Designation: B564 – 22

Standard Specification 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 U.S. 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, N06044
Low-carbon Ni-Cr-Mo-Cu	N06200
Low-carbon Ni-Cr-Mo-W	N06686
Low-carbon Ni-Fe-Cr-Mo-Cu	N08031, N08034
Low-carbon Ni-Mo-Cr	N10276, N06022, N10362
Low-carbon Ni-Mo-Cr-Ta	N06210
Ni	N02200
Ni-Co-Cr-Si	N12160
Ni-Cr-Al	N06699
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, N08827
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.

1.1.3 Nickel-chromium-molybdenum-columbium (UNS N06625) products are furnished in two grades of different heat-treated conditions:

1.1.3.1 *Grade 1 (Annealed)*—Material is normally employed in service temperatures up to 1100 °F (593 °C).

1.1.3.2 *Grade 2 (Solution annealed)*—Material is normally employed in service temperatures above 1100 °F (593 °C) where resistance to creep and rupture are required.

NOTE 1—Hot-working or reannealing may change properties significantly, depending on working history and temperatures.

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 Safety Data Sheet (SDS) for this product/material as provided by the manufacturer, to establish appropriate safety, health, and environmental practices, and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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/E8M Test Methods for Tension Testing of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to

[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 April 1, 2022. Published April 2022. Originally approved in 1972. Last previous edition approved in 2019 as B564 – 19. DOI: 10.1520/B0564-22.

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

[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.

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

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
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).

3.1.2.1 Unless otherwise specified, UNS N06625 Grade 1 will be supplied.

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.

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. Specimens transverse to the direction of flow may be used provided all other requirements of this standard are satisfied.

10.3 The specimens shall be the largest possible round type shown in Test Methods E8/E8M.

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/E8M
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

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

[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	Composition, %									
	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	Low-Carbon Nickel-Chromium-Molybdenum Alloy UNS N06044	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
Nickel	99.0[B] min	63.0[B] min	balance[B]	balance	balance[B]	balance	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	0.3 max	21.0-25.0	1.5	1.5	1.0
Manganese	0.35	2.0	0.50	0.15	0.50	0.07-0.30	1.0	0.50	0.5	1.0
Carbon	0.15	0.3	0.015	0.15-0.25	0.050	0.02 max	0.05-0.12	0.010	0.010	0.15
Silicon	0.35	0.5	0.08	0.5	0.60	0.20 max	2.5-3.0	0.10	0.10	1.0
Sulfur	0.01	0.024	0.02	0.01	0.015	0.020 max	0.010	0.010	0.010	0.015
Chromium	...	...	20.0-22.5	24.0-26.0	32.25-34.25	43.5-45.3	26.0-29.0	20.0-23.0	22.0-24.0	28.0-33.0
Aluminum	...	...	...	1.8-2.4	0.40	0.30 max	...	0.40	0.1-0.4	1.0
Titanium	...	...	...	0.1-0.2	...	0.10-0.30	...	...	...	1.0
Columbium (Nb) + Tantalum	...	...	...	...	...	...	...	...	...	1.0
Molybdenum	...	...	12.5-14.5	...	7.60-9.00	0.80-1.20	...	18.5-21.0	15.0-16.5	9.0-12.0
Phosphorus	...	...	0.02	0.02	0.030	0.020 max	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	Composition, %								
	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
	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.

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

Element	Composition, %											
	Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy	Nickel-Chromium-Iron Alloy	Nickel-Chromium-Aluminum Alloy	Low-Carbon Nickel-Iron-Chromium-Molybdenum-Copper Alloy	Low-Carbon Nickel-Iron-Chromium-Molybdenum-Copper Alloy	Nickel-Iron-Chromium Alloy	Iron-Nickel-Chromium-Molybdenum-Nitrogen Alloy	Nickel-Iron-Chromium Alloy	Nickel-Iron-Chromium Alloy	Nickel-Iron-Chromium Alloy	Nickel-Iron-Chromium-Molybdenum-Copper Alloy	Nickel-Iron-Chromium-Molybdenum-Copper Alloy
	UNS N06686	UNS N06690	UNS N06699	UNS N08031	UNS N08034	UNS N08120	UNS N08367	UNS N08800	UNS N08810	UNS N08811	UNS N08825	UNS N08827
Nickel	remainder	58.0[B] min	remanider	30.0–32.0	33.5–35.0	35.0–39.0	23.50–25.50	30.0–35.0	30.0–35.0	30.0–35.0	38.0–46.0	39.0–43.0
Copper	...	0.5	0.50	1.0–1.4	0.5–1.5	0.50	0.75	0.75	0.75	0.75	1.5–3.0	1.6–2.3
Iron	5.0	7.0–11.0	2.5	balance[B]	balance[B]	balance	balance[B]	39.5[B] min	39.5[B] min	39.5[B] min	22.0[B] min	balance[B]
Manganese	0.75	0.5	0.50	2.0	1.0–4.0	1.5	2.00	1.5	1.5	1.5	1.0	0.5–0.9
Carbon	0.010	0.05	0.005-0.10	0.015	0.01	0.02–0.10	0.030	0.10	0.05–0.10	0.06–0.10	0.05	0.015
Silicon	0.08	0.5	0.50	0.3	0.1	1.0	1.00	1.0	1.0	1.0	0.5	0.2–0.5
Sulfur	0.02	0.015	0.01	0.010	0.010	0.03	0.030	0.015	0.015	0.015	0.03	0.005
Chromium	19.0–23.0	27.0–31.0	26.0-30.0	26.0-28.0	26.0–27.0	23.0–27.0	20.0–22.0	19.0–23.0	19.0–23.0	19.0–23.0	19.5–23.5	21.0–23.0
Aluminum	...	...	1.9-3.0	...	0.3	0.40	...	0.15–0.60	0.15–0.60	0.15–0.60	0.2	0.06–0.25
Titanium	0.02–0.25	...	0.60	...	...	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	6.0–7.0	2.50	6.00–7.00	...	...	...	2.5–3.5	4.5–6.5
Phosphorus	0.04	...	0.02	0.020	0.020	0.040	0.040	...	...	...	...	...
Tungsten	3.0–4.4	...	...	...	...	2.50	...	...	...	...	...	...
Cobalt	...	...	...	...	...	3.0	...	...	...	...	...	0.5
Vanadium	...	...	...	...	...	...	...	...	...	...	...	...
Nitrogen	...	...	0.05	0.15-0.25	0.10–0.25	0.15–0.30	0.18–0.25	...	...	...	...	0.03
Boron	...	...	0.008	...	...	0.010	...	...	...	...	...	0.002–0.004
Lanthanum	...	...	...	...	...	...	...	...	...	...	...	...
Aluminum + Titanium	...	...				...	...	...	...	0.85–1.20	...	...
Nickel + Molybdenum	...	...	...	...	...	...	...	...	...	...	...	...
Columbium (Nb)	...	...	0.50	...	...	...	...	...	...	...	...	0.15
Tantalum	...	...	...	...	...	...	...	...	...	...	...	...
Zirconium	...	...	0.10	...	...	...	...	...	...	...	...	...
Cerium	...	...	...	...	...	...	...	...	...	...	...	...
Yttrium	...	...	...	...	...	...	...	...	...	...	...	...
Magnesium	...	...	...	...	...	...	...	...	...	...	...	0.006–0.015

[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	Composition, %								
	Nickel-Molybdenum-Chromium-Iron Alloy	Low-Carbon Nickel-Molybdenum-Chromium Alloy	Low-Carbon Nickel-Molybdenum-Chromium Alloy	Nickel-Molybdenum-Chromium-Iron Alloy	Nickel-Molybdenum Alloy	Nickel-Molybdenum Alloy	Nickel-Molybdenum Alloy	Nickel-Cobalt-Chromium-Silicon Alloy	Chromium-Nickel-Iron-Nitrogen Alloy
	UNS N10242	UNS N10276	UNS N10362	UNS N10624	UNS N10629	UNS N10665	UNS N10675	UNS N12160	UNS R200033
Nickel	balance[B]	balance[B]	balance[B]	balance[B]	balance	balance[B]	65.0 min	balance[B]	30.0–33.0
Copper	...	...	...	0.5	0.5	...	0.20	...	0.30–1.20
Iron	2.0	4.0–7.0	1.25	5.0-8.0	1.0–6.0	2.0	1.0–3.0	3.5	balance[B]
Manganese	0.80	1.0	0.60	1.0	1.5	1.0	3.0	1.5	2.0
Carbon	0.03	0.010	0.010	0.01	0.010	0.02	0.01	0.15	0.015
Silicon	0.80	0.08	0.08	0.10	0.05	0.10	0.10	2.4–3.0	0.50
Sulfur	0.015	0.03	0.010	0.01	0.01	0.03	0.010	0.015	0.01
Chromium	7.0-9.0	14.5–16.5	13.8-15.6	6.0-10.0	0.5–1.5	1.0	1.0–3.0	26.0–30.0	31.0–35.0
Aluminum	0.50	...	0.50	0.5	0.1–0.5	...	0.50	...	...
Titanium	...	...	...	...	...	...	0.20	0.20–0.80	...
Columbium (Nb) + Tantalum	...	...	...	...	...	...	...	...	...
Molybdenum	24.0-26.0	15.0–17.0	21.5-23.0	21.0-25.0	26.0–30.0	26.0–30.0	27.0–32.0	1.0	0.50–2.0
Phosphorus	0.030	0.04	0.025	0.025	0.04	0.04	0.030	0.030	0.02
Tungsten	...	3.0–4.5	...	...	...	...	3.0	1.0	...
Cobalt	1.00	2.5	...	1.0	2.5	1.00	3.0	27.0–33.0	...
Vanadium	...	0.35	...	...	...	...	0.20	...	...
Nitrogen	...	...	...	...	...	...	...	...	0.35–0.60
Boron	0.006	...	...	...	...	...	...	...	...
Lanthanum	...	...	...	...	...	...	...	...	...
Aluminum + Titanium	...	...			...		...	...	...
Nickel + Molybdenum	...	...	...	...	...	...	94.0–98.0	...	...
Columbium (Nb)	...	...	...	...	...	...	0.20	1.0	...
Tantalum	...	...	...	...	...	...	0.20	...	...
Zirconium	...	...	...	...	...	...	0.10	...	...
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.

TABLE 2 Mechanical Property Requirements[A]

Material and Condition	Maximum Section Thickness or Diameter, 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, %
Iron-nickel-chromium-molybdenum-nitrogen alloy UNS N08367, solution annealed	...	95 (655)	45 (310)	30
Low-carbon chromium-nickel-iron-nitrogen alloy UNS R20033, solution annealed	...	109 (750)	55 (380)	40
Low-carbon nickel-chromium-molybdenum				
alloy UNS N06035, solution annealed	...	85 (586)	35 (241)	30
alloy UNS N06044, solution annealed	...	100 (690)	45 (310)	30
alloy UNS N06058, solution annealed	...	110 (760)	52 (360)	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
Low-carbon nickel-chromium-molybdenum-tungsten alloy UNS N06686, solution annealed	...	100 (690)	45 (310)	45
Low-carbon nickel-iron-chromium-molybdenum-copper-alloy				
UNS N08031, solution annealed	...	94 (650)	40 (276)	40
UNS N08034, solution annealed	...	94 (650)	40 (280)	40
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
Low-carbon nickel-molybdenum-chromium UNS N10362, solution annealed	...	105 (725)	45 (310)	40
Low-carbon nickel-molybdenum-chromium-tantalum alloy UNS N06210, solution annealed	...	100 (690)	45 (310)	45
Nickel alloy UNS N02200, annealed	...	55 (380)	15 (105)	40
Nickel-cobalt-chromium-silicon alloy UNS N12160, solution annealed	...	90 (620)	35 (240)	40
Nickel-chromium-aluminum alloy UNS N06699, solution annealed	...	89 (610)	35 (240)	40
Nickel-chromium-cobalt-molybdenum alloy UNS N06617, annealed	...	95 (655)	35 (241)	35
Nickel-chromium-iron alloy UNS N06600, annealed	...	80 (552)	35 (241)	30
Nickel-chromium-iron-aluminum alloy UNS N06603, annealed	...	94 (650)	43 (300)	25
Nickel-chromium-iron alloy UNS N06690, annealed	...	85 (586)	35 (241)	30
Nickel-chromium-iron-aluminum alloy UNS N06025, solution annealed	Up to 4 (102)	98 (680)	39 (270)	30
	Over 4 (102) to 12 (305) incl	84 (580)	39 (270)	15
Nickel-chromium-iron-silicon alloy UNS N06045, solution annealed	...	90 (620)	35 (240)	35
Nickel-chromium-molybdenum-columbium alloy UNS N06625 grade 1, (annealed)[B]	Up to 4 (102), incl	120 (827)	60 (414)	30
	Over 4 (102) to 10 (254), incl	110 (758)	50 (345)	25
Nickel-chromium-molybdenum-columbium alloy UNS N06625 grade 2, (solution annealed)[C]	All sizes	100 (690)	40 (276)	30
Nickel-chromium-molybdenum-silicon alloy UNS N06219, solution annealed	...	96 (660)	39 (270)	50
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-chromium-tungsten-molybdenum alloy UNS N06230, solution annealed[D]	...	110 (758)	45 (310)	40
Nickel-copper alloy UNS N04400, annealed	...	70 (483)	25 (172)	35

TABLE 2 *Continued*

Material and Condition	Maximum Section Thickness or Diameter, 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-iron-chromium alloys:				
UNS N08120, solution annealed	...	90 (621)	40 (276)	30
UNS N08800, annealed	...	75 (517)	30 (207)	30
UNS N08810 and UNS N08811, annealed	...	65 (448)	25 (172)	30
Nickel-iron-chromium-molybdenum-copper alloys:				
UNS N08825, annealed	...	85 (586)	35 (241)	30
UNS N08827, annealed	...	85 (586)	35 (241)	30
Nickel-iron-chromium-tungsten alloy UNS N06674, solution annealed[D]	...	86 (590)	34 (235)	30
Nickel-molybdenum alloy UNS N10665, solution annealed	...	110 (760)	51 (350)	40
Nickel-molybdenum alloy UNS N10675, solution annealed	...	110 (760)	51 (350)	40
Nickel-molybdenum alloy UNS N10629, solution annealed	...	110 (760)	51 (350)	40
Nickel-molybdenum-chromium-iron alloy UNS N10242, annealed	...	105 (725)	45 (310)	40
Nickel-molybdenum-chromium-iron alloy UNS N10624, annealed	...	104 (720)	46 (320)	40

[A] Forging quality is furnished to chemical requirements and surface inspection only.
[B] Annealed at 1600 °F (871 °C) minimum.
[C] Solution annealed at 2000 °F (1093 °C) minimum, with or without subsequent stabilization anneal at 1800 °F (982 °C) minimum to increase resistance to sensitization.
[D] Solution annealed at a minimum temperature of 2150 °F (1177 °C) followed by a water quench or rapidly cooled by other means.

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 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 lb 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 S5.2.3.1 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 1⅛ 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 that 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 (B564 – 19) that may impact the use of this standard. (Approved April 1, 2022.)

(1) Added two different grades for N06625 in base of heat treatment condition in 1.1.3.
(2) Added mechanical property data to Table 2 for UNS N06625 grade 2 (solution annealed).
(3) Replaced previous footnote B and added new footnote C to Table 2.