



Designation: B 637 – 98

Standard Specification for Precipitation-Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High-Temperature Service¹

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification² covers hot- and cold-worked precipitation-hardenable nickel alloy rod, bar, forgings, and forging stock for high-temperature service (Table 1).

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in brackets are for information only.

2. Referenced Documents

2.1 ASTM Standards:

E 8 Test Methods for Tension Testing of Metallic Materials³

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁴

E 139 Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials³

E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys⁵

3. Terminology

3.1 Definitions:

3.1.1 *bar*—material of rectangular (flats), hexagonal, octagonal, or square solid section in straight lengths.

3.1.2 *rod*—material of round solid section furnished in straight lengths.

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for the safe and satisfactory performance of material ordered under this specification. Examples of such requirements include, but are not limited to, the following:

4.1.1 Alloy (Table 1).

4.1.2 Condition (temper) (Table 2).

4.1.3 *Shape*—Rod or bar (round, rectangle, square, hexagon, octagon).

4.1.3.1 Forging (sketch or drawing).

4.1.4 *Dimensions*, including length.

4.1.5 Quantity (mass or number of pieces).

4.1.6 *Forging Stock*—Specify if material is stock for reforging.

4.1.7 Finish.

4.1.8 *Certification*—State if certification is required (Section 15).

4.1.9 *Samples for Product (Check) Analysis*—Whether samples for product (check) analysis shall be furnished (9.2).

4.1.10 *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 (Section 13).

5. Chemical Composition

5.1 The material shall conform to the requirements as to chemical composition prescribed in Table 1.

5.2 If a product (check) analysis is performed by the purchaser, the material shall conform to the product (check) analysis variations prescribed in Table 1.

6. Mechanical Properties

6.1 Unless otherwise specified, the material shall be supplied in the solution treated condition, suitable for subsequent age hardening.

6.2 The solution treated material shall be capable of meeting the mechanical property requirements of Table 3, and the stress rupture requirements of Table 4, following the precipitation hardening treatment described in Table 2.

6.3 When the material is to be supplied in the solution treated plus aged condition, the requirements of Table 3 and Table 4 shall apply, with the precipitation hardening treatment of Table 2, or as agreed upon between the purchaser and the manufacturer as part of the purchase contract.

7. Dimensions and Permissible Variations

7.1 *Diameter, Thickness, or Width*—The permissible variations from the specified dimensions of cold-worked rod and bar

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² For ASME Boiler and Pressure Vessel Code applications, see related Specification SB-637 in Section II of that Code.

³ *Annual Book of ASTM Standards*, Vol 03.01.

⁴ *Annual Book of ASTM Standards*, Vol 14.02.

⁵ *Annual Book of ASTM Standards*, Vol 03.06.



TABLE 1 Chemical Requirements

Element	Composition Limits, %	Product (Check) Analysis Variations, under min or over max, of the Specified Limit of Element	
		Composition Limits, %	Product (Check) Analysis Variations, under min or over max, of the Specified Limit of Element
		UNS N07252 (Formerly Grade 689)	UNS N07001 (Formerly Grade 685)
Carbon	0.10–0.20	0.01	0.03–0.10
Manganese	0.50 max	0.03	1.00 max
Silicon	0.50 max	0.03	0.75 max
Phosphorus	0.015 max	0.005	0.030 max
Sulfur	0.015 max	0.003	0.030 max
Chromium	18.00–20.00	0.25	18.00–21.00
Cobalt	9.00–11.00	0.10 under min, 0.15 over max	12.00–15.00
Molybdenum	9.00–10.50	0.15	3.50–5.00
Titanium	2.25–2.75	0.07	2.75–3.25
Aluminum	0.75–1.25	0.10	1.20–1.60
Zirconium	0.02–0.12
Boron	0.003–0.01	0.002	0.003–0.01
Iron	5.00 max	0.07	2.00 max
Copper	0.50 max
Nickel	remainder ^A	...	remainder ^A
		UNS N07500 (Formerly Grade 684)	UNS N07750 (Formerly Grade 688)
Carbon	0.15 max	0.01	0.08 max
Manganese	0.75 max	0.03	1.00 max
Silicon	0.75 max	0.05	0.50 max
Phosphorus	0.015 max	0.005	...
Sulfur	0.015 max	0.003	0.01 max
Chromium	15.00–20.00	0.15 under min, 0.25 over max	14.00–17.00
Cobalt	13.00–20.00	0.15 under min, 0.20 over max	1.00 max ^B
Molybdenum	3.00–5.00	0.10	...
Columbium (Nb) + tantalum	0.70–1.20
Titanium	2.50–3.25	0.07	2.25–2.75
Aluminum	2.50–3.25	0.20	0.40–1.00
Boron	0.003–0.01	0.002	...
Iron	4.00 max	0.07	5.00–9.00
Copper	0.15 max	0.02	0.50 max
Nickel	remainder ^A	...	70.00 min
		UNS N07718 (Formerly Grade 718)	UNS N07080 (Formerly Grade 80A)
Carbon	0.08 max	0.01	0.10 max
Manganese	0.35 max	0.03	1.00 max
Silicon	0.35 max	0.03	1.00 max
Phosphorus	0.015 max	0.005	...
Sulphur	0.015 max	0.003	0.015 max
Chromium	17.0–21.0	0.25	18.00–21.00
Cobalt ^B	1.0 max	0.03	...
Molybdenum	2.80–3.30	0.05 under min, 0.10 over max	...
Columbium (Nb) + tantalum	4.75–5.50	0.15 under min, 0.20 over max	...
Titanium	0.65–1.15	0.04 under min, 0.05 over max	1.80–2.70
Aluminum	0.20–0.80	0.05 under min, 0.10 over max	0.50–1.80
Boron	0.006 max	0.002	...
Iron	remainder ^A	...	3.00 max
Copper	0.30 max	0.03	...
Nickel	50.0–55.0	0.35	remainder ^A
		UNS N07752	
Carbon	0.020–0.060	0.01	
Manganese	1.00 max	0.03	
Silicon	0.50 max	0.03	
Phosphorus	0.008 max	0.003	
Sulfur	0.003 max	0.001	
Chromium	14.50–17.00	0.15 under min, 0.25 over max	
Cobalt	0.050 max	0.03	
Columbium + tantalum	0.70–1.20	0.05	
Titanium	2.25–2.75	0.07	
Aluminum	0.40–1.00	0.05 under min, 0.10 over max	
Boron	0.007 max	0.002	
Iron	5.00–9.00	0.10	
Copper	0.50 max	0.03	
Zirconium	0.050 max	0.01	
Vanadium	0.10 max	0.01	
Nickel	70.0 min	0.45	

^A The element shall be determined arithmetically by difference.

^B If determined.



TABLE 2 Heat Treatment^A

Alloy	Recommended Annealing Treatment	Recommended Solution Treatment	Recommended Stabilizing Treatment	Precipitation Hardening Treatment
N07252	...	1950 ± 25°F [1066 ± 14°C], hold 4 h, air cool	...	1400 ± 25°F [760 ± 14°C], hold 15 h, air cool or furnace cool
N07001	...	1825 to 1900°F [996 to 1038°C], hold 4 h, oil or water quench	1550 ± 25°F [843 ± 14°C], hold 4 h, air cool	1400 ± 25°F [760 ± 14°C], hold 16 h, air cool or furnace cool
N07500	2150 ± 25°F [1177 ± 14°C], hold 2 h, air cool (bars only)	1975 ± 25°F [1080 ± 14°C], hold 4 h, air cool	1550 ± 25°F [843 ± 14°C], hold 24 h, air cool	1400 ± 25°F [760 ± 14°C], hold 16 h, air cool or furnace cool
N07750 Type 1 (Service above 1100°F) [593°C]	...	2100 ± 25°F [1149 ± 14°C], hold 2 to 4 h, air cool	1550 ± 25°F [843 ± 14°C], hold 24 h, air cool	1300 ± 25°F [704 ± 14°C], hold 20 h, air cool or furnace cool
N07750 Type 2 (Service up to 1100°F) [593°C]	...	1800 ± 25°F [982 ± 14°C], hold ½ h min, cool at rate equivalent to air cool or faster	...	1350 ± 25°F [732 ± 14°C], hold 8 h, furnace cool to 1150 ± 25°F [621 ± 14°C], hold until total precipitation heat treatment has reached 18 h, air cool
N07750 Type 3	...	1975 – 2050°F [1079 – 1121°C], hold 1 to 2 h, air cool	...	1300 ± 25°F [704 ± 14°C], hold 20 h, + 4 – 0 h, air cool
N07752 Type 1	...	1975 ± 25°F [1080 ± 14°C], hold 1 to 2 h, cool by water or oil quenching	...	1320 ± 25°F [715 ± 14°C], hold 20 h, + 2, – 0 h, air cool
N07752 Type 2	...	1975 ± 25°F [1080 ± 14°C], hold 1 to 2 h, cool by water or oil quenching	...	1400 ± 25°F [760 ± 14°C], hold 100 h, + 4, – 0 h, air cool
N07718	...	1700 to 1850°F [924 to 1010°C], hold ½ h min, cool at rate equivalent to air cool or faster	...	1325 ± 25°F [718 ± 14°C], hold at temperature for 8 h, furnace cool to 1150 ± 25°F [621 ± 14°C], hold until total precipitation heat treatment time has reached 18 h, air cool
N07080	...	1950 ± 25°F [1066 ± 14°C], hold 8 h, air cool	1560 ± 25°F [849 ± 14°C], hold 24 h, air cool	1290 ± 25°F [699 ± 14°C], hold 16 h, air cool

^A The purchaser shall designate on the purchase order or inquiry any partial stage of heat treatment required on material to be shipped.

shall be as prescribed in Table 5, and of hot-worked rod and bar as prescribed in Table 6.

7.1.1 *Out of Round*—Cold-worked and hot-worked rod, all sizes, in straight lengths, shall not be out-of-round by more than one half the total permissible variations in diameter shown in Table 5 and Table 6, except for hot-worked rod ½ in. [12.7 mm] and under, which may be out-of-round by the total permissible variations in diameter shown in Table 6.

7.1.2 *Corners*—Cold-worked bar shall have practically exact angles and sharp corners.

7.1.3 *Cut Lengths*—A specified length to which all rod and bar will be cut with a permissible variation of + ⅛ in. [3.18 mm], – 0 for sizes 8 in. [203 mm] and less in diameter or the distance between parallel surfaces. For larger sizes, the permissible variation shall be + ¼ in. [6.35 mm], – 0.

7.1.4 *Straightness for Cold-Worked and Hot-Worked Rod and Bar*—The maximum curvature (depth of chord) shall not exceed 0.050 in. multiplied by the length in feet [0.04 mm multiplied by the length in centimetres]. Material under ½ in. [12.7 mm] in diameter or the distance between parallel surfaces shall be reasonably straight and free of sharp bends and kinks.

7.1.5 For forgings, dimensions and tolerances shall be as specified on the order, sketch, or drawing.

7.1.6 Dimensions and tolerances for forging stock shall be as agreed upon between the purchaser and the manufacturer.

8. Workmanship, Finish, and Appearance

8.1 The material shall be uniform in quality and condition, smooth, commercially straight or flat, and free of injurious imperfections.

9. Sampling

9.1 *Lot*—Definition:

9.1.1 A lot for chemical analysis shall consist of one heat.

9.1.2 *Mechanical Properties*—A lot for tension, hardness, and stress-rupture testing shall consist of all material from the same heat, nominal diameter or thickness, or forging size, and condition (temper).

9.1.2.1 For forging stock, a lot shall consist of one heat.

9.1.2.2 Where material cannot be identified by heat, a lot shall consist of not more than 500 lb [227 kg] of material in the same size and condition (temper).

9.2 *Test Material Selection*:

9.2.1 *Chemical Analysis*—Representative samples shall be taken during pouring or subsequent processing.

9.2.1.1 *Product (Check) Analysis* shall be wholly the responsibility of the purchaser.

9.2.2 *Mechanical Properties*—Samples of the material to provide test specimens for mechanical properties shall be taken from such locations in each lot as to be representative of that lot.