



Designation: B 639 – 97

Standard Specification for Precipitation Hardening Cobalt-Containing Alloys (UNS R30155 and UNS R30816) Rod, Bar, Forgings, and Forging Stock for High-Temperature Service¹

This standard is issued under the fixed designation B 639; 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 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 the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 ASTM Standards:

E 8 Test Methods for Tension Testing of Metallic Materials²

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications³

E 38 Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys⁴

E 139 Practice for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials²

E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys⁵

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

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 the safe and satisfactory

performance of 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. Table 2/3

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 in Table 1.

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

¹ This specification is under the jurisdiction of ASTM Committee B-2 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 E 527 and SAE J1086. Practice for Numbering Metals and Alloys (UNS).

Current edition approved Apr. 10, 1997. Published February 1998. Originally published as A 639 – 70. Redesignated B 639 in 1980. Last previous edition B 639 – 92.

² *Annual Book of ASTM Standards*, Vol 03.01.

³ *Annual Book of ASTM Standards*, Vol 14.02.

⁴ Discontinued—See 1989 *Annual Book of ASTM Standards*, Vol 03.05.

⁵ *Annual Book of ASTM Standards*, Vol 03.06.



TABLE 1 Chemical Requirements

Element	Composition Limits, %	Product (Check) Analysis Variations, under min or over max, of the Specified Limit of Element	Composition Limits, %	Product (Check) Analysis Variations, under min or over max, of the Specified Limit of Element
		UNS R30155 (Formerly Grade 661)		UNS R30816 (Formerly Grade 671)
Carbon	0.08 to 0.16	0.01	0.32 to 0.42	0.02
Manganese	1.00 to 2.00	0.03 under min—0.04 over max	1.00 to 2.00	0.03 under min—0.04 over max
Silicon	1.00 max	0.05	1.00 max	0.05
Phosphorus	0.040 max	0.005	0.040 max	0.005
Sulfur	0.030 max	0.005	0.030 max	0.005
Chromium	20.00 to 22.50	0.25	19.00 to 21.00	0.25
Nickel	19.00 to 21.00	0.20 under min—0.25 over max	19.00 to 21.00	0.20 under min—0.25 over max
Molybdenum	2.50 to 3.50	0.05 under min—0.10 over max	3.50 to 4.50	0.10
Tungsten	2.00 to 3.00	0.10	3.50 to 4.50	0.15
Columbium + tantalum	0.75 to 1.25	0.05	3.50 to 4.50	0.15
Iron	remainder ^A		5.00 max	0.07
Cobalt	18.50 to 21.00	0.20 under min—0.25 over max	40.00 min	0.50
Nitrogen	0.20 max	0.01

^AElement shall be determined arithmetically by difference.

TABLE 2 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. or 50.8 mm or 4D, 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

^AThe 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^A

Alloy	Heat Treatment	Test Temperature, °F (°C)	Stress, psi (MPa) ^B	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

^AThe supplier shall demonstrate that material will meet fully heat-treated properties after full heat treatment in accordance with Table 4.

^BTest specimens meeting minimum requirements may be overloaded to produce rupture in a reasonable and practical time period.

TABLE 4 Heat Treatment^A

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

^AThe purchaser shall designate on the purchase order or inquiry any partial stage of heat treatment required on the material to be shipped.

shall be as prescribed in Table 5, and of hot-worked rod and bar

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

Specified Dimension, in. (mm) ^A	Permissible Variations from Specified Dimension, in. (mm)	
	+	-
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 1/16 (23.81 to 49.2), incl	0.0015 (0.038)	0.003 (0.076)
Over 1 1/16 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)

^ADimensions 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.

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.

7.1.3 Cut Lengths—A specified length to which all rod and bar will be cut with a permissible variation of + 1/8 in. (3.18 mm), - 0 for sizes 8 in. (203 mm) and less in diameter or distance between parallel surfaces. For larger sizes, the permissible variation shall be + 1/8 in. (6.35 mm), - 0.

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 (0.41)	0.016 (0.41)
Over 1 to 2 (25.4 to 50.8), incl	0.031 (0.79)	0.016 (0.41)
Over 2 to 4 (50.8 to 101.6), incl	0.047 (1.19)	0.031 (0.79)
Over 4 (101.6)	0.125 (3.18)	0.063 (1.60)
Rod, hot-finished and rough-turned or ground:		
Under 1 (25.4)	0.005 (0.13)	0.005 (0.13)
1 (25.4) and over	0.031 (0.79)	0