~~Designation:B564–06~~ 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
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
~~E527Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)~~
E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys

2.2 *Military Standards:*[4]

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

[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.

Current edition approved ~~July~~Dec. 1, 2006. Published ~~July 2006.~~January 2007. Originally approved in 1972. Last previous edition approved in ~~2004~~2006 as B 564 – 0~~4~~6.

[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] 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.**

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).

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.

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-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-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.