Designation: B 564 – 00a

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 alloy UNS N06058, low-carbon Ni-Cr-Mo alloy 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 the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

B 880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys[3]

E 8 Test Methods for Tension Testing of Metallic Materials[4]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[5]

E 76 Test Methods for Chemical Analysis of Nickel-Copper Alloys[6]

E 112 Test Methods for Determining the Average Grain Size[4]

E 350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron[6]

E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys[7]

2.2 *Military Standards:*[8]

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 the safe and satisfactory performance of 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).

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).

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[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 E527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

[3] *Annual Book of ASTM Standards*, Vol 02.04.

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

[5] *Annual Book of ASTM Standards*, Vol 14.02.

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

[7] *Annual Book of ASTM Standards*, Vol 03.06.

[8] Available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111–5094, Attn: NPODS.

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-Molybdenum-Chromium Alloy UNS N10276	Low-Carbon Nickel-Molybdenum-Chromium Alloy UNS N06022	Iron-Nickel-Chromium-Molybdenum-Nitrogen Alloy UNS N08367	Low-Carbon Nickel-Chromium Molybdenum Alloy UNS N06059	Low-Carbon Nickel-Chromium Molybdenum 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-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]	balance[A]	30.0–32.0	remainder[A]	44.5 min	balance	remainder[A]
Copper	1.3–1.9	0.50 max	1.0–1.4	...	0.5 max	0.5 max	...
Iron	3.0 max	2.0-4.0	balance[A]	3.0 max	3.0 max	1.0–6.0	2.0 max
Manganese	0.50 max	0.50 max	2.0 max	0.30–1.00	1.0 max	1.5	1.0 max
Carbon	0.010 max	0.05 max	0.015 max	0.05–0.15	0.05–0.15	0.010 max	0.02 max
Silicon	0.08 max	0.70-1.10	0.3 max	0.25–0.75	1.0 max	0.05	0.10 max
Sulfur, max	0.010	0.010	0.010	0.015	0.015	0.01	0.03
Chromium	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	0.50 max	0.50 max	...	0.20–0.50	0.8–1.5	0.1–0.5	...
Titanium	...	0.50 max	...	...	0.6 max	...	...
Columbium (Nb) + tantalum	...	...	...	...	...	...	...
Molybdenum	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	0.025 max	0.020 max	0.020 max	0.030 max	...	0.04 max	0.04 max
Tungsten	...	...	...	13.0–15.0	...	...	...
Cobalt	2.0 max	1.0 max	...	5.0 max	10.0 min–15.0 max	2.5	1.00 max
Vanadium, max	...	...	...	...	...	...	...
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	...	...	...	...	...	...	...

[A] Element shall be determined arithmetically by difference.

TABLE 1 Chemical Requirements *(continued)*

Element	Composition, %						
	Nickel-Molybdenum Alloy UNS N10675	Nickel-Molybdenum-Chromium-Iron Alloy UNS N10242	Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy UNS N06686	Nickel-Cobalt-Chromium-Silicon Alloy UNS N12160	Nickel Alloy UNS N02200	Nickel-Molybdenum Chromium-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.

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 per 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.

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 N06058	...	110 (760)	52 (3600	40
alloy UNS N06059	...	100 (690)	45 (310)	45
Low carbon nickel-chromium molybdenum-copper alloy UNS N06200	...	100 (690)	41 (283)	45
Nickel-iron-chromium alloys:				
Annealed (alloy UNS N08120)	...	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-molybenum-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	...	85 (586)	35 (241)	30
Low carbon nickel-molybdenum-chromium alloy UNS N10276, annealed	...	100 (690)	41 (283)	40
Low-carbon nickel-molybdenum-chromium alloy UNS N06022	...	100 (690)	45 (310)	45
Iron-nickel-chromium-molybdenum-nitrogen alloy UNS N08367	...	95 (655)	45 (310)	30
Low-carbon nickel-iron-chromium-molybdenum-copper-alloy UNS N08031	...	94 (650)	40 (276)	40
Nickel-chromium-tungsten-molybdenum alloy UNS N06230, annealed[C]	...	110 (758)	45 (310)	40
Nickel-chromium-cobalt-molybdenum alloy UNS N06617	...	95 (655)	35 (241)	35
Nickel-molybdenum alloy UNS N10665, annealed	...	110 (760)	51 (350)	40
Nickel-molybdenum alloy UNS N10675, 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	...	100 (690)	45 (310)	45
Nickel-cobalt-chromium -silicon alloy UNS N12160, annealed	...	90 (620)	35 (240)	40
Low-carbon chromium-nickel-iron-nitrogen alloy UNS R20033	...	109 (750)	55 (380)	40
Nickel-molybdenum alloy UNS N10629, annealed	...	110 (760)	51 (350)	40
Nickel-chromium- iron-aluminum alloy UNS N06025, 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, 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, annealed	...	100 (690)	45 (310)	45
Nickel-chromium-molybdenum-silicon alloy UNS N06219	...	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