Designation: ~~B637 – 16~~ B637 – 18

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~~ safety, health, and ~~health~~environmental practices, and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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~~E8/E8M Test Methods for Tension Testing of Metallic Materials ~~[Metric] E0008_E0008M~~

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

E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

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).

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[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 ~~Oct. 1, 2016~~Nov. 1, 2018. Published ~~October 2016~~December 2018. Originally approved in 1970. Last previous edition addition approved in ~~2015~~2016 as B637~~–15.~~ –16. DOI: ~~10.1520/B0637-16.~~10.1520/B0637-18.

[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.

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.

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.

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.

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 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.