Designation: B564 – 11

StandardSpecification for Nickel Alloy Forgings[1]

This standard is issued under the fixed designation B564; 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:

Alloy Type	UNS Number(s)
Fe-Ni-Cr-Mo-N	N08367
Low-carbon Cr-Ni-Fe-N	R20033
Low-carbon Ni-Cr-Mo	N06035, N06058, N06059
Low-carbon Ni-Cr-Mo-Cu	N06200
Low-carbon Ni-Cr-Mo-W	N06686
Low-carbon Ni-Fe-Cr-Mo-Cu	N08031
Low-carbon Ni-Mo-Cr	N10276, N06022, N10362
Low-carbon Ni-Mo-Cr-Ta	N06210
Ni	N02200
Ni-Co-Cr-Si	N12160
Ni-Cr-Co-Mo	N06617
Ni-Cr-Fe	N06600, N06603, N06690
Ni-Cr-Fe-Al	N06025
Ni-Cr-Fe-Si	N06045
Ni-Cr-Mo-Nb	N06625
Ni-Cr-Mo-Si	N06219
Ni-Cr-Mo-W	N06110
Ni-Cr-W-Mo	N06230
Ni-Cu	N04400
Ni-Fe-Cr	N08120, N08800, N08810, N08811
Ni-Fe-Cr-Mo-Cu	N08825
Ni-Fe-Cr-W	N06674
Ni-Mo	N10665, N10675, N10629
Ni-Mo-Cr-Fe	N10242, N10624

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 (593°C) where resistance to creep and rupture is required, and are annealed to develop controlled grain size for optimum properties in this temperature range.

1.1.2 Nickel-iron-chromium-tungsten alloy UNS N06674 is normally employed in service temperatures above 1100°F (593°C) where resistance to creep and rupture is required, and is annealed to develop 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]

B880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys

E8 Test Methods for Tension Testing of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E76 Test Methods for Chemical Analysis of Nickel-Copper Alloys (Withdrawn 2003)[4]

E112 Test Methods for Determining Average Grain Size

E350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

[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 Oct. 1, 2011. Published November 2011. Originally approved in 1972. Last previous edition approved in 2010 as B564 – 10. DOI: 10.1520/B0564-11.

[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] 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] The last approved version of this historical standard is referenced on www.astm.org.

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

E1473 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).

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 B880.

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. Annealed alloy UNS N06674 shall conform to an average grain size of ASTM No. 7 or coarser.

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

TABLE 1 Chemical Requirements[A]

Element	Nickel Alloy UNS N02200	Nickel-Copper Alloy UNS N04400	Low-Carbon Nickel-Molybdenum-Chromium Alloy UNS N06022	Nickel-Chromium-Iron-Aluminum Alloy UNS N06025	Low-Carbon Nickel-Chromium-Molybdenum Alloy UNS N06035	Nickel-Chromium-Iron-Silicon Alloy UNS N06045	Low-Carbon Nickel-Chromium-Molybdenum Alloy UNS N06058	Low-Carbon Nickel-Chromium-Molybdenum Alloy UNS N06059	Nickel-Chromium-Molybdenum-Tungsten Alloy UNS N06110
	Composition, %								
Nickel	99.0[B] min	63.0[B] min	balance[B]	balance	balance[B]	45 min	balance	balance[B]	51.0[B] min
Copper	0.25	28.0–34.0	...	0.10	0.30	0.3	0.50	0.50	0.50
Iron	0.40	2.5	2.0–6.0	8.0–11.0	2.00	21.0–25.0	1.5	1.5	1.0
Manganese	0.35	2.0	0.50	0.15	0.50	1.0	0.50	0.5	1.0
Carbon	0.15	0.3	0.015	0.15–0.25	0.050	0.05–0.12	0.010	0.010	0.15
Silicon	0.35	0.5	0.08	0.5	0.60	2.5–3.0	0.10	0.10	1.0
Sulfur	0.01	0.024	0.02	0.01	0.015	0.010	0.010	0.010	0.015
Chromium	...	...	20.0–22.5	24.0–26.0	32.25–34.25	26.0–29.0	20.0–23.0	22.0–24.0	28.0–33.0
Aluminum	...	...	...	1.8–2.4	0.40	...	0.40	0.1–0.4	1.0
Titanium	...	...	...	0.1–0.2	...	...	...	...	1.0
Columbium (Nb) + Tantalum	...	...	...	...	...	...	...	...	1.0
Molybdenum	...	...	12.5–14.5	...	7.60–9.00	...	19.0 - 21.0	15.0–16.5	9.0–12.0
Phosphorus	...	...	0.02	0.02	0.030	0.02	0.015	0.015	0.50
Tungsten	...	...	2.5–3.5	...	0.60	...	0.3	...	1.0-4.0
Cobalt	...	...	2.5	...	1.00	...	0.3	0.3	...
Vanadium	...	...	0.35	...	0.20	...	...	...	...
Nitrogen	...	...	...	...	...	...	0.02 - 0.15	...	...
Boron	...	...	...	...	...	...	...	...	...
Lanthanum	...	...	...	...	...	...	...	...	...
Aluminum + Titanium	...	...	...	...	...	...	...	...	...
Nickel + Molybdenum	...	...	...	...	...	...	...	...	...
Columbium (Nb)	...	...	...	...	...	...	...	...	...
Tantalum	...	...	...	...	...	...	...	...	...
Zirconium	...	...	...	0.01–0.10	...	...	...	...	...
Cerium	...	...	...	...	...	0.03–0.09	...	...	...
Yttrium	...	...	...	0.05–0.12	...	...	...	...	...

[A] Maximum unless range or minimum is given. Where ellipses (...) appear in this table there is no requirement and the element need neither be analyzed for nor reported.
[B] Element shall be determined arithmetically by difference.

TABLE 1 Chemical Requirements[A] *(continued)*

Element	Low-Carbon Nickel-Chromium-Molybdenum-Copper Alloy	Low-Carbon Nickel-Molybdenum-Chromium-Tantalum Alloy	Nickel-Chromium-Molybdenum-Silicon Alloy	Nickel Chromium-Tungsten-Molybdenum Alloy	Nickel-Chromium-Iron-Aluminum Alloy	Nickel Chromium-Cobalt-Molybdenum Alloy	Nickel-Chromium-Molybdenum-Columbium Alloy	Nickel-Chromium-Iron Alloy	Nickel-Iron-Chromium-Tungsten Alloy
	Composition, %								
	UNS N06200	UNS N06210	UNS N06219	UNS N06230	UNS N06603	UNS N06617	UNS N06625	UNS N06600	UNS N06674
Nickel	balance[B]	balance[B]	balance[B]	balance[B]	balance[B]	44.5 min	58.0[B] min	72.0[B] min	balance[B]
Copper	1.3–1.9	...	0.50	...	0.5	0.5	...	0.5	...
Iron	3.0	1.0	2.0-4.0	3.0	8.0–11.0	3.0	5.0	6.0–10.0	20.0-27.0
Manganese	0.50	0.5	0.50	0.30–1.00	0.15	1.0	0.5	1.0	1.50
Carbon	0.010	0.015	0.05	0.05–0.15	0.20–0.40	0.05–0.15	0.10	0.15	0.10
Silicon	0.08	0.08	0.70-1.10	0.25–0.75	0.5	1.0	0.5	0.5	1.0
Sulfur	0.010	0.02	0.010	0.015	0.010	0.015	0.015	0.015	0.015
Chromium	22.0–24.0	18.0-20.0	18.0-22.0	20.0–24.0	24.0–26.0	20.0–24.0	20.0–23.0	14.0–17.0	21.5-24.5
Aluminum	0.50	...	0.50	0.50	2.4–3.0	0.8–1.5	0.4	...	...
Titanium	...	...	0.50	...	0.01–0.25	0.6	0.4	...	0.05-0.20
Columbium (Nb) + Tantalum	...	...	...	...	...	...	3.15–4.15	...	...
Molybdenum	15.0–17.0	18.0-20.0	7.0-9.0	1.0–3.0	...	8.0–10.0	8.0–10.0	...	...
Phosphorus	0.025	0.02	0.020	0.030	0.02	...	0.015	...	0.030
Tungsten	...	...	...	13.0–15.0	...	...	...	...	6.0-8.0
Cobalt	2.0	1.0	1.0	5.0	...	10.0 min–15.0	...	...	...
Vanadium	...	0.35	...	...	...	...	...	...	...
Nitrogen	...	...	...	...	...	...	...	...	0.02
Boron	...	...	...	0.015	...	0.006	...	...	0.0005-0.006
Lanthanum	...	...	...	0.005–0.050	...	...	...	...	...
Aluminum + Titanium				...		...	...	...	
Nickel + Molybdenum	...	...	...	...	...	...	...	...	...
Columbium (Nb)	...	...	...	...	...	...	...	...	0.10-0.35
Tantalum	...	1.5-2.2	...	...	...	...	...	...	...
Zirconium	...	...	...	...	0.01–0.10	...	...	...	...
Cerium	...	...	...	...	...	...	...	...	...
Yttrium	...	...	...	...	0.01–0.15	...	...	...	...

[A] Maximum unless range or minimum is given. Where ellipses (...) appear in this table there is no requirement and the element need neither be analyzed for nor reported.
[B] Element shall be determined arithmetically by difference.

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, UNS N08811, and N06674, 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.

TABLE 1 Chemical Requirements[A] *(continued)*

Element	Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy UNS N06686	Nickel-Chromium-Iron Alloy UNS N06690	Low-Carbon Nickel-Iron-Chromium-Molybdenum-Copper Alloy UNS N08031	Nickel-Iron-Chromium Alloy UNS N08120	Iron-Nickel-Chromium-Molybdenum-Nitrogen Alloy UNS N08367	Nickel-Iron-Chromium Alloy UNS N08800	Nickel-Iron-Chromium Alloy UNS N08810	Nickel-Iron-Chromium Alloy UNS N08811	Nickel-Iron-Chromium-Molybdenum-Copper Alloy UNS N08825
	Composition, %								
Nickel	remainder	58.0[B] min	30.0–32.0	35.0–39.0	23.50–25.50	30.0–35.0	30.0–35.0	30.0–35.0	38.0–46.0
Copper	...	0.5	1.0–1.4	0.50	0.75	0.75	0.75	0.75	1.5–3.0
Iron	5.0	7.0–11.0	balance[B]	balance	balance[B]	39.5[B] min	39.5[B] min	39.5[B] min	22.0[B] min
Manganese	0.75	0.5	2.0	1.5	2.00	1.5	1.5	1.5	1.0
Carbon	0.010	0.05	0.015	0.02–0.10	0.030	0.10	0.05–0.10	0.06–0.10	0.05
Silicon	0.08	0.5	0.3	1.0	1.00	1.0	1.0	1.0	0.5
Sulfur	0.02	0.015	0.010	0.03	0.030	0.015	0.015	0.015	0.03
Chromium	19.0–23.0	27.0–31.0	26.0-28.0	23.0–27.0	20.0–22.0	19.0–23.0	19.0–23.0	19.0–23.0	19.5–23.5
Aluminum	...	...	...	0.40	...	0.15–0.60	0.15–0.60	0.15–0.60	0.2
Titanium	0.02–0.25	...	...	0.20	...	0.15–0.60	0.15–0.60	0.15–0.60	0.6–1.2
Columbium (Nb) + Tantalum	...	...	...	0.4–0.9	...	...	...	...	...
Molybdenum	15.0–17.0	...	6.0-7.0	2.50	6.00–7.00	...	...	...	2.5–3.5
Phosphorus	0.04	...	0.020	0.040	0.040	...	...	...	...
Tungsten	3.0–4.4	...	...	2.50	...	...	...	...	...
Cobalt	...	...	...	3.0	...	...	...	...	...
Vanadium	...	...	...	...	...	...	...	...	...
Nitrogen	...	...	0.15-0.25	0.15–0.30	0.18–0.25	...	...	...	...
Boron	...	...	...	0.010	...	...	...	...	...
Lanthanum	...	...	...	...	...	...	...	...	...
Aluminum + Titanium	...	...	...	...	...	...	...	0.85–1.20	...
Nickel + Molybdenum	...	...	...	...	...	...	...	...	...
Columbium (Nb)	...	...	...	...	...	...	...	...	...
Tantalum	...	...	...	...	...	...	...	...	...
Zirconium	...	...	...	...	...	...	...	...	...
Cerium	...	...	...	...	...	...	...	...	...
Yttrium	...	...	...	...	...	...	...	...	...

[A] Maximum unless range or minimum is given. Where ellipses (...) appear in this table there is no requirement and the element need neither be analyzed for nor reported.
[B] Element shall be determined arithmetically by difference.

10.3 The specimens shall be the largest possible round type shown in Test Methods E8.

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	E76, E350, E1473
Tension	E8
Rounding Procedure	E29
Grain Size	E112

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 E112. 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 E29:

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