



Designation: B637 – 23

# Standard Specification for Precipitation-Hardening and Cold Worked Nickel Alloy Bars, Forgings, and Forging Stock for Moderate or High Temperature Service<sup>1</sup>

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 ( $\epsilon$ ) 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<sup>2</sup> 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, health, and 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:*<sup>3</sup>

**B880 Specification for General Requirements for Chemical**

<sup>1</sup> 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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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications, see related Specification SB-637 in Section II of that Code.

<sup>3</sup> 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.

**Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys**

**B899 Terminology Relating to Non-ferrous Metals and Alloys**

**E8/E8M 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**

**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 For definitions of terms used in this specification, refer to Terminology **B899**.

## 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 re-forging.

4.1.7 Finish.

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

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

**TABLE 1 Chemical Requirements<sup>A</sup>**

| Element                                    | Composition Limits, % |                  |                  |                  |                  |                  |                   |                  |
|--|-----------------------|------------------|------------------|------------------|------------------|------------------|-------------------|------------------|
|  | UNS N07022            | UNS N07208       | UNS N07252       | UNS N07001       | UNS N07500       | UNS N07740       | UNS N07750        | UNS N07718       |
| Carbon                                     | 0.010                 | 0.04–0.08        | 0.10–0.20        | 0.03–0.10        | 0.15             | 0.005–0.08       | 0.08              | 0.08             |
| Manganese                                  | 0.5                   | 0.3              | 0.50             | 1.00             | 0.75             | 1.00             | 1.00              | 0.35             |
| Silicon                                    | 0.08                  | 0.15             | 0.50             | 0.75             | 0.75             | 1.00             | 0.50              | 0.35             |
| Phosphorus                                 | 0.025                 | 0.015            | 0.015            | 0.030            | 0.015            | 0.030            | ...               | 0.015            |
| Sulfur                                     | 0.015                 | 0.015            | 0.015            | 0.030            | 0.015            | 0.030            | 0.01              | 0.015            |
| 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                   | 9.0–11.0         | 9.00–11.00       | 12.00–15.00      | 13.00–20.00      | 15.00–22.00      | 1.00 <sup>B</sup> | 1.0 <sup>B</sup> |
| Molybdenum                                 | 15.5–17.4             | 8.0–9.0          | 9.00–10.50       | 3.50–5.00        | 3.00–5.00        | 2.00             | ...               | 2.80–3.30        |
| Niobium <sup>D</sup><br>+ 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                   | 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            | ...              | 0.02–0.12        | ...              | ...              | ...               | ...              |
| Boron                                      | 0.006                 | 0.003–0.010      | 0.003–0.01       | 0.003–0.01       | 0.003–0.01       | 0.0008–0.006     | ...               | 0.006            |
| Iron                                       | 1.8                   | 1.5              | 5.00             | 2.00             | 4.00             | 3.00             | 5.00–9.00         | rem <sup>B</sup> |
| Copper                                     | 0.5                   | 0.1              | ...              | 0.50             | 0.15             | 0.50             | 0.50              | 0.30             |
| Nickel                                     | rem <sup>B</sup>      | rem <sup>B</sup> | rem <sup>C</sup> | rem <sup>B</sup> | rem <sup>B</sup> | rem <sup>B</sup> | 70.00 min         | 50.0–55.0        |
| Tantalum                                   | 0.2                   | 0.1 max          | ...              | ...              | ...              | ...              | ...               | ...              |
| Columbium<br>(Niobium)                     | ...                   | 0.2              | ...              | ...              | ...              | 0.50–2.50        | ...               | ...              |
| Tungsten                                   | 0.8                   | 0.5              | ...              | ...              | ...              | ...              | ...               | ...              |
|  | UNS N07080            | UNS N07752       | UNS N09925       | UNS N07725       |                  |                  |                   |                  |
| Carbon                                     | 0.10                  | 0.020–0.060      | 0.03             | 0.03             |                  |                  |                   |                  |
| Manganese                                  | 1.00                  | 1.00             | 1.0              | 0.35             |                  |                  |                   |                  |
| Silicon                                    | 1.00                  | 0.50             | 0.5              | 0.20             |                  |                  |                   |                  |
| Phosphorus                                 | ...                   | 0.008            | 0.03             | 0.015            |                  |                  |                   |                  |
| Sulfur                                     | 0.015                 | 0.003            | 0.03             | 0.010            |                  |                  |                   |                  |
| Chromium                                   | 18.00–21.00           | 14.50–17.00      | 19.5–22.5        | 19.00–22.50      |                  |                  |                   |                  |
| Cobalt                                     | ...                   | 0.050            | ...              | ...              |                  |                  |                   |                  |
| Molybdenum                                 | ...                   | ...              | 2.5–3.5          | 7.00–9.50        |                  |                  |                   |                  |
| Niobium <sup>D</sup><br>(Nb) +<br>Tantalum | ...                   | 0.70–1.20        | 0.5 (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             |                  |                  |                   |                  |
| Boron                                      | ...                   | 0.007            | ...              | ...              |                  |                  |                   |                  |
| Iron                                       | 3.00                  | 5.00–9.00        | 22.0 min         | rem <sup>C</sup> |                  |                  |                   |                  |
| Copper                                     | ...                   | 0.50             | 1.5–3.0          | ...              |                  |                  |                   |                  |
| Zirconium                                  | ...                   | 0.050            | ...              | ...              |                  |                  |                   |                  |
| Vanadium                                   | ...                   | 0.10             | ...              | ...              |                  |                  |                   |                  |
| Nickel                                     | rem <sup>C</sup>      | 70.0 min         | 42.0–46.0        | 55.0–59.0        |                  |                  |                   |                  |

<sup>A</sup> Values in the table are maximums, unless a range or a minimum is indicated.

<sup>B</sup> If determined.

<sup>C</sup> Iron or nickel shall be determined arithmetically by difference, "rem" means remainder.

<sup>D</sup> Columbium and Niobium are interchangeable names for the same element and both names are acceptable for use in B02.07 specifications.

4.1.9 *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.

## 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