



Designation: B639 – 02 (Reapproved 2013)

# Standard Specification for Precipitation Hardening Cobalt-Containing Alloys (UNS R30155 and UNS R30816) Rod, Bar, Forgings, and Forging Stock for High-Temperature Service<sup>1</sup>

This standard is issued under the fixed designation B639; 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.

## 1. Scope

1.1 This specification covers hot- and cold-worked precipitation hardenable cobalt-containing alloys (UNS R30155 and UNS R30816) rod, bar, forgings, and forging stock for high-temperature service.

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 Material Safety Data Sheet (MSDS) 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:*<sup>2</sup>

**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,

<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.

\* New designation established in accordance with Practices E527 and SAE J1086. Practice for Numbering Metals and Alloys (UNS).

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

## Cobalt, and High-Temperature Alloys

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

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 Name or UNS Number* (see **Table 1**).

4.1.2 *ASTM Designation*, including year of issue.

4.1.3 *Condition* (temper) (**Table 4**).

4.1.4 *Section*—Rod or bar (round, rectangle, square, hexagon, octagon).

4.1.4.1 *Forging* (sketch or drawing).

4.1.5 *Dimensions*, including length.

4.1.6 *Quantity* (mass or number of pieces).

4.1.7 *Forging stock*—Specify if material is stock for reforging.

4.1.8 *Finish*.

4.1.9 *Certification*—State if certification or a report of test results is required (**Section 15**).

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

4.1.11 *Purchaser Inspection*—If the purchaser wishes to witness the 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 chemical composition limits specified 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 per Specification **B880**.



TABLE 1 Chemical Requirements

Element	Composition Limits, %	
	UNS R30155 (Formerly Grade 661)	UNS R30816 (Formerly Grade 671)
Carbon	0.08 to 0.16	0.32 to 0.42
Manganese	1.00 to 2.00	1.00 to 2.00
Silicon	1.00 max	1.00 max
Phosphorus	0.040 max	0.040 max
Sulfur	0.030 max	0.030 max
Chromium	20.00 to 22.50	19.00 to 21.00
Nickel	19.00 to 21.00	19.00 to 21.00
Molybdenum	2.50 to 3.50	3.50 to 4.50
Tungsten	2.00 to 3.00	3.50 to 4.50
Columbium + tantalum	0.75 to 1.25	3.50 to 4.50
Iron	remainder <sup>A</sup>	5.00 max
Cobalt	18.50 to 21.00	40.00 min
Nitrogen	0.20 max	...

<sup>A</sup> Element shall be determined arithmetically by difference.

TABLE 2 Tensile and Hardness Requirements<sup>A</sup>

Alloy	Heat Treatment	Tensile Strength, min, psi (MPa)	Yield Strength (0.2 % offset), min, psi (MPa)	Elongation in 2 in. or 50.8 mm or 4 D, min, %	Reduction of Area, min, %	Brinell Hardness, min
R30155	solution + precipitation harden	110 000 (760)	50 000 (345)	30	30	192
R30816	solution + precipitation harden	130 000 (895)	60 000 (415)	20	20	248

<sup>A</sup> The supplier shall demonstrate that the material will meet fully heat-treated properties after full heat treatment in accordance with Table 4.

TABLE 3 Stress-Rupture Requirements<sup>A</sup>

Alloy	Heat Treatment	Test Temperature, °F (°C)	Stress, psi (MPa) <sup>B</sup>	Minimum, h	Elongation in 2 in. or 50.8 mm, or 4D, min, %
R30155	solution + precipitation harden	1350 (732)	24 000 (165)	100	10
R30816	solution + precipitation harden	1350 (732)	38 000 (260)	100	8

<sup>A</sup> The supplier shall demonstrate that material will meet fully heat-treated properties after full heat treatment in accordance with Table 4.

<sup>B</sup> Test specimens meeting minimum requirements may be overloaded to produce rupture in a reasonable and practical time period.

TABLE 4 Heat Treatment<sup>A</sup>

Alloy	Recommended Solution Treatment	Precipitation Hardening Treatment
R30155	2125 to 2175°F (1162 to 1190°C) hold 30 min, minimum, water quench	1475 to 1525°F (801 to 829°C) hold 4 h, air cool or furnace cool
R30816	2130 to 2170°F (1165 to 1187°C), hold 1 h, water quench	1390 to 1410°F (754 to 765°C) hold 12 h, air cool or furnace cool

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

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

Specified Dimension, in. (mm) <sup>A</sup>	Permissible Variations from Specified Dimension, in. (mm)	
	+	-
<b>Rods:</b>		
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 1 5/16 (12.70 to 23.81), incl	0.001 (0.025)	0.002 (0.051)
Over 1 5/16 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)
<b>Bars:</b>		
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)

<sup>A</sup> Dimensions apply to the diameter of rods, to the distance between parallel surfaces of hexagonal, octagonal, and square bar, and separately to the width and thickness of rectangular bar.

## 6. Mechanical Requirements

6.1 *Tensile and Hardness Requirements*—The material shall conform to the requirements for tensile and hardness properties in Table 2.

6.2 *Stress-Rupture Requirements*—The material shall conform to the requirements for stress-rupture properties in Table 3.

## 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 1/2 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.