RELIABLE

RELIABLE PIPES & TUBES LTD.

ISO 9001:2008
TÜVRheinland CERTIFIED
www.tuv.com ID 9105069984

OHSAS 18001:2007 CERTIFIED
ISO 9001:2008 CERTIFIED
ISO 14001:2004 CERTIFIED
PED CERT NO 01 202 IND/Q-11-0033
GOVT. RECOGNIZED EXPORT HOUSE

Manufacturer & Exporters of
Monel , Inconel , Incoloy , Hastelloy, Titanium, Stainless Steel,
High Nickel Alloys, SMO254, Super Duplex, Titanium-B2,Duplex, B5 - Round Bar,
Square Bar, Hexagon Bar, Forged Bar, Pipes & Fittings, Finned Tubes, Studded Pipes

Corp. Off. : C-16, Anand Bhuvan, 163/165, V. P. Road, Mumbai - 400 004. India. Tel. : +91 22 2389 4513 · Fax : +91 22 2389 4511
Email : sales@reliablealloys.com· Website : www.reliablealloys.com

Designation: B 637 – 03

Standard Specification for Precipitation-Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High-Temperature Service[1]

This standard is issued under the fixed designation B 637; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope

1.1 This specification[2] covers 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.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet 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:*

B 880 Specification for General Requirements for Chemical Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys[3]

E 8 Test Methods for Tension Testing of Metallic Materials[4]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[5]

E 139 Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials[4]

E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys[6]

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 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 Specification B 880.

---

[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 June 10, 2003. Published July 2003. Originally approved in 1970. Last previous edition approved in 1998 as B 637 – 98.

[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 02.04.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] *Annual Book of ASTM Standards*, Vol 03.05.

TABLE 1 Chemical Requirements

Element	Composition Limits, %	Composition Limits, %
	UNS N07252 (Formerly Grade 689)	UNS N07001 (Formerly Grade 685)
Carbon	0.10–0.20	0.03–0.10
Manganese	0.50 max	1.00 max
Silicon	0.50 max	0.75 max
Phosphorus	0.015 max	0.030 max
Sulfur	0.015 max	0.030 max
Chromium	18.00–20.00	18.00–21.00
Cobalt	9.00–11.00	12.00–15.00
Molybdenum	9.00–10.50	3.50–5.00
Titanium	2.25–2.75	2.75–3.25
Aluminum	0.75–1.25	1.20–1.60
Zirconium	...	0.02–0.12
Boron	0.003–0.01	0.003–0.01
Iron	5.00 max	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	0.08 max
Manganese	0.75 max	1.00 max
Silicon	0.75 max	0.50 max
Phosphorus	0.015 max	...
Sulfur	0.015 max	0.01 max
Chromium	15.00–20.00	14.00–17.00
Cobalt	13.00–20.00	1.00 max[B]
Molybdenum	3.00–5.00	...
Columbium (Nb) + tantalum	...	0.70–1.20
Titanium	2.50–3.25	2.25–2.75
Aluminum	2.50–3.25	0.40–1.00
Boron	0.003–0.01	...
Iron	4.00 max	5.00–9.00
Copper	0.15 max	0.50 max
Nickel	remainder[A]	70.00 min
	UNS N07718 (Formerly Grade 718)	UNS N07080 (Formerly Grade 80A)
Carbon	0.08 max	0.10 max
Manganese	0.35 max	1.00 max
Silicon	0.35 max	1.00 max
Phosphorus	0.015 max	...
Sulphur	0.015 max	0.015 max
Chromium	17.0–21.0	18.00–21.00
Cobalt[B]	1.0 max	...
Molybdenum	2.80–3.30	...
Columbium (Nb) + tantalum	4.75–5.50	...
Titanium	0.65–1.15	1.80–2.70
Aluminum	0.20–0.80	0.50–1.80
Boron	0.006 max	...
Iron	remainder[A]	3.00 max
Copper	0.30 max	...
Nickel	50.0–55.0	remainder[A]
	UNS N07752	
Carbon	0.020–0.060	
Manganese	1.00 max	
Silicon	0.50 max	
Phosphorus	0.008 max	
Sulfur	0.003 max	
Chromium	14.50–17.00	
Cobalt	0.050 max	
Columbium + tantalum	0.70–1.20	
Titanium	2.25–2.75	
Aluminum	0.40–1.00	
Boron	0.007 max	

TABLE 1 *Continued*

Element	Composition Limits, %	Composition Limits, %
Iron	5.00–9.00	
Copper	0.50 max	
Zirconium	0.050 max	
Vanadium	0.10 max	
Nickel	70.0 min	

[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.

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 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.

TABLE 3 Tensile and Hardness Requirements[A]

Alloy	Heat Treatment	Tensile Strength, min, psi [MPa]	Yield Strength (0.2 % offset), min, psi [MPa]	Elongation in 2 in. [50 mm] or 4*D*, min, %	Reduction of Area, min, %	Brinell Hardness
N07252	solution + precipitation harden	160 000 [1100]	90 000 [620]	20	18	310 min
N07001	solution + stabilize + precipitation harden	160 000 [1100]	110 000 [760]	15[B]	18[B]	310 min
N07500 (rod and bar)	anneal + solution + stabilize + precipitation harden	175 000 [120]	105 000 [725]	15	15	310 min
N07500 (forgings)	solution + stabilize + precipitation harden	170 000 [1170]	100 000 [690]	20	18	310 min
N07750 Type 1	solution at 2100°F [1149°C] + stabilize + precipitation harden	140 000 [965]	90 000 [620]	8	...	262 min
N07750 Type 2[C]	solution at 1800°F [982°C] + precipitation harden	170 000 [1170]	115 000 [790]	18	18	302 to 363
N07750 Type 2[D]	solution at 1800°F [982°C] + precipitation harden	170 000 [1170]	115 000 [790]	15 (10)[E]	15 (12)[E]	302 to 363
N07750 Type 3	solution anneal at 2000°F [1093°C] + precipitation harden	160 000 [1103], min 185 000 [1276], max	100 000 [689], min 130 000 [896], max	20	20	267–363, Bm 27–40, Rc
N07752 Type 1	solution anneal at 1975°F [1080°C] + precipitation harden	160 000 [1103], min 185 000 [1276], max	100 000 [689], min 130 000 [896], max	20	20	267 to 363, Ba 27 to 40, Rc
N07752 Type 2	solution anneal at 1975°F (1080°C) + precipitation harden	140 000 [965]	85 0000 [585]	20	20	...
N07718	solution + precipitation harden	185 000 [1275]	150 000 [1034]	12 (6)[E]	15 (8)[E]	331 min
N07080	solution + stabilize + precipitation harden	135 000 [930]	90 000 [620]	20	...	...

[A] The supplier shall demonstrate that the material will meet fully heat-treated properties after full heat treatment in accordance with Table 2.
[B] Forgings.
[C] Up to 2.50 in. [63.5 mm], exclusive.
[D] 2.50 to 4.00 in. [63.5 to 101.6 mm], exclusive.
[E] These values apply for tension specimens machined tangentially from near the center of large disk forgings over 50 in.^{2} [3225.8 mm^2] in cross section or radially from rings 3 in. [76.2 mm] or more in thickness.

TABLE 4 Stress-Rupture Requirements[A]

Alloy	Heat Treatment	Test Temperature, °F [°C]	Stress, psi [MPa][B]	Minimum Hours	Elongation in 2 in. or 50 mm (or 4*D*), min, %
N07252	solution + precipitation harden	1500 [816]	30 000 [205]	100	10
N07001	solution + stabilize + precipitation harden	1500 [816]	33 000 [230]	100	5
N07500 (rod and bar)	anneal + solution + stabilize + precipitation harden	1500 [816]	38 000 [260]	100	5
N07500 (forgings)	solution + stabilize + precipitation harden	1500 [816]	38 000 [260]	100	5
N07750 Type 1	solution at 2100°F [1149°C] + stabilize + precipitation harden	1350 [732]	45 000 [310]	100	5 (3 if hours exceed 136)
N07718	solution + precipitation harden	1200 [649]	100 000 [690]	23	5
N07080	solution + stabilize + precipitation harden	1400 [760]	47 000 [325]	23	3.5

[A] The supplier shall demonstrate that the material will meet fully heat-treated properties after full heat treatment in accordance with Table 2.
[B] Test specimens meeting minimum requirements may be overloaded to produce rupture in a reasonable and practical time period.

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.

TABLE 5 Permissible Variations in Diameter or Distance Between Parallel Surfaces of Cold-Worked Rods and Bars

Specified Dimension, in. [mm][A]	Permissible Variations from Specified Dimension, in. [mm]	
	Plus	Minus
Rods:		
1/16 to 3/16 [1.59 to 4.76], excl	0	0.002 [0.051]
3/16 to 1/2 [4.76 to 12.70], excl	0	0.003 [0.076]
1/2 to 15/16 [12.70 to 23.81], incl	0.001 [0.025]	0.002 [0.051]
Over 15/16 to 1 15/16 [23.81 to 49.2], incl	0.0015 [0.038]	0.003 [0.076]
Over 1 15/16 to 2 1/2 [49.2 to 63.5], incl	0.002 [0.051]	0.004 [0.102]
Bars:		
1/16 to 3/16 [1.59 to 4.76], excl	0	0.002 [0.051]
3/16 to 1/2 [4.76 to 12.7], excl	0	0.003 [0.076]

[A] Dimensions apply to the diameter of rods, to the distance between parallel surfaces of hexagonal, octagonal, and square bar, and separately to width and thickness of rectangular bar.

TABLE 6 Permissible Variations in Diameter or Distance Between Parallel Surfaces of Hot-Worked Rods and Bars

Specified Dimension, in. [mm][A]	Permissible Variations from Specified Dimension, in. [mm]	
	+	−
Rod and bar, hot-finished:		
1 [25.4] and under	0.016 [0.406]	0.016 [0.406]
Over 1 to 2 [25.4 to 50.8], incl	0.031 [0.787]	0.016 [0.406]
Over 2 to 4 [50.8 to 101.6], incl	0.047 [1.19]	0.031 [0.787]
Over 4 [101.6]	0.125 [3.18]	0.063 [1.60]
Rod, hot-finished and rough-turned or ground:		
Under 1 [25]	0.005 [0.13]	0.005 [0.13]
1 [25] and over	0.031 [0.79]	0

[A] Dimensions apply to the diameter of rods, to the distance between parallel surfaces of hexagonal, octagonal, and square bar, and separately to width and thickness of rectangular bar.

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.

10. Number of Tests

10.1 *Chemical Analysis*—One test per lot.

10.2 *Tension*—One test per lot.

10.3 *Hardness*—One test per lot.

10.4 *Stress-Rupture*—One test per lot.

11. Specimen Preparation

11.1 *Rod and Bar*:

11.1.1 Tension test specimens shall be taken from material in the final condition (temper) and tested in the direction of fabrication.

11.1.2 All rod and bar shall be tested in full cross-section size when possible. When a full cross-section size test cannot be performed, the largest possible round specimen shown in Test Methods E 8 shall be used. Longitudinal strip specimens shall be prepared in accordance with Test Methods E 8 for rectangular bar up to ½ in. [12.7 mm], inclusive, in thickness, which are too wide to be pulled full size.

11.1.3 Forging stock test specimens shall be taken from a forged-down coupon or a sample taken directly from stock.

11.2 *Forgings*:

11.2.1 The tension test specimen representing each lot shall be taken from a forging or from a test prolongation.

11.2.2 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.

11.2.3 The specimens shall be the largest possible round-type shown in Test Methods E 8.

11.3 Stress-rupture specimens shall be the same as tension specimens except modified as necessary for stress-rupture testing in accordance with Test Methods E 139.

12. Test Methods

12.1 Determine the chemical composition and mechanical and other properties of the material as enumerated in this specification, in case of disagreement, in accordance with the following methods:

Test	ASTM Designation
Chemical analysis	E 1473
Tension	E 8
Rounding procedure	E 29
Stress-rupture	E 139

12.2 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 in accordance with the rounding method of Practice E 29.

Test	Rounded Unit for Observed Or Calculated Value

Test	Rounded Unit for Observed Or Calculated Value
Chemical composition, tolerances (when expressed in decimals), and hardness	Nearest unit in the last right-hand place of figures of the specified limit. If two choices are possible, as when the digits dropped are exactly a 5 or a 5 followed only by zeros, choose the one ending in an even digit, with zero defined as an even digit.
Tensile strength and yield strength	Nearest 1000 psi [6.9 MPa]
Elongation	Nearest 1 %
Rupture life	1 h

13. Inspection

13.1 Inspection of the material shall be made as agreed upon between the manufacturer and the purchaser as part of the purchase contract.

14. Rejection and Rehearing

14.1 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.

15. Certification

15.1 When specified in the purchase order or contract, a producer's or supplier's certification shall be furnished to the purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

16. Product Marking

16.1 Each bundle or shipping container shall be marked with the name of the material; condition (temper); this specification number; the size; gross, tare, and net weight; consignor and consignee address; contract or order number; or such other information as may be defined in the contract or order.

17. Keywords

17.1 N07252; N07001; N07500; N07750; N07718; N07080; N07752; bar; billet