Designation: B637 – 16

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

This standard is issued under the fixed designation B637; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 This specification[2] covers hot- and cold-worked precipitation-hardenable nickel alloy rod, bar, forgings, and forging stock for moderate or high temperature service (Table 1).

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 Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E139 Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

E1473 Test Methods for Chemical Analysis of Nickel, Cobalt and High-Temperature Alloys

3. Terminology

3.1 *Definitions:*

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

3.1.2 *rod, n*—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 or cold worked) (Tables 2 and 3 and 6.1).

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.

[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-637 in Section II of that Code.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

TABLE 1 Chemical Requirements

Element	Composition Limits, %							
	UNS N07022	UNS N07208	UNS N07252 (Formerly Grade 689)	UNS N07001 (Formerly Grade 685)	UNS N07500 (Formerly Grade 684)	UNS N07740	UNS N07750 (Formerly Grade 688)	UNS N07718 (Formerly Grade 718)
Carbon	0.010 max	0.04–0.08	0.10–0.20	0.03–0.10	0.15 max	0.005–0.08	0.08 max	0.08 max
Manganese	0.5 max	0.3 max	0.50 max	1.00 max	0.75 max	1.00 max	1.00 max	0.35 max
Silicon	0.08 max	0.15 max	0.50 max	0.75 max	0.75 max	1.00 max	0.50 max	0.35 max
Phosphorus	0.025 max	0.015 max	0.015 max	0.030 max	0.015 max	0.030 max	...	0.015 max
Sulfur	0.015 max	0.015 max	0.015 max	0.030 max	0.015 max	0.030 max	0.01 max	0.015 max
Chromium	20.0–21.4	18.5–20.5	18.00–20.00	18.00–21.00	15.00–20.00	23.50–25.50	14.00–17.00	17.0–21.0
Cobalt	1.0 max	9.0–11.0	9.00–11.00	12.00–15.00	13.00–20.00	15.00–22.00	1.00 max[A]	1.0 max[A]
Molybdenum	15.5–17.4	8.0–9.0	9.00–10.50	3.50–5.00	3.00–5.00	2.00 max	...	2.80–3.30
Columbium (Nb) + tantalum	...	...	...	...	...	...	0.70–1.20	4.75–5.50
Titanium	...	1.90–2.30	2.25–2.75	2.75–3.25	2.50–3.25	0.50–2.50	2.25–2.75	0.65–1.15
Aluminum	0.5 max	1.38–1.65	0.75–1.25	1.20–1.60	2.50–3.25	0.20–2.00	0.40–1.00	0.20–0.80
Zirconium	...	0.020 max	...	0.02–0.12	...	...	...	...
Boron	0.006 max	0.003–0.010	0.003–0.01	0.003–0.01	0.003–0.01	0.0008–0.006	...	0.006 max
Iron	1.8 max	1.5 max	5.00 max	2.00 max	4.00 max	3.00 max	5.00–9.00	remainder[B]
Copper	0.5 max	0.1 max	...	0.50 max	0.15 max	0.50 max	0.50 max	0.30 max
Nickel	remainder[B]	remainder[B]	remainder[B]	remainder[B]	remainder[B]	remainder[B]	70.00 min	50.0–55.0
Tantalum	0.2 max	0.1 max	...	...	...	...	...	...
Columbium (Niobium)	...	0.2 max	...	...	...	0.50–2.50	...	...
Tungsten	0.8 max	0.5 max	...	...	...	...	...	...

	UNS N07080 (Formerly Grade 80A)	UNS N07752	UNS N09925	UNS N07725
Carbon	0.10 max	0.020–0.060	0.03 max	0.03 max
Manganese	1.00 max	1.00 max	1.0 max	0.35 max
Silicon	1.00 max	0.50 max	0.5 max	0.20 max
Phosphorus	...	0.008 max	0.03 max	0.015 max
Sulfur	0.015 max	0.003 max	0.03 max	0.010 max
Chromium	18.00–21.00	14.50–17.00	19.5–22.5	19.00–22.50
Cobalt	...	0.050 max	...	...
Molybdenum	...	...	2.5–3.5	7.00–9.50
Columbium (Nb) + tantalum	...	0.70–1.20	0.5 max (Nb only)	2.75–4.00
Titanium	1.80–2.70	2.25–2.75	1.9–2.40	1.00–1.70
Aluminum	0.50–1.80	0.40–1.00	0.1–0.5	0.35 max
Boron	...	0.007 max	...	...
Iron	3.00 max	5.00–9.00	22.0 min	remainder[B]
Copper	...	0.50 max	1.5–3.0	...
Zirconium	...	0.050 max	...	...
Vanadium	...	0.10 max	...	...
Nickel	remainder[B]	70.0 min	42.0–46.0	55.0–59.0

[A] If determined.
[B] The element shall be determined arithmetically by difference.

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 B880.

6. Mechanical Properties

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

6.2 The cold worked or solution treated material shall be capable of meeting the mechanical property requirements of Table 3, and the stress rupture requirements of Table 4 (except alloys UNS N07022, N09925 and N07725), following the precipitation hardening treatment described in Table 2.

6.3 When the material is to be supplied in the cold worked or solution treated plus aged condition, the requirements of Table 3 and Table 4 (except alloys UNS N07022, N09925 and N07725) 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.

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

TABLE 2 Heat Treatment[A]

Alloy	Recommended Annealing Treatment	Recommended Solution Treatment	Recommended Stabilizing Treatment	Precipitation Hardening Treatment
N07022[B] Type 1A or 1B	...	1800 to 2100°F (982 to 1149°C), hold ½ h/in., 5 minutes minimum, rapid air cool or water quench	...	
N07022[C] Type 2	...	1800 to 2100°F (982 to 1149°C),hold ½ h/in., 5 minutes minimum, rapid air cool or water quench	...	1125 ± 25°F (605 ± 14°C), hold 10 h, air cool[B]
N07022 Type 3	...	1800 to 2100°F (982 to 1149°C), hold ½ h/in., 5 minutes minimum, rapid air cool or water quench	...	1300 ± 25°F (705 ± 14°C), hold 16 h, furnace cool to 1125 ± 25°F (605 ± 14°C), hold 32 h, air cool
N07208	...	2000 to 2125°F (1093 to 1163°C), hold ½ h/in., 5 to 10 minutes minimum, water quench or rapid air cool	...	1850 ± 25°F (1010 ±14°C), hold 2 h, air cool, followed by 1450 ± 25°F (788 ± 14°C), hold 8 h, air cool
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
N07740	...	2010°F (1100°C) minimum, hold 1 h per in. of thickness with ½ h minimim hold, water quench or rapid air cool	...	1400 to 1500°F (760 to 815°C), hold 4 h minimum for up to 2 in. thickness + additional ½ h per each additional in. of thickness, air 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 (62 1 ± 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

TABLE 2 *Continued*

Alloy	Recommended Annealing Treatment	Recommended Solution Treatment	Recommended Stabilizing Treatment	Precipitation Hardening Treatment
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
N07725	...	1900 ± 25°F (1038 ± 14°C), hold ½ min, and 4 h max, cool at rate equivalent to air cool	...	1350 ± 25°F (732 ± 14°C), hold at temperature for 5 to 8½ h, furnace cool to 1150 ± 25°F (621 ± 14°C), hold at temperature for 5 to 8 ½ h, air cool or faster
N09925	...	1825 to 1875°F (996 to 1024°C), hold ½ min, and 4 h max, cool at rate equivalent to air cool or faster	...	1365 ± 25°F (740 ± 14°C), hold at temperature for 6 to 9 hr, furnace cool to 1150 ± 25°F (621 ± 14°C), hold until total precipitation heat treatment time has reached 18 h, air cool or faster

[A] The purchaser shall designate on the purchase order or inquiry any partial stage of heat treatment required on material to be shipped.
[B] For solution treated + cold worked material only, when specified.
[C] For solution treated + cold worked + precipitation hardened material only, when specified.

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.

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 E8 shall be used. Longitudinal strip specimens shall be prepared in accordance with Test Methods E8 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 E8.

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
N07022 Type 1A	solution + cold worked	160 000 (1103)	150 000 (1034)	17	50	382 max
N07022 Type 1B	solution + cold worked	185 000 (1276)	180 000 (1240)	13	30	425 max
N07022 Type 2	solution + cold worked + precipitation harden	178 000 (1227)	160 000 (1103)	15	24	479 max
N07022 Type 3	solution + precipitation harden	145 000 (1000)	80 000 (552)	15	14	228 min
N07208	solution + precipitation harden	150 000 (1034)	90 000 (620)	20	14	250 min
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
N07740	solution + precipitation harden	150 000 (1035)	90 000 (620)	20	18	...
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	...	...
N07725	solution + precipitation harden	150 000 (1034)	120 000 (827)	20	35	43, Rc max
N09925[F]	solution + precipitation harden	140 000 (965)	105 000 (724)	18	25	38, Rc max
N09925[G]	solution + precipitation harden	140 000 (965)	110 000 (758)	18	25	38, Rc max

[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.
[F] Cold worked, solution annealed and aged, 0.625 in. (15.9 mm) to 3 in. (76.2 mm), inclusive.
[G] Hot worked, solution annealed and aged, 1 in. (25.4 mm) or over.

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 E139.

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	E1473
Tension	E8
Rounding procedure	E29
Stress-rupture	E139

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, %
N07208	solution + precipitation harden	1700 (927)	13 000 (89)	50	10
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
N07740[A]	solution + precipitation harden	1472 (800)	41 700 (288)	23	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
N09925[A]	solution + precipitation harden	...	...	...	...
N07725[A]	solution + precipitation harden	...	...	...	...

[A] The supplier shall demonstrate that the material will meet fully heat-treated properties after full heat treatment in accordance with Table 2. Stress rupture is not required for alloys N09925 and N07725.
[B] Test specimens meeting minimum requirements may be overloaded to produce rupture in a reasonable and practical time period.

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.

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 E29.

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 bar; billet; forging; N07001; N07022; N07208; N07080; N07252; N07500; N07740; N07718; N07725; N07750; N07752; N09925

SUMMARY OF CHANGES

Committee B02 has identified the location of selected changes to this standard since the last issue (B637–15) that may impact the use of this standard. (Approved October 1, 2016.)

(1) Inclusion of UNS N07740 Bars and Forgings in the standard.

(2) The new alloy has been added to Tables 1 through 4.

Designation: B983 – 16

Standard Specification for Precipitation Hardened or Cold Worked, Seamless Nickel Alloy Pipe and Tube[1]

This standard is issued under the fixed designation B983; 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.

1. Scope*

1.1 This specification covers high strength, seamless pipe and tube of nickel alloys (UNS N07022, UNS N07725, UNS N07740, UNS N09945, UNS N09925, UNS N07718, UNS N10276, UNS N06985)[2] as shown in Table 1.

1.2 Pipe and tube shall be supplied in the cold worked or cold worked and precipitations hardened or solution annealed plus precipitation hardened and descaled conditions. When atmosphere control is used, descaling is not necessary.

1.3 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.

1.4 *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]

B829 Specification for General Requirements for Nickel and Nickel Alloys Seamless Pipe and Tube

B899 Terminology Relating to Non-ferrous Metals and Alloys

E8 Test Methods for Tension Testing of Metallic Materials

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

3. Terminology

3.1 Terms shall be defined in accordance with Terminology B899.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *average diameter, n*—See Terminology B899.

3.2.2 *pipe, n*—See Terminology B899 and Specification B829.

3.2.3 *tube, n*—See Terminology B899.

4. General Requirements

4.1 Material furnished under this specification shall conform to the applicable requirements of Specification B829 unless otherwise provided herein.

5. Ordering Information

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

5.1.1 *Alloy*—Table 1.

5.1.1.1 *Heat Treatment or Cold Work or Type* (Table 2 and Table 3.)

5.1.2 *Dimensions:*

5.1.2.1 *Tube*—Outside diameter, minimum or average wall thickness, and length.

5.1.2.2 *Pipe*—Standard pipe size and schedule (Specification B829).

5.1.3 *Ends*—Plain ends cut and deburred will be furnished.

5.1.4 *Certification*—State if certification or a report of test results is required (Section 16).

5.1.5 *Samples for Check Analysis*—State whether samples for check analysis should be furnished.

5.1.6 *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 15).

6. Chemical Composition

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

[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] New designation established in accordance with Practice 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.

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

TABLE 1 Chemical Requirements

Element	UNS N07022	UNS N07725	UNS N07740	UNS N09945	UNS N09925	UNS N07718	UNS N10276	UNS N06985
Carbon	0.010 max	0.03 max	0.005-0.08	0.005-0.04	0.03 max	0.08 max	0.02 max	0.015 max
Manganese	0.5 max	0.35 max	1.0 max	1.0 max	1.00 max	0.35 max	1.0 max	1.0 max
Silicon	0.08 max	0.20 max	1.0 max	0.5 max	0.50 max	0.35 max	0.08 max	1.0 max
Phosphorous	0.025 max	0.015 max	0.030 max	0.03 max	...	0.015 max	0.030 max	0.04 max
Sulfur	0.015 max	0.010 max	0.030 max	0.03 max	0.030 max	0.015 max	0.030 max	0.03 max
Chromium	20.0-21.4	19.0-22.5	23.5-25.5	19.5-23.0	19.5-23.5	17.0-21.0	14.5-16.5	21.0-23.5
Cobalt	1.0 max	...	15.0-22.0	...	...	1.0 max	2.5 max	5.0 max
Molybdenum	15.5-17.4	7.00-9.50	2.0 max	3.0-4.0	2.50-3.50	2.80-3.30	15.0-17.0	6.0-8.0
Columbium	...	2.75-4.00	...	2.4-4.5	0.50 max	4.75-5.50	...	...
Titanium	...	1.00-1.70	0.5-2.5	0.5-2.5	1.90-2.40	0.65-1.15	...	...
Aluminum	0.5 max	0.35 max	0.2-2.0	0.01-0.7	0.10-0.50	2.20-0.80	...	...
Zirconium	...	...	...	...	...	...	...	...
Boron	0.006 max	...	0.0006–0.006	...	...	0.006 max	...	...
Iron	1.8 max	Remainder[B]	3.0 max	Remainder[B]	22.0 min[A]	Remainder[B]	4.0-7.0	18.0-21.0
Copper	0.5 max	...	0.50 max	1.5-3.0	1.50-3.00	0.30 max	...	1.5-2.5
Nickel	Remainder[B]	55.0–59.0	Remainder[B]	45.0-55.0	38.0-46.0	50.0-55.0	Remainder[B]	Remainder[B]
Tantalum	0.2 max	...	...	...	...	...	...	...
Tungsten	0.8 max	...	...	...	...	...	3.0-4.5	1.5 max
Columbium + Tantalum	...	...	0.50–2.5	...	...	...	...	0.50 max
Vanadium	...	...	...	...	...	...	0.35 max	...

[A] Minimum: The element may be determined arithmetically by difference.
[B] Remainder: The element may be determined arithmetically by difference.

6.2 If a product (check) analysis is made by the purchaser, the material shall conform to the requirements specified in Table 1 subject to the permissible tolerances per Specification B829.

7. Mechanical Properties

7.1 Unless otherwise specified, the material shall be supplied in the cold worked (cw), or cold worked and precipitation hardened (prec hard), or solution annealed plus precipitation hardened condition as described in Table 2 and Table 3.

7.2 The mechanical properties of the material at room temperature shall conform to those shown in Table 3.

8. Hydrostatic Test or Non-Destructive Electric Test

8.1 Each pipe or tube shall be tested by the manufacturer by either hydrostatic or a non-destructive electric test in accordance with Specification B829. Hydrostatic testing at a pressure greater than 1000 psi may be performed upon agreement between the purchaser and manufacturer or at the option of the manufacturer provided that the allowable fiber stress per Specification B829 is not exceeded.

9. Weight

9.1 For calculation of mass or weight, the following densities shall be tested:

Alloy	Density	
	lb/in.^{3}	g/cm^3
UNS N07022	0.311	8.60
UNS N07725	0.300	8.31
UNS N07740	0.291	8.05
UNS N09945	0.296	8.2
UNS N09925	0.292	8.08
UNS N07718	0.296	8.19
UNS N10276	0.321	8.89
UNS N06985	0.294	8.14

10. Sampling

10.1 *Lots for Chemical Analysis and Mechanical Testing are as defined in Specification B829.*

10.2 *Sampling of Chemical Analysis:*

10.2.1 A representative sample shall be taken from each lot during pouring or subsequent processing.

10.2.2 Product (check) analysis shall be wholly the responsibility of the purchaser.

10.3 *Sampling for Mechanical Testing:*

10.3.1 A representative sample shall be taken from each lot of finished material.

11. Number of Tests and Retests

11.1 *Chemical Analysis*—One test per lot.

11.2 *Tension Test*—One test per lot.

11.3 *Retests*—If the specimen used in the mechanical test of any lot fails to meet the specified requirements, tow additional specimens shall be taken from different sample pieces and tested. The results of the tests on both of these specimens shall meet the specified requirements.

12. Specimen Preparation

12.1 Tension test specimens shall be taken from material after final heat treatment and tested in the direction of fabrication.

12.2 Whenever possible, all pipe and tube shall be tested in full tubular size. When testing in full tubular size is not possible, longitudinal strip specimens, or the largest possible round specimen prepared in accordance with Test Methods E8, shall be used.

TABLE 2 Heat Treatments

Alloy	Recommended Solution Annealing Treatment	Recommended Precipitation Hardening Treatment
UNS N07022 Type 1A or 1B	1800–2100°F (982–1149°C), hold ½ hr/in., 5 min. minimum, rapid air cool or water quench	none
UNS N07022 Type 2	1800–2100°F (982–1149°C), hold ½ hr/in., 5 min. minimum, rapid air cool or water quench	1075–1150°F (579–621°C), hold 10 h, air cool
UNS N07725 Type 1	1900 ± 25°F (1040 ± 14°C), hold 1 h per in. of thickness, water quench or rapid air/gas cool	1350 ± 25°F (730 ± 14°C), hold 8 h, furnace cool at 100°F (56°C) per min. to 1150 ± 25°F (620 ± 14°C), hold for 8 h, air cool
UNS N07725 Type 2	1900 ± 25°F (1040 ± 14°C), hold 1 h per in. of thickness, water quench or rapid air/gas cool	1350 ± 25°F (730 ± 14°C), hold 8 h, furnace cool at 100°F (56°C) per min. to 1150 ± 25°F (620 ± 14°C), hold for 8 h, air cool
UNS N07740	2012°F (1100°C), minimum, hold 1 h per in. of thickness with½ h minimum, hold, water quench or rapid air cool	1400–1500°F (760–815°C), hold 4 h minimum for up to 2 in. thickness + additional ½ h per each additional in. of thickness, air cool
UNS N09945 Type 1	1850–1950°F (1010–1066°C) hold 0.5 to 4 h, water quench	1300–1350°F (704–732°C), for 6 to 8 h, furnace cool at 50–100°F (26–56°C)/h to 1125–1175°F (607–635°C) hold 6 to 8 h, air cool
UNS N09945 Type 2	1850–1950°F (1010–1066°C) hold 0.5 to 4 h, water quench	1300–1350°F (704–732°C), for 6 to 8 h, furnace cool at 50–100°F (26–56°C)/h to 1125–1175°F (607–635°C) hold 6 to 8 h, air cool
UNS N09925	Batch Anneal 1825–1875°F (996–1024°C) hold 0.5 to 4 h, air cool or faster	1365–15°F (740–9°C) hold 6 to 9 h, furnace cool to 1150°F (621°C) for total aging time of 18 min., air cool
UNS N07718	1875 ± 25°F (1024 ± 14°C) for 1 to 2 h, water quench	1425–1475°F (774–802°C) hold 6 to 8 h, air cool
UNS N10276	2050°F (1121°C) minimum for time commensurate with thickness	none
UNS N06985	2050°F (1121°C) minimum for time commensurate with thickness	none

13. Test Methods

13.1 The chemical composition and mechanical properties of the material is as enumerated in this specification shall be determined in accordance with the methods in Specification B829.

14. Dimensions and Permissible Variations

14.1 The permissible variations for outside diameter and wall thickness of hot finished seamless tubes and pipes shall conform to Table 4 and Table 5. The tables include permissible variations for pipes and tubes over 9¼ in. outside diameter that is not available in Specification B829.

14.2 Dimensions, straightness, ovality, and permissible variations of precipitation hardened or cold worked seamless pipe and tubes shall conform to the requirements specified in Section 6 of Specification B829.

15. Inspection

15.1 Inspection of the material shall be in accordance with this specification and agreements between the manufacturer and purchaser as part of the purchase contract.

16. Certification

16.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the purchaser

TABLE 3 Mechanical Properties

Alloy	Condition[A]	Tensile Strength, min., ksi (MPa)	Yield Strength min., ksi (MPa)	Elongation in 2 in., (50 mm) or 4D[B], min, %	Hardness Rc max
UNS N07022 Type 1A	Solution Ann + cw	160 (1103)	150 (1034)	17	42
UNS N07022 Type 1B	Solution Ann + cw	185 (1276)	180 (1240)	13	46
UNS N07022 Type 2	Solution Ann + cw + prec hard	178 (1227)	160 (1103)	15	50
UNS N07725 Type 1	Solution Ann + prec hard	150 (1035)	120 (827)	20	43
UNS N07725 Type 2	Solution Ann + cw + prec hard	150 (1035)	120 (827)	20	...
UNS N07740	Solution Ann + prec hard	150 (1035)	90 (620)	20	...
UNS N09945 Type 1	Solution Ann + prec hard	150 (1035)	130 (896)	18	42
UNS N09945 Type 2	Solution Ann + prec hard	165 (1138)	140 (965)	18	42
UNS N09925	Solution Ann + prec hard	140 (965)	110 (758)	18	38
UNS N07718	Solution Ann + prec hard	150 (1034)	125 (862)	20	40
UNS N10276 Type 1	Solution Ann + cw	115 (793)	110 (758)	11	40
UNS N10276 Type 2	Solution Ann + cw	130 (896)	125 (862)	10	40
UNS N06985 Type 1	Solution Ann + cw	115 (793)	110 (758)	11	40
UNS N06985 Type 2	Solution Ann + cw	130 (896)	125 (862)	10	40

[A] See Table 2.
[B] D refers to the diameter of the tension specimen.

TABLE 4 Permissible Variations for Outside Diameter and Wall Thickness of Hot-Finished Tube[A]

Nominal Outside Diameter, in. (mm)	Outside Diameter, in. (mm)		Permissible Variations, % of Thickness of Specified Nominal Wall		% of Thickness of Specified Minimum Wall	
	Plus	Minus	Plus	Minus	Plus	Minus
¾ (19) to 1½ (38), incl	0.015 (0.4)	0.031 (0.8)	12.5	12.5	28.5	0
Over 1½ (38.1) to 4 (102), incl	0.031 (0.8)	0.031 (0.8)	12.5	12.5	28.5	0
Over 4 (102) to 9¼ (235), incl	0.062 (1.6)	0.031 (0.8)	12.5	12.5	28.5	0
Over 9¼ (235) to 12 (305), incl	0.110 (2.8)	0.110 (2.8)	12.5	12.5	...	...

[A] *Ovality*—Tube 5 in. (127 mm) and under in outside diameter, the tolerance on the outside diameter applies for individual measurements and includes ovality. Tube 5 in. (127 mm) in outside diameter, the mean outside diameter shall conform to the permissible variations of this table and individual measurements shall not exceed twice the permissible variations of this table.

TABLE 5 Permissible Variations for Outside Diameter and Wall Thickness of Seamless Hot-Worked Pipe[A,B]

Nominal Outside Diameter, in. (mm)	Outside Diameter, in. (mm)		Permissible Variations, % of Thickness of Specified Nominal Wall		% of Thickness of Specified Minimal Wall	
	Plus	Minus	Plus	Minus	Plus	Minus
1 (25) to 1.900 (48), incl	0.015 (0.40)	0.031 (0.79)	16.0	12.5	28.5	0
Over 1.900 (48) to 4½ (114), incl	0.031 (0.79)	0.031 (0.79)	16.0	12.5	28.5	0
Over 4½ (114) to 6½ (165), incl	0.047 (1.2)	0.047 (1.2)	16.0	12.5	28.5	0
Over 6½ (165) to 9¼ (235), incl	0.062 (1.6)	0.062 (1.6)	16.0	12.5	28.5	0
Over 9¼ (235) to 14 (356), incl	0.120 (30.5)	0.120 (3.05)	16.0	12.5	...	...
Over 14 (356) to 24 (610), incl	0.20 (5.08)	0.20 (5.08)	16.0	12.5	...	...

[A] *Ovality*—For pipe 5 in. (127 mm) and under in outside diameter, the tolerance on the outside diameter applies for individual measurements and includes ovality. For pipe over 5 in. (125 mm) in outside diameter, the mean outside diameter shall conform to the permissible variations of this table and individual measurements shall not exceed twice the permissible variations of this table.
[B] *Eccentricity*—The permissible variations in this table apply to individual measurements including eccentricity.

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.

17. Keywords

17.1 seamless cold worked pipe; seamless cold worked tube; seamless precipitation hardened pipe; seamless precipitation hardened tube; UNS N07022; UNS N07725; UNS N07740; UNS N09945; UNS N09925; UNS N07718; UNS N10276; UNS N06985

APPENDIX

(Nonmandatory Information)

X1. HEAT TREATMENT

X1.1 Proper heat treatment during or subsequent to fabrication is necessary for optimum performance and the manufacturer shall be consulted for details.

SUMMARY OF CHANGES

Committee B02 has identified the location of selected changes to this standard since the last issue (B983–15) that may impact the use of this standard. (Approved October 1, 2016.)

(1) The heat treatment description for UNS N07740 in Table 2 is modified to match with ASME Code case 2702 and B31 Case 190 and ASTM B637.

Committee B02 has identified the location of selected changes to this standard since the last issue (B983–13a) that may impact the use of this standard. (Approved October 1, 2015.)

(1) Added Type 1A or 1B to UNS N07022 in Table 2.
(2) Added UNS N07022 Type 1A and UNS N07022 1B to Table 3.