNS N02200, annealed	...	55 (380)	15 (105)	40
Nickel-copper alloy UNS N04400, annealed	...	70 (483)	25 (172)	35
Nickel-chromium-iron alloy UNS N06600, annealed	...	80 (552)	35 (241)	30
UNS N06690, annealed	...	85 (586)	35 (241)	30
Low-carbon nickel-chromium molybdenum				
Alloy UNS N06035, solution annealed	...	85 (586)	35 (241)	30
Alloy UNS N06058, solution annealed	...	110 (760)	52 (3600	40
Alloy UNS N06059, solution annealed	...	100 (690)	45 (310)	45
Low carbon nickel-chromium molybdenum-copper alloy UNS N06200, solution annealed	...	100 (690)	45 (310)	45
Nickel-iron-chromium alloys:				
UNS N08120), solution annealed	...	90 (621)	40 (276)	30
Annealed (alloy UNS N08800)	...	75 (517)	30 (207)	30
Annealed (alloys UNS N08810 and UNS N08811)	...	65 (448)	25 (172)	30
Nickel-chromium-molybdenum-columbium alloy UNS N06625, annealed	Up to 4 (102), incl	120 (827)	60 (414)	30
	Over 4[B] (102) to 10 (254), incl	110 (758)	50 (345)	25
Nickel-chromium-molybdenum-tungsten alloy UNS N06110, annealed	Up to 4 (102), incl	95 (655)	45 (310)	60
	Over 4 (102) to 10 (254), incl	90 (621)	40 (276)	50
Nickel-iron-chromium-molybdenum-copper alloy UNS N08825, annealed	...	85 (586)	35 (241)	30
Low carbon nickel-chromium-molybdenum alloy UNS N10276, solution annealed	...	100 (690)	41 (283)	40
Low-carbon nickel-chromium-molybdenum alloy UNS N06022, solution annealed	...	100 (690)	45 (310)	45
Iron-nickel-chromium-molybdenum-nitrogen alloy UNS N08367, solution annealed	...	95 (655)	45 (310)	30
Low-carbon nickel-iron-chromium-molybdenum-copper-alloy UNS N08031, solution annealed	...	94 (650)	40 (276)	40
Nickel-chromium-tungsten-molybdenum alloy UNS N06230, solution annealed[C]	...	110 (758)	45 (310)	40
Nickel-chromium-cobalt-molybdenum alloy UNS N06617, annealed	...	95 (655)	35 (241)	35
Nickel-molybdenum alloy UNS N10665, solution annealed	...	110 (760)	51 (350)	40

TABLE 2 *Continued*

Material and Condition	Maximum Section Thickness, in. (mm)	Tensile Strength, min, ksi (MPa)	Yield Strength, 0.2 % Offset, min, ksi (MPa)	Elongation in 2 in. or 50 mm or 4*D*, min, %
Nickel-molybdenum alloy UNS N10675, solution annealed	...	110 (760)	51 (350)	40
Nickel-molybdenum-chromium-iron alloy UNS N10242, annealed	...	105 (725)	45 (310)	40
Low-carbon nickel-chromium-molybdenum-tungsten alloy UNS N06686, solution annealed	...	100 (690)	45 (310)	45
Nickel-cobalt-chromium-silicon alloy UNS N12160, solution annealed	...	90 (620)	35 (240)	40
Low-carbon chromium-nickel-iron-nitrogen alloy UNS R20033, solution annealed	...	109 (750)	55 (380)	40
Nickel-molybdenum alloy UNS N10629, solution annealed	...	110 (760)	51 (350)	40
Nickel-chromium- iron-aluminum alloy UNS N06025, solution annealed	Up to 4 (102) incl.	98 (680)	39 (270)	30
	Over 4 (102) to 12 (305) incl	84 (580)	39 (270)	15
Nickel-chromium- iron-aluminum alloy UNS N06603, annealed	...	94 (650)	43 (300)	25
Nickel-chromium-iron-silicon alloy UNS N06045, solution annealed	...	90 (620)	35 (240)	35
Nickel-molybdenum-chromium-iron alloy UNS N10624, annealed	...	104 (720)	46 (320)	40
Low-carbon nickel-molybdenum-chromium-tantalum alloy UNS N06210, solution annealed	...	100 (690)	45 (310)	45
Nickel-chromium-molybdenum-silicon alloy UNS N06219, solution annealed	...	96 (660)	39 (270)	50

[A] Forging quality is furnished to chemical requirements and surface inspection only.
[B] Over 4 to 10-in. (102 to 254-mm) diameter for parts machined from forged bar.
[C] Solution annealed at a minimum temperature of 2150°F (1177°C) followed by a water quench or rapidly cooled by other means.

3.1.4 Forging, sketch or drawing.

3.1.5 *Certification*—State if certification or a report of test results is required (14.1).

3.1.6 *Samples for Product (Check) Analysis*—Whether samples for product (check) analysis should be furnished (see 4.2).

3.1.7 *Purchaser Inspection*—If the purchaser wishes to witness tests or inspection of material at the place of manufacture, the purchase order must so state indicating which tests or inspections are to be witnessed (12.1).

4. Chemical Composition

4.1 The material shall conform to the composition limits specified in Table 1.

4.2 If a product (check) analysis is performed by the purchaser, the material shall conform to the product (check) analysis variations in accordance with Specification B 880.

5. Mechanical Properties and Other Requirements

5.1 *Mechanical Properties*—The material shall conform to the mechanical properties specified in Table 2.

5.2 *Grain Size*—Annealed alloys (UNS N08810, N08120, and UNS N08811) shall conform to an average grain size of ASTM No. 5 or coarser.

6. Dimensions and Permissible Variations

6.1 Dimensions and tolerances shall be as specified on the applicable forging sketch or drawing.

7. Workmanship, Finish, and Appearance

7.1 The material shall be uniform in quality and condition, sound, and free of injurious imperfections.

8. Sampling

8.1 *Lot Definition*:

8.1.1 A lot for chemical analysis shall consist of one heat.

8.1.2 A lot for mechanical properties and grain size testing shall consist of all material from the same heat, size, finish, condition, and processed at one time.

8.2 *Test Material Selection*:

8.2.1 *Chemical Analysis*—Representative samples shall be taken during pouring or subsequent processing.

8.2.1.1 Product (check) analysis shall be wholly the responsibility of the purchaser.

8.2.2 *Mechanical Properties and Grain Size*—Samples of the material to provide test specimens for mechanical properties and grain size shall be taken from such locations in each lot as to be representative of that lot.

9. Number of Tests

9.1 *Chemical Analysis*—One test per lot.

9.2 *Mechanical Properties*—One test per lot.

9.3 *Grain Size*—For alloys N08810, N08120, and UNS N08811, one test per lot.

10. Specimen Preparation

10.1 The tension test specimen representing each lot shall be taken from a forging or from a test prolongation.

10.2 The axis of the 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 metal flow.

10.3 The specimens shall be the largest possible round type shown in Test Methods E 8.

11. Test Methods

11.1 The chemical composition, mechanical, and other properties of the material as enumerated in this specification shall be determined, in case of disagreement, in accordance with the following methods:

Test	ASTM Designation
Chemical Analysis	E 76, E 350, E 1473
Tension	E 8
Rounding Procedure	E 29
Grain Size	E 112

11.2 The measurement of average grain size may be carried out by the planimetric method, the comparison method, or the intercept method described in Test Methods E 112. In case of dispute, the "referee" method for determining average grain size shall be the planimetric method.

11.3 For purposes of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value, or a calculated value, shall be rounded as indicated as follows, in accordance with the rounding method of Practice E 29:

Test	Rounded Unit for Observed or Calculated Value
Chemical composition	nearest unit in the last right-hand place of figures of the specified limit
Tensile strength, yield strength	nearest 1000 psi (6.9 MPa)
Elongation	nearest 1 %
Grain size:	
0.0024 in. (0.060 mm) or larger	nearest multiple of 0.0002 in. (0.005 mm)
less than 0.0024 in. (0.060 mm)	nearest multiple of 0.0001 in. (0.002 mm)

12. Inspection

12.1 Inspection of the material by the purchaser shall be made as agreed upon between the purchaser and the seller as part of the purchase contract.

13. Rejection and Rehearing

13.1 Material, tested by the purchaser, that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

14. Certification

14.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the purchaser stating that material has been manufactured, tested, and inspected in accordance with this specification, and that the test results on representative samples meet specification requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

15. Product Marking

15.1 The material shall be marked legibly with the name of the material, this specification number, the heat number and condition, and such other information as may be defined in the contract or order.

16. Keywords

16.1 nickel alloy forgings

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. Referenced Documents

S1.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein.

S1.1.1 *Federal Standards*:

Fed. Std. No. 102 Preservation, Packaging and Packing Levels

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

Fed. Std. No. 185 Identification Marking of Copper and Copper-Base Alloy Mill Products

S1.1.2 *Military Standards*:

MIL-STD-129 Marking for Shipment and Storage

S1.1.3 *Military Specification*:

MIL-C-3993 Packaging of Copper

MIL-STD-792 Copper-Base Alloy Mill Products

S2. Chemical Composition

S2.1 UNS alloy N04400 shall conform to the composition limits specified in Table 1 except as specified in Table S2.1

S3 Mechanical Properties

S3.1 Mechanical property requirements for UNS alloy N04400 forgings in the hot finished and hot finished/high tensile conditions shall be as specified in Table S3.1

S4. Number of Tests

S4.1 One tensile specimen is required for each forging greater than 250 pounds in as shipped weight.

S5. Nondestructive Tests

S5.1 When specified by the purchaser, each piece of each lot shall be inspected. The purchaser shall specify if one or both tests are required.

S5.2 *Ultrasonic Tests*:

S5.2.1 *General Requirements*:

S5.2.1.1 Ultrasonic testing shall be performed in accordance with MIL-STD-271 as modified by the requirements specified herein. Testing shall be done by a longitudinal wave or shear wave technique as specified herein.

S5.2.1.2 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.

S5.2.2 *Calibration*:

S5.2.2.1 *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 of 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 overly, 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.

S5.2.2.2 *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.

S5.2.2.3 *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.

S5.2.3 *Procedure*—Paragraphs S 5.2.3.1 through S5.2.3.4 describe the requirements for rod, bar, and simple forged shapes.

S5.2.3.1 *Rod*—Rod shall be testing using the longitudinal wave technique. The scanning path shall be circumferential or helical with the beam directed along a radius of the rod.

S5.2.3.2 *Bar*—Bar shall be tested using the longitudinal wave technique through one side of each pair of parallel sides (thickness and width only).

S5.2.3.3 *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

TABLE S2.1 Chemical Requirements

Element	Composition Limits, % UNS 04400
Carbon	0.2 max
Sulfur	0.015 max
Aluminum	0.5 max
Lead	0.006 max
Tin	0.006 max
Zinc	0.02 max
Phosphorous	0.02 max

TABLE S3.1 Mechanical Properties of UNS N04400 Forgings

Condition and Diameter Between Parallel Surfaces, in. (mm)	Tensile Strength, min, psi (Mpa)	Yield Strength, min, psi (Mpa) (0.2% offset)	Elongation in 2 in. or 50 mm, or 4D, min, %
Hot Finished -to 12 (305)	80 000 (552)	40 000 (276)	30
Hot Finished -over 12 (305)	75 000 (517)	40 000 (276)	30
Hot Finished/High Tensile - Rounds 3 to 6 (76 to 152) inclusive	95 000 (655)	70 000 (483)	20
Hot Finished/High Tensile - Rounds over 6 to 12 (152 to 305) and hex, squares, and flats 3 to 12 (76 to 305)	85 000 (586)	60 000 (414)	25

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

Material Thickness, in. (mm)	Hole Diameter, in. (mm)
Up to and including 6 (152)	⅛ 5(3.18)
Over 6 (152) and including 16 (406)	¼ (6.4)
Over 16 (406)	As agreed upon

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.

S5.2.3.4 *Disc or Pancake Forgings*—Disc or pancake forgings shall be inspected with a longitudinal wave technique from both parallel surfaces.

S5.2.4 *Acceptance Criteria*:

S5.2.4.1 *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.

S5.2.4.2 *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 one square inch 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 1-1/8 in. (25.4 to 28.6 mm) diameter transducer or one whose area falls within this range.

S5.2.4.3 *Reference Notch Removal*—If reference notches or flat-bottomed holes are made in the material to be tested, they shall be so located than their subsequent removal will not impair the suitability of the material for its intended use.

S5.3 *Liquid Penetrant Inspection*:

S5.3.1 *Procedure*—Liquid penetrant inspection shall be in accordance with MIL-STD-271.

S5.3.2 *Surface Requirements*—The surface produced by hot working is not suitable for liquid penetrant testing Therefore, liquid penetrant testing will not be applicable to products ordered with a hot finished surface.

S5.3.3 *Acceptance Criteria*—Linear defects revealed by liquid penetrant inspection shall be explored by grinding or other suitable means. Depth of defects shall not exceed the dimensional tolerance of the material.

S6. Quality Assurance

S6.1 *Responsibility for Inspection*:

S6.1.1 Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspections and test requirements specified. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own or any other suitable facilities for the performance of the inspection and test requirements unless disapproved by the purchaser at the time the order is placed. The purchaser shall have the right to perform any of the inspections or tests set forth when such inspections and tests are deemed necessary to ensure that the material conforms to prescribed requirements.

S7. Identification Marking

S7.1 All material shall be properly marked for identification in accordance with Fed. Std. No. 185 except that the ASTM specification number and the alloy number shall be used. In addition, the method and location of marking shall be in accordance with MIL-STD-792. Forging stock shall be marked with low stress die stamps or vibroetching.

S8. Preparation for Delivery

S8.1 *Preservation, Packaging, and Packing*:

S8.1.1 *Military Agencies*—The material shall be separated by size, composition, grade, or class, and shall be preserved and packaged level A or C, and packed Level A, B, or C as specified in the contract or purchase order.

S8.1.2 *Civil Agencies*—The requirements of Fed. Std. No. 102 shall be referenced for definitions for the various levels of packaging protection.

S8.2 *Marking*:

S8.2.1 *Military Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with MIL-STD-129.

S8.2.2 *Civil Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with Fed. Std. No. 123.

SUMMARY OF CHANGES

Committee B02 has identified the location of selected changes to this standard since the last issue (B 564 - 06) that may impact the use of this standard. (Approved December 1, 2006.)

(*1*) Heat treat condition, solution annealed, was added to alloys in Table 2.

Committee B02 has identified the location of selected changes to this standard since the last issue (B 564 - 04) that may impact the use of this standard. (Approved July 1, 2006.)

(*1*) The aluminum content for Alloy UNS N06230 was changed to 0.50 max in Table 1.

(*2*) The maximum yield strength value for Alloy UNS N06200 was changed to 45 ksi (310 MPa) in Table 2.