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ТРУБЫ, ФЛАНЦЫ, КРЕПЕЖ, ДЕТАЛИ ТРУБОПРОВОДА

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Standard Specification for Nickel Alloy Forgings¹

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 specification² covers forgings of:

Interfere Interfere 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-Cu N06031 Low-carbon Ni-Fe-Cr-Mo-Cu N08031 Low-carbon Ni-Fe-Cr-Mo-Cu N06210 Ni N02200 Ni-Cr-Co-Cr-Si N12160 Ni-Cr-Fe N06607 Ni-Cr-Fe N06600, N06603, N06690 Ni-Cr-Fe-Al N06025 Ni-Cr-Fe-Si N06045 Ni-Cr-Mo-Nb N06219 Ni-Cr-Mo-Nb N06230 Ni-Cr-Mo-W N06110 Ni-Cr-Mo-W N06230 Ni-Cr-Mo-Nb N06230 Ni-Cr-Mo-Nb N06230 Ni-Cu N04400 Ni-Fe-Cr N08825 Ni-Fe-Cr-W N08825 Ni-Fe-Cr-W N08825 Ni-Fe-Cr-Fe N106674 Ni-Mo N106674 Ni-Mo N10242, N10624	Alloy Type	UNS Number(s)
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-Fe-Cr-Mo-Cu N08031 Low-carbon Ni-Mo-Cr N10276, N06022, N10362 Low-carbon Ni-Mo-Cr N06210 Ni N02200 Ni-Cr-Co-Mo N06617 Ni-Cr-Fe-Al N06000, N06603, N06690 Ni-Cr-Fe-Al N06025 Ni-Cr-Mo-Nb N06625 Ni-Cr-Mo-Nb N06219 Ni-Cr-Mo-W N06110 Ni-Cr-Mo-W N06230 Ni-Cr-Mo-Si N06219 Ni-Cr-Mo-Cu N08230 Ni-Cr-Mo-Cu N08420 Ni-Cr-Mo-Cu N0825 Ni-Cr-W-Mo N06230 Ni-Cr-W-Mo N06825 Ni-Cu N08400 Ni-Fe-Cr N08420, N08810, N08811 Ni-Fe-Cr-Wo N08674 Ni-Fe-Cr-W N06674 Ni-Mo N1066		
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 N06210 Ni N12160 Ni-Co-Cr-Si N12160 Ni-Cr-Co-Mo N06617 Ni-Cr-Fe N06600, N06603, N06690 Ni-Cr-Fe-Al N06025 Ni-Cr-Mo-Nb N06625 Ni-Cr-Mo-Si N06219 Ni-Cr-Mo-Si N06210 Ni-Cr-Wo N06230 Ni-Cr-Wo N06230 Ni-Cr-Wo N04400 Ni-Fe-Cr N08825 Ni-Fe-Cr-Wo N08825 Ni-Fe-Cr-W N06674 Ni-Fe-Cr-W N0665, N10675, N10629		B20033
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-Nb N06625 Ni-Cr-Mo-Si N06219 Ni-Cr-Wo-Si N06230 Ni-Cr-W-Mo N06230 Ni-Cu N04400 Ni-Fe-Cr N08825 Ni-Fe-Cr N08825 Ni-Fe-Cr-W N06674 Ni-Fe-Cr-W N06674 Ni-Fe-Cr-W N0665, N10675, N10629	Low-carbon Ni-Cr-Mo	N06035, N06058, N06059
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 N06000, N06603, N06690 Ni-Cr-Fe-Al N06025 Ni-Cr-Fe-Si N06045 Ni-Cr-Mo-Nb N06625 Ni-Cr-Mo-Si N06219 Ni-Cr-Wo N06110 Ni-Cr-Wo N06230 Ni-Cr-Mo-Si N064400 Ni-Fe-Cr N08120, N08800, N08810, N08811 Ni-Fe-Cr N08825 Ni-Fe-Cr-W N06674 Ni-Fe-Cr-W N06674 Ni-Mo N10655, N10675, N10629	Low-carbon Ni-Cr-Mo-Cu	
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-Mo-Nb N06219 Ni-Cr-Mo-Si N06219 Ni-Cr-W-Mo N06230 Ni-Cr-W-Mo N06230 Ni-Cr-W-Mo N04400 Ni-Fe-Cr N08120, N08800, N08810, N08811 Ni-Fe-Cr-Mo-Cu N08825 Ni-Fe-Cr-W N06674 Ni-Mo N10665, N10675, N10629	Low-carbon Ni-Cr-Mo-W	N06686
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-Mo-Nb N06219 Ni-Cr-Mo-W N06110 Ni-Cr-W-Mo N06230 Ni-Cr-W-Mo N06230 Ni-Cr-W-Mo N04400 Ni-Fe-Cr N08120, N08800, N08810, N08811 Ni-Fe-Cr-W N06674 Ni-Fe-Cr-W N06674 Ni-Mo N10665, N10675, N10629	Low-carbon Ni-Fe-Cr-Mo-Cu	N08031
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-Mo-Nb N06625 Ni-Cr-Mo-Nb N06219 Ni-Cr-Wo-No N06230 Ni-Cr-Wo-Mo N06230 Ni-Cr-Wo-Mo N04400 Ni-Fe-Cr N08120, N08800, N08810, N08811 Ni-Fe-Cr-Wo N06674 Ni-Fe-Cr-W N06674 Ni-Mo N10665, N10675, N10629	Low-carbon Ni-Mo-Cr	N10276, N06022, N10362
Ni-Co-Cr-Si N12160 Ni-Cr-Co-Mo N06617 Ni-Cr-Fe N06600, N06603, N06690 Ni-Cr-Fe-Al N06025 Ni-Cr-Mo-Nb N06625 Ni-Cr-Mo-Si N06219 Ni-Cr-W-Mo N06230 Ni-Cr-W-Mo N06230 Ni-Fe-Cr N08120, N08800, N08810, N08811 Ni-Fe-Cr-Wo N06674 Ni-Fe-Cr-W N0665, N10675, N10629	Low-carbon Ni-Mo-Cr-Ta	N06210
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-W-Mo N06230 Ni-Cr-W-Mo N06420 Ni-Fe-Cr N08120, N08800, N08810, N08811 Ni-Fe-Cr-Mo-Cu N08825 Ni-Fe-Cr-W N06674 Ni-Mo N10665, N10675, N10629	Ni	N02200
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-Wo-W N06110 Ni-Cr-W-Mo N06230 Ni-Cu N04400 Ni-Fe-Cr N08120, N08800, N08810, N08811 Ni-Fe-Cr-W N06674 Ni-Fe-Cr, N10629 N10665, N10675, N10629	Ni-Co-Cr-Si	N12160
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-Cr-Co-Mo	N06617
Ni-Cr-Fe-Si N06045 Ni-Cr-Mo-Nb N06045 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-Cr-Fe	N06600, N06603, N06690
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-Cr-Fe-Al	N06025
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-Fo-Cr-W N0665, N10675, N10629	Ni-Cr-Fe-Si	N06045
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-Cr-Mo-Nb	N06625
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-Cr-Mo-Si	N06219
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-Cr-Mo-W	N06110
Ni-Fe-Cr N08120, N08800, N08810, N08811 Ni-Fe-Cr-Mo-Cu N08825 Ni-Fe-Cr-W N06674 Ni-Mo N10665, N10675, N10629	Ni-Cr-W-Mo	N06230
Ni-Fe-Cr-Mo-Cu N08825 Ni-Fe-Cr-W N06674 Ni-Mo N10665, N10675, N10629	Ni-Cu	N04400
Ni-Fe-Cr-W N06674 Ni-Mo N10665, N10675, N10629	Ni-Fe-Cr	N08120, N08800, N08810, N08811
Ni-Mo N10665, N10675, N10629	Ni-Fe-Cr-Mo-Cu	N08825
	Ni-Fe-Cr-W	N06674
Ni-Mo-Cr-Fe N10242, N10624	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 Safety Data Sheet (SDS) 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 MaterialsE29 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

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

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 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.

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).

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

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.

TABLE 1 Chemical Requirements^A

					sition, %				
Element	Nickel Alloy	Nickel- Copper Alloy	Low- Carbon Nickel- Molybdenum- Chromium Alloy	Nickel- Chromium- Iron- Aluminum Alloy	Low- Carbon Nickel- Chromium- Molybdenum Alloy	Nickel- Chromium- Iron-Silicon Alloy	Low- Carbon Nickel- Chromium- Molybdenum Alloy	Low- Carbon Nickel- Chromium- Molybdenum Alloy	Nickel- Chromium- Molybdenum- Tungsten Alloy
	UNS N02200	UNS N04400	UNS N06022	UNS N06025	UNS N06035	UNS N06045	UNS N06058	UNS N06059	UNS N06110
Nickel	99.0 ^{<i>B</i>} min	63.0 ^{<i>B</i>} min	balance ^B	balance	balance ^B	45 min	balance	balance ^B	51.0 ^{<i>B</i>} 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		18.5-21.0	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)

				Compositio	n, %				
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
	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. Specimens transverse to the

TABLE 1 Chemical Requirements^A (continued)

				Compos	ition, %				
Element	Low- Carbon Nickel- Chromium- Molybdenum- Tungsten Alloy	Nickel- Chromium- Iron 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
	UNS N06686	UNS N06690	UNS N08031	UNS N08120	UNS N08367	UNS N08800	UNS N08810	UNS N08811	UNS N08825
Nickel	remainder	58.0 ^{<i>B</i>} 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 ^{<i>B</i>} min	39.5 ^{<i>B</i>} min	39.5 ^{<i>B</i>} 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.

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.

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
Test	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)

TABLE 1 Chemical Requirements^A (continued)

				Compositio	on, %				
Element	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.

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

₩ B564 – 15

TABLE 2 Mechanical Property Requirements^A

Material and Condition Macanum Section Transiers Tendits Stempin, in mo biological status Vehicl Description, biological status Description, biological status Description biological status Description status Description status Description status Description status Description status Description status Description status Description status Description status Description status <thdescriptio< th=""><th></th><th>TABLE 2 Mechanical</th><th>Property Requirements^A</th><th></th><th></th></thdescriptio<>		TABLE 2 Mechanical	Property Requirements ^A		
Introgen aloy UKS N05367, solution anrealed Low-schon charmium-indication- moduled manual distance inducts manual distance concentro indication distance and the introduct distance indication charmium- molyciderum indication annealed annealed indication distance indication distance indication annealed indication indindi indindindindi indication indindication indication indication		Thickness,		Strength, 0.2 % Offset, min,	in 2 in. or 50 mm or 4 <i>D</i> ,
nhtogen alley UNS P20203, solution annealed Low-catton indexi-chronium- molyderunum- annealed ancellos, solution 109 (750) 55 (280) 40 Low-catton indexi-chronium- molyderunum- annealed ancellos, solution 85 (080) 35 (241) 30 alloy UNS N0050, solution 100 (090) 45 (310) 45 alloy UNS N0050, solution annealed Low-catton indexi-chronium- molyderunum-torgen alloy 100 (090) 45 (310) 45 UNS N0050, solution annealed Low-catton indexi-chronium- molyderunum-torgen alloy 94 (650) 40 (276) 40 UNS N0050, solution annealed Low-catton indexi-chronium- molyderunum-torgen alloy 94 (650) 41 (283) 40 Low-catton indexi-chronium- molyderunum-torgen alloy 100 (690) 41 (283) 40 Low-catton indexi-chronium- molyderunum-torgen alloy 100 (690) 45 (310) 45 Low-catton indexi-chronium- molyderunum alloy UNS N0220, solution annealed 100 (690) 45 (310) 45 Low-catton indexi-chronium- molyderunum alloy UNS N0220, solution annealed 100 (690) 45 (310) 45 Low-catton	nitrogen alloy UNS N08367, solution annealed		95 (655)	45 (310)	30
air y UNS N02035, solution 85 (586) 35 (241) 30 ally UNS N02068, solution 110 (760) 52 (360) 40 arreaded 100 (690) 45 (310) 45 Low cathon nickel-homium- molyddeum-copper alloy 100 (690) 45 (310) 45 Low cathon nickel-homium- molyddeum-copper alloy 100 (690) 45 (310) 45 Low cathon nickel-homium- molyddeum-apper alloy 100 (690) 41 (283) 40 Low cathon nickel-homium- molyddeum-alloy 100 (690) 45 (310) 45 Low cathon nickel-homium- molyddeum-alloy 100 (690) 45 (310) 40 Low-cathon nickel-homium- molyddeum-alloy 100 (690) 45 (310) 45 Low-cathon nickel-homium- molyddeum-alloy 100 (690) 45 (310) 40 Low-cathon nickel-molyddiff 100 (690) 45 (310) 40 Low-cathon nickel-molyddiff 100 (690) 45 (310) 40 Ammaled <td>nitrogen alloy UNS R20033, solution annealed Low-carbon nickel-chromium-</td> <td></td> <td>109 (750)</td> <td>55 (380)</td> <td>40</td>	nitrogen alloy UNS R20033, solution annealed Low-carbon nickel-chromium-		109 (750)	55 (380)	40
annealed 110 (160) $2c$ (280) 40 alloy LNS N0520, solution 100 (690) 45 (310) 45 Low carbon nickel-thronium- metydebrum-tungsten alloy 100 (690) 45 (310) 45 Low carbon nickel-thronium- metydebrum-tungsten alloy 100 (690) 46 (310) 45 Low carbon nickel-thronium- metydebrum-tungsten alloy 94 (650) 40 (276) 40 Low carbon nickel-thronium- metydebrum alloy UNS N0227, solution annealed 94 (650) 41 (283) 40 Low-carbon nickel-thronium- metydebrum alloy UNS N0227, solution annealed 100 (690) 45 (310) 45 Low-carbon nickel-thronium- metydebrum alloy UNS N0220, solution annealed 105 (725) 45 (310) 40 Low-carbon nickel-thronium- metydebrum alloy UNS N0220, annealed 100 (690) 45 (310) 45 N022 (1) solution annealed 100 (690) 45 (310) 40 Low-carbon nickel-thronium- metydebrum alloy UNS N0220, solution annealed 100 (690) 45 (310) 40 Low-car	alloy UNS N06035, solution		85 (586)	35 (241)	30
alicy UNS NG059, Solution 100 (990) 45 (310) 45 Low-catton nickel-chronium- molydedum-copper alicy 100 (690) 45 (310) 45 Low-catton nickel-chronium- molydedum-copper alicy 100 (690) 45 (310) 45 Low-catton nickel-chronium- molydedum-copper alicy 94 (550) 40 (276) 40 Low-catton nickel-chronium- molydedum-disploredum-copper alicy 100 (690) 41 (283) 40 Low-catton nickel-chronium- molydedum-disploredum-copper alicy 100 (690) 45 (310) 45 Low-catton nickel-chronium- molydedum-disploredum- soluton annealed 100 (690) 45 (310) 45 Low-catton nickel-molydeum- chronium UNS N10382, solution 100 (690) 45 (310) 45 Low-catton nickel-molydeum- chronium Low SN 10382, solution 100 (690) 45 (310) 45 Low-catton nickel-molydeum- chronium Low SN 10382, solution annealed 100 (690) 35 (240) 40 Low-catton nickel-molydeum- chronium Low SN 10382, solution annealed 90 (620) 35 (240) 30 <td></td> <td></td> <td>110 (760)</td> <td>52 (360)</td> <td>40</td>			110 (760)	52 (360)	40
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motybdenum-tungsten aloy 100 (690) 45 (310) 45 UNS N0685, solution annealed 94 (650) 40 (276) 40 Low-carbon nickel-toronium- motybdenum aloy UNS N0262, 100 (690) 41 (283) 40 Low-carbon nickel-toronium- motybdenum aloy UNS N0262, 100 (690) 45 (310) 45 Solution annealed 100 (690) 45 (310) 45 Low-carbon nickel-toronium- motybdenum- annealed 100 (690) 45 (310) 40 Low-carbon nickel-toronium- motybdenum- chromium-tantalum aloy UNS N0262, 100 (690) 45 (310) 45 Low-carbon nickel-toronium-toronium- toronium-tantalum aloy UNS N0262, solution annealed 100 (690) 45 (310) 40 Nickel-toronium-toronium-toronium- toronium-toronium-toronium-toronium- columium-toron	molybdenum-copper alloy UNS N06200, solution annealed		100 (690)	45 (310)	45
maintybdenum-coper-alloy 94 (650) 40 (276) 40 UNS N0805, solution namealed 100 (690) 41 (283) 40 Low-carbon nickel-bromium- molybdenum alloy UNS N10276, solution annealed 100 (690) 45 (310) 45 Low-carbon nickel-molybdenum- chromium UNS N10362, solution 100 (690) 45 (310) 40 Low-carbon nickel-molybdenum- chromium UNS N10362, solution 100 (690) 45 (310) 40 Low-carbon nickel-molybdenum- chromium UNS N10362, solution annealed 100 (690) 45 (310) 40 Nofe210, solution annealed 100 (690) 35 (240) 40 Nickel-chromium-silicon alloy 90 (620) 35 (241) 30 Nickel-chromium-inc-aluminum 96 (655) 35 (241) 30 Nickel-chromium-inc-aluminum 96 (650) 39 (270) 30 Nickel-chromium-inc-aluminum 86 (566) 39 (270) 35 Nickel-chromium-inc-aluminum 90 (620) 35 (240) 35	molybdenum-tungsten alloy UNS N06686, solution annealed		100 (690)	45 (310)	45
motybdenum alky UNS N10276, solution annealed 100 (690) 41 (283) 40 Low-carbon nickel-thormium- molybdenum alky UNS N0622, solution annealed 100 (690) 45 (310) 45 Low-carbon nickel-molybdenum- chromium UNS N10326, solution annealed 105 (725) 45 (310) 40 Low-carbon nickel-molybdenum- chromium-tantum alky UNS N0262, solution annealed 100 (690) 45 (310) 40 Nickel alby UNS N2200, annealed 100 (690) 35 (240) 40 Nickel cobat-chromium-silicon alloy UNS N12160, solution annealed 90 (620) 35 (241) 30 Nickel-chromium-silicon alloy UNS N12160, annealed 80 (552) 35 (241) 30 Nickel-chromium-inconaltrium 80 (552) 35 (241) 30 Nickel-chromium-inconaltrium 86 (586) 36 (271) 30 Nickel-chromium-inconaltrium 86 (586) 39 (270) 30 Nickel-chromium-inconaltrium 86 (680) 39 (270) 35 Nickel-chromium-inco-allorium <t< td=""><td>molybdenum-copper-alloy UNS N08031, solution annealed</td><td></td><td>94 (650)</td><td>40 (276)</td><td>40</td></t<>	molybdenum-copper-alloy UNS N08031, solution annealed		94 (650)	40 (276)	40
motybdenum alloy UNS N06022, solution annealed 100 (690) 45 (310) 45 Low-carbon nickl-molybdenum- dromaum UNS N10362, solution annealed 100 (690) 45 (310) 40 Low-carbon nickl-molybdenum- dromaum UNS N10362, solution annealed 100 (690) 45 (310) 45 Nickle alogy UNS Nickle alogy UNS N2200, annealed 55 (380) 15 (105) 40 Nickle Alogy UNS N2200, annealed 90 (620) 35 (240) 40 Nickle Alogy UNS N2160, annealed 95 (655) 35 (241) 30 Nickle-horonium-ion alloy UNS N06603, annealed 80 (552) 35 (241) 30 Nickle-horonium-ion alloy UNS N06603, annealed 85 (586) 35 (241) 30 Nickle-horonium-iron-aluminum UNS N06603, annealed 86 (580) 39 (270) 30 Nickle-horonium-iron-aluminum UNS N06602, solution annealed 90 (620) 35 (240) 35 Nickle-horonium-iron-aluminum UNS N06602, solution annealed 90 (620) 35 (240) 35 Nickle-horonium-molybdenum- UNS N066215	molybdenum alloy UNS N10276, solution annealed		100 (690)	41 (283)	40
chromium UNS N10362, solution 105 (725) 45 (310) 40 Low-carbon nickel-molybdenum- chromium-tantalum alloy UNS 100 (690) 45 (310) 45 N08210, solution annealed 55 (380) 15 (105) 40 Nickel-about-chromium-silicon alloy 90 (620) 35 (240) 40 Nickel-chromium-silicon alloy 90 (620) 35 (241) 35 Nickel-chromium-silicon alloy 95 (655) 35 (241) 30 Nickel-chromium-ion alloy 94 (650) 43 (300) 25 Nickel-chromium-ion alloy 94 (650) 39 (270) 30 alloy UNS N06603, annealed 94 (650) 39 (270) 30 alloy UNS N06603, annealed 90 (620) 35 (241) 30 Nickel-chromium-inon-aluminum 91 (620) 39 (270) 15 annealed 90 (620) 35 (241) 30 UNS N06603, annealed 90 (620) 35 (241) <td>molybdenum alloy UNS N06022, solution annealed</td> <td></td> <td>100 (690)</td> <td>45 (310)</td> <td>45</td>	molybdenum alloy UNS N06022, solution annealed		100 (690)	45 (310)	45
chromium-tantalum alföy UNS 100 (690) 45 (310) 45 Nöcktö allöy UNS N02200, annealed 55 (380) 15 (105) 40 Nickel-chromium-silicon alloy UNS N12160, solution annealed 90 (620) 35 (240) 40 Nickel-chromium-cobalt- molybdenum allog UNS N06617, annealed 95 (655) 35 (241) 30 Nickel-chromium-tion alloy UNS N06600, annealed 80 (552) 35 (241) 30 Nickel-chromium-tion-alloy UNS N06600, annealed 80 (552) 35 (241) 30 Nickel-chromium-iron-allorinum 94 (650) 43 (300) 25 Nickel-chromium-iron-allorinum 85 (586) 35 (241) 30 Nickel-chromium-iron-allorinum 85 (586) 39 (270) 30 Nickel-chromium-iron-allorinum- 90 (620) 35 (240) 35 Nickel-chromium-iron-silicon alloy 90 (620) 35 (240) 35 Nickel-chromium-iron-silicon alloy 90 (620) 35 (240) 35 <td< td=""><td>chromium UNS N10362, solution annealed</td><td></td><td>105 (725)</td><td>45 (310)</td><td>40</td></td<>	chromium UNS N10362, solution annealed		105 (725)	45 (310)	40
annealed 55 (50) 15 (105) 40 Nickel-oblit-bromium-silicon alloy 90 (620) 35 (240) 40 Nickel-oblit-bromium-cobalt 90 (620) 35 (241) 35 annealed 90 (652) 35 (241) 35 Nickel-bromium-iron alloy 80 (552) 35 (241) 30 UNS N06600, annealed 94 (650) 43 (300) 25 Nickel-bromium-iron-aluminum 85 (586) 35 (241) 30 UNS N06600, annealed 85 (586) 35 (241) 30 UNS N06600, annealed 85 (586) 35 (241) 30 Nickel-bromium-iron-aluminum Up to 4 (102) to 84 (580) 39 (270) 30 alloy UNS N06625, solution Over 4 (102) to 12 (305) incl 10 15 annealed 90 (620) 35 (240) 35 36 Nickel-bromium-iron-aluminum Up to 4 (102), incl 120 (827) 60 (414) 30	chromium-tantalum alloy UNS		100 (690)	45 (310)	45
UNS N12160, solution annealed 90 (620) 35 (240) 40 Nickel-chromium-cobalt- molyddenum alloy UNS N06617, annealed 95 (655) 35 (241) 35 Nickel-chromium-iron alloy UNS N06600, annealed 80 (552) 35 (241) 30 Nickel-chromium-iron alloy UNS N06603, annealed 94 (650) 43 (300) 25 Nickel-chromium-iron-aluminum alloy UNS N06603, annealed 94 (650) 35 (241) 30 Nickel-chromium-iron-aluminum alloy UNS N06603, annealed 94 (650) 39 (270) 30 Nickel-chromium-iron-aluminum alloy UNS N06602, solution Over 4 (102) to 88 (680) 39 (270) 30 annealed 12 (305) incl 80 (522) 60 (414) 30 Nickel-chromium-molybdenum- columbium alloy UNS N0625, annealed 90 (620) 39 (270) 50 Nickel-chromium-molybdenum- silicon alloy UNS N06210, solution annealed 96 (660) 39 (270) 50 Nickel-chromium-molybdenum- silicon alloy UNS N06230, annealed 96 (655) 45 (310) 60 Nickel-chromium			55 (380)	15 (105)	40
molybdenum alloy UNS N06617, annealed 95 (655) 35 (241) 35 annealed 80 (552) 35 (241) 30 Nickel-chromium-inon alloy UNS N06600, annealed 94 (650) 43 (300) 25 Nickel-chromium-inon-aluminum alloy UNS N06600, annealed 85 (586) 35 (241) 30 Nickel-chromium-inon-aluminum alloy UNS N06605, annealed 85 (586) 35 (241) 30 Nickel-chromium-inon-aluminum alloy UNS N06605, solution 86 (580) 39 (270) 30 Nickel-chromium-inon-silicon alloy UNS N06625, solution annealed 90 (620) 35 (240) 35 Nickel-chromium-molybdenum- columbium alloy UNS N06625, DVer 4 ¹⁰ (102) to 10 (254), incl 120 (827) 60 (414) 30 Nickel-chromium-molybdenum- silicon alloy UNS N06215, solution 96 (660) 39 (270) 50 Annealed 96 (660) 39 (270) 50 Nickel-chromium-molybdenum- silicon alloy UNS N06230, solution annealed 96 (660) 39 (270) 50 Nickel-chromium-togsten- molybdenum aloy	UNS N12160, solution annealed		90 (620)	35 (240)	40
UNS N06600, annealed 80 (552) 35 (241) 30 Nickel-chromium-iron-aluminum 94 (650) 43 (300) 25 Nickel-chromium-iron alloy 85 (586) 35 (241) 30 UNS N06603, annealed 85 (586) 35 (241) 30 Nickel-chromium-iron-aluminum Up to 4 (102) 98 (680) 39 (270) 30 alloy UNS N06025, solution Over 4 (102) to 84 (580) 36 (240) 35 nanealed 12 (305) incl 90 (620) 35 (240) 35 Nickel-chromium-iron-silicon alloy 90 (620) 35 (241) 30 Nickel-chromium-iron-silicon alloy Up to 4 (102), incl 120 (827) 60 (414) 30 columbium alloy UNS N06219, solution 96 (660) 39 (270) 50 annealed	molybdenum alloy UNS N06617,		95 (655)	35 (241)	35
alloy UNS N06603, annealed 94 (650) 43 (300) 25 Nickel-chromium-iron alloy 85 (586) 35 (241) 30 UNS N06690, annealed 85 (586) 39 (270) 30 alloy UNS N06025, solution Over 4 (102) to 84 (580) 39 (270) 15 annealed 12 (305) incl 90 (620) 35 (240) 35 Nickel-chromium-iron-silicon alloy 90 (620) 35 (240) 35 UNS N06045, solution annealed 90 (620) 35 (240) 35 Nickel-chromium-molybdenum- Up to 4 (102), incl 120 (827) 60 (414) 30 columbium alloy UNS N0625, Duer 4 ^F (102) to 110 (758) 50 (345) 25 annealed 96 (660) 39 (270) 50 annealed 90 (621) 40 (276) 50 annealed 90 (621) 40 (276) 50 annealed 110 (758) 45 (310) 40 Nickel-chromium-tungsten- 110 (758) 45 (310) 40	UNS N06600, annealed		80 (552)	35 (241)	30
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			65 (448)	25 (172)	30

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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 <i>D</i> , min, %
Nickel-iron-chromium-molybdenum- copper alloy UNS N08825, annealed		85 (586)	35 (241)	30
Nickel-iron-chromium-tungsten alloy UNS N06674, solution annealed ^C		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 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.

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

TABLE S2.1 Chemical Requirements

	Composition Limits, %
Element	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

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.

S5.2.2Calibration:

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	TABLE S3.1	Mechanical	Properties	of UNS	N04400	Forgings
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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

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 $\frac{1}{4}$ 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 $\pm \frac{1}{8}$ 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 $\pm \frac{1}{8}$ 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).

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)	1⁄8 5(3.18)
Over 6 (152) and including 16 (406)	1⁄4 (6.4)
Over 16 (406)	As agreed upon

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 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 1½ 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 $(B564-11^{\epsilon 1})$ that may impact the use of this standard. (Approved October 1, 2015.)

(1) Revised chemistry for molybdenum in UNS N06058 in Table 1.

(2) Revised 10.2 to permit transverse orientation for tensile specimens.

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