

ASTM B564 / ASME SB564

Standard Specification for Nickel Alloy Forgings

This specification covers forgings of:

<u>Alloy Type</u>	<u>UNS Number(s)</u>
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

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.

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.

A. Chemical Composition :-

The material shall conform to the composition limits specified in Table 1.

Table 1

Element	N02200	N04400	N06022	N06025	N06035	N06045	N06058	N06059	N06110
Nickel	99.0Bmin	63.0Bmin	balance ^B	balance	balance ^B	45min	balance	balance ^B	51.0 ^B min
Copper	0.25	28.0–34.0	...	0.1	0.3	0.3	0.5	0.5	0.5
Iron	0.4	2.5	2.0–6.0	8.0–11.0	2.0	21.0–25.0	1.5	1.5	1.0
Manganese	0.35	2.0	0.5	0.15	0.5	1.0	0.5	0.5	1.0
Carbon	0.15	0.3	0.015	0.15–0.25	0.05	0.05–0.12	0.01	0.01	0.15
Silicon	0.35	0.5	0.08	0.5	0.6	2.5–3.0	0.1	0.1	1.0
Sulfur	0.01	0.024	0.02	0.01	0.015	0.01	0.01	0.01	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	0.4	...	0.4	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	0.03	0.02	0.015	0.015	0.5
Tungsten	...	...	2.5–3.5	...	0.6	...	0.3	...	1.0–4.0
Cobalt	...	...	2.5	...	1.0	...	0.3	0.3	...
Vanadium	...	...	0.35	...	0.2	...	...	...	...
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	...	...	...	...	...

Element	N06200	N06210	N062169	N06230	N06603	N06617	N06625	N06600	N06674
Nickel	balance ^B	balance ^B	balance ^B	balance ^B	balance ^B	44.5min	58.0Bmin	72.0Bmin	balance ^B
Copper	1.3–1.9	...	0.5	...	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	0.5	0.5	0.5	0.30–1.00	0.15	1.0	0.5	1.0	1.5
Carbon	0.01	0.015	0.05	0.05–0.15	0.20–0.40	0.05–0.15	0.1	0.15	0.1
Silicon	0.08	0.08	0.70-1.10	0.25–0.75	0.5	1.0	0.5	0.5	1.0
Sulfur	0.01	0.02	0.01	0.015	0.01	0.015	0.015	0.015	0.015
Chromium	22.0–24.0	18.0-20.	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	0.5	...	0.5	0.5	2.4–3.0	0.8–1.5	0.4	...	...
Titanium	...	...	0.5	...	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	0.02	0.03	0.02	...	0.015	...	0.03
Tungsten	...	...	...	13.0–15.0	...	...	...	...	6.0-8.0
Cobalt	2.0	1.0	1.0	5.0	...	10.0–15.0	...	...	...
Vanadium	...	0.35	...	...	...	...	...	...	...
Nitrogen	...	...	...	...	...	...	...	...	0.02
Boron	...	...	...	0.015	...	0.006	...	...	0.0005-0.006
Lanthanum	...	...	...	0.005–0.05	...	...	...	...	...
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	...	...	...	...

Element	N06686	N06690	N08031	N08120	N08367	N08800	N08810	N08811	N08825
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	0.5	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	2.0	1.5	1.5	1.5	1.0
Carbon	0.01	0.05	0.015	0.02–0.10	0.03	0.1	0.05–0.10	0.06–0.10	0.05
Silicon	0.08	0.5	0.3	1.0	1.0	1.0	1.0	1.0	0.5
Sulfur	0.02	0.015	0.01	0.03	0.03	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	...	...	...	0.4	...	0.15–0.60	0.15–0.60	0.15–0.60	0.2
Titanium	0.02–0.25	...	...	0.2	...	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	2.5	6.00–7.00	...	...	...	2.5–3.5
Phosphorus	0.04	...	0.02	0.04	0.04	...	...	...	...
Tungsten	3.0–4.4	...	...	2.5	...	...	...	...	...
Cobalt	...	...	...	3.0	...	...	...	...	...
Vanadium	...	...	...	...	...	...	...	...	...
Nitrogen	...	...	0.15–0.25	0.15–0.30	0.18–0.25	...	...	...	...
Boron	...	...	...	0.01	...	...	...	...	...
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.

B. Mechanical Properties and Other Requirements :-

1. Mechanical Properties—The material shall conform to the mechanical properties specified in Table 2.
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 2^A

Material and Condition	Maximum Section Thickness, in.(mm)	Tensile Strength, min, ksi (MPa)	Yield Strength, 0.2% Offset, min, ksi (MPa)	Elongation in 2 in. Or 50 mm or 4D, min,%
Iron-nickel-chromium-molybdenum-nitrogen-alloy UNSN08367, solution annealed	...	95 (655)	45 (310)	30
Low-carbon-chromium-nickel-iron-nitrogen alloy UNSR20033, solution-annealed	...	109 (750)	55 (380)	40
Low-carbon-nickel-chromium-molybdenum:				
alloy UNSN06035, solution annealed	...	85 (586)	35 (241)	30
alloy UNSN06058, solution annealed	...	110 (760)	52 (360)	40
alloy UNSN06059, solution annealed	...	100 (690)	45 (310)	45
Low-carbon-nickel-chromium-molybdenum-copper alloy UNSN06200, solution annealed	...	100 (690)	45 (310)	45
Low-carbon-nickel-chromium-molybdenum-tungsten alloy UNSN06686, solution annealed	...	100 (690)	45 (310)	45
Low-carbon-nickel-iron-chromium-molybdenum-copper-alloy UNSN08031,solutionannealed	...	94 (650)	40 (276)	40
Low-carbon-nickel-chromium-molybdenum alloy UNSN10276,solutionannealed	...	100 (690)	41 (283)	40
Low-carbon-nickel-chromium molybdenum alloy UNSN06022, solution annealed	...	100 (690)	45 (310)	45
Low-carbon-nickel-molybdenum-chromium UNSN10362,solution annealed	...	105 (725)	45 (310)	40
Low-carbon-nickel-molybdenum-chromium-tantalum alloy UNSN06210,solutionannealed	...	100 (690)	45 (310)	45
Nickel alloy UNSN02200, annealed	...	55 (380)	15 (105)	40
Nickel-cobalt-chromium-silicon alloy UNSN12160,solutionannealed	...	90 (620)	35 (240)	40
Nickel-chromium-cobalt-molybdenum alloy UNSN06617,annealed	...	95 (655)	35 (241)	35
Nickel-chromium-iron alloy UNSN06600,annealed	...	80 (552)	35 (241)	30

Nickel-chromium-iron-aluminum alloy UNSN06603,annealed	...	94 (650)	43 (300)	25
Nickel-chromium-iron alloy UNSN06690,annealed	...	85 (586)	35 (241)	30
Nickel-chromium-iron-aluminum alloy UNSN06025,solution annealed	Upto 4 (102)	98 (680)	39 (270)	30
	Over 4 (102) to 12 (305)incl	84 (580)	39 (270)	15
Nickel-chromium-iron-silicon alloy UNSN06045,solutionannealed	...	90 (620)	35 (240)	35
Nickel-chromium molybdenum-columbium alloy UNSN06625, annealed	Upto 4 (102), incl	120 (827)	60 (414)	30
	Over 4 ^B (102) to 10 (254), incl	110 (758)	50 (345)	25
Nickel-chromium-molybdenum-silicon alloy UNSN06219,solution annealed	...	96 (660)	39 (270)	50
Nickel-chromium-molybdenum-tungsten alloy UNSN06110, annealed	Upto 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 UNSN06230, solution annealed ^C	...	110 (758)	45 (310)	40
Nickel-copper alloy UNSN04400, annealed	...	70 (483)	25 (172)	35
Nickel-iron-chromium alloys:				
UNSN08120,solutionannealed	...	90 (621)	40 (276)	30
UNSN08800,annealed	...	75 (517)	30 (207)	30
UNSN08810and UNSN08811, annealed	...	65 (448)	25 (172)	30
Nickel-iron-chromium-molybdenum-copper alloy UNSN08825, annealed	...	85 (586)	35 (241)	30
Nickel-iron-chromium-tungsten alloy UNSN06674, 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 UNSN10242,annealed	...	105 (725)	45 (310)	40
Nickel-molybdenum-chromium-iron	...	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.

C. Test Methods :-

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:

<u>Test</u>	<u>ASTM Designation</u>
Chemical Analysis	E350, E1473
Tension	E8
Rounding Procedure	E29
Grain Size	E112

D. Supplementary Requirements :-

1. Chemical Composition—

UNS alloy N04400 shall conform to the composition limits specified in Table 1 except as specified in Table 3.

Table 3

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

2. Mechanical Properties—

Mechanical property requirements for UNS alloy N04400 forgings in the hot finished and hot finished/high tensile conditions shall be as specified in Table 4.

Table 4

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)	80000 (552)	40000 (276)	30
Hot Finished -over 12 (305)	75000 (517)	40000 (276)	30
Hot Finished/High Tensile - Rounds 3 to 6 (76 to 152) inclusive	95000 (655)	70000 (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)	85000 (586)	60000 (414)	25

3. Non-destructive Tests—

i. Ultrasonic Tests:-

Testing shall be done by a longitudinal wave or shear wave technique.

ii. Liquid Penetrant Inspection:-

Liquid penetrant inspection shall be in accordance with MIL-STD-271.

iii. The purchaser shall specify if one or both tests are required.

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