Designation: B 160 – 99

Standard Specification for Nickel Rod and Bar[1]

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1. Scope

1.1 This specification[2] covers nickel (UNS N02200)* and low carbon nickel (UNS N02201)* in the form of hot-worked and cold-worked rod and bar in the conditions shown in Table 1.

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:*

B 162 Specification for Nickel Plate, Sheet, and Strip[3]

B 880 General Requirements for Chemical Check Analysis of Nickel, Nickel Alloys, and Cobalt Alloys[3]

E 8 Test Methods for Tension Testing of Metallic Materials[4]

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials[4]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[5]

E 39 Test Methods for Chemical Analysis of Nickel[6]

E 140 Hardness Conversion Tables for Metals[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *bar*—material of rectangular (flats), hexagonal, or square solid section up to and including 10 in. (254 mm) in width and ⅛ in. (3.2 mm) and over in thickness in straight lengths.

NOTE 1—Hot-worked rectangular bar in widths 10 in. (254 mm) and under may be furnished as hot-rolled plate with sheared or cut edges in accordance with Specification B 162, provided the mechanical property requirements of Specification B 160 are met.

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 ASTM designation and year of issue.

4.1.2 UNS number.

4.1.3 *Section*—Rod (round) or bar (square, hexagonal, or rectangular).

4.1.4 *Dimensions*—Dimensions including length.

4.1.5 Condition.

4.1.6 Finish.

4.1.7 *Quantity*—feet or number of pieces.

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

4.1.9 *Samples for Product (Check) Analysis*—State whether samples for product (check) analysis should be furnished.

4.1.10 *Purchaser Inspection*—If purchaser wishes to witness tests or inspection of material at place of manufacture, the purchase order must so state indicating which test or inspections are to be witnessed.

5. Chemical Composition

5.1 The material shall conform to the composition limits specified in Table 2.

5.2 If a product (check) analysis is performed by the purchaser, the material shall be done per ASTM B 880 and the material shall conform to the product (check) analysis variations defined in Table 1 of ASTM B 880.

6. Mechanical and Other Requirements

6.1 *Mechanical Properties*—The material shall conform to the mechanical properties specified in Table 1.

7. Dimensions and Permissible Variations

7.1 *Diameter, Thickness, or Width*—The permissible variations from the specified dimensions as measured on the diameter or between parallel surfaces of cold-worked rod and

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SB-160 in Section II of that Code.

* New designations established in accordance with ASTM E527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

[3] *Annual Book of ASTM Standards*, Vol 02.04.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] *Annual Book of ASTM Standards*, Vol 03.05.

TABLE 1 Mechanical Properties

Condition and Diameter or Distance Between Parallel Surfaces, in. (mm)	Tensile Strength, min, psi (MPa)	Yield Strength (0.2 % offset), min. psi (MPa)[A]	Elongation in 2 in. or 50 mm or 4*D*,min %
Nickel (UNS N02200)			
Cold-worked (as worked):			
Rounds, 1 (25.4) and under	80 000 (550)	60 000 (415)	10[B]
Rounds over 1 to 4 (25.4 to 101.6) incl.	75 000 (515)	50 000 (345)	15
Squares, hexagons, and rectangles, all sizes	65 000 (450)	40 000 (275)	25[B]
Hot-worked:			
All sections, all sizes	60 000 (415)	15 000 (105)	35[C]
Rings and disks[D]	—	—	—
Annealed:			
Rods and bars, all sizes	55 000 (380)	15 000 (105)	40[B]
Rings and disks[E]	—	—	—
Forging quality			
All sizes	[F]	[F]	[F]
Low-Carbon Nickel (UNS N02201)			
Hot-worked:			
All sections, all sizes	50 000 (345)	10 000 (70)	40[C]
Annealed:			
All products, all sizes	50 000 (345)	10 000 (70)	40[B]

[A] See 12.2.
[B] Not applicable to diameters or cross sections under 3⁄32 in. (2.4 mm).
[C] For hot-worked flats 5⁄16 in. (7.9 mm) and under in thickness the elongation shall be 25%, min.
[D] Hardness B45 to B80, or equivalent.
[E] Hardness B45 to B70 or equivalent.
[F] Forging quality is furnished to chemical requirements and surface inspection only. No tensile properties are required.

TABLE 2 Chemical Requirements

Element	Composition Limits, %: Nickel (UNS N02200)	Composition Limits, %: Low-Carbon Nickel (UNS N02201)
Nickel, min[A]	99.0	99.0
Copper, max	0.25	0.25
Iron, max	0.40	0.40
Manganese, max	0.35	0.35
Carbon, max	0.15	—
Carbon, max	—	0.02
Silicon, max	0.35	0.35
Sulfur, max	0.01	0.01

[A] Element shall be determined arithmetically by difference.

bar shall be as prescribed in Table 3, and of hot-worked rod and bar as prescribed in Table 4.

7.2 *Out-of-Round*— Hot-worked rods and cold-worked rods (except "forging quality"), all sizes, in straight lengths, shall not be out-of-round by more than one half the total permissible variations in diameter shown in Tables 3 and 4, except for hot-worked rods ½ in. (12.7 mm) in diameter and under, which may be out-of-round by the total permissible variations in diameter shown in Table 4.

7.3 *Corners*—Cold-worked bars will have practically exact angles and sharp corners.

7.4 *Machining Allowances for Hot-Worked Materials*— When the surfaces of hot-worked products are to be machined, the allowances prescribed in Table 5 are recommended for normal machining operations.

7.5 *Length*—The permissible variations in length of cold-worked and hot-worked rod and bar shall be as prescribed in Table 6.

7.5.1 Rods and bars ordered to random or nominal lengths will be furnished with either cropped or saw-cut ends; material ordered to cut lengths will be furnished with square saw-cut or machined ends.

TABLE 3 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): +	−
Rounds:		
1⁄16 (1.6) to 3⁄16 (4.8), excl	0	0.002 (0.05)
3⁄16 (4.8) to ½ (12.7), excl	0	0.003 (0.08)
½ (12.7) to 15⁄16 (23.8), incl	0.001 (0.03)	0.002 (0.05)
Over 15⁄16 (23.8) to 1 15⁄16 (49.2), incl	0.0015 (0.04)	0.003 (0.08)
Over 1 15⁄16 (49.2) to 2½ (63.5), incl	0.002 (0.05)	0.004 (0.10)
Over 2½ (63.5) to 3 (76.2), incl	0.0025 (0.06)	0.005 (0.13)
Over 3 (76.2) to 3 (88.9), incl	0.003 (0.08)	0.006 (0.15)
Over 3½ (88.9) to 4 (101.6), incl	0.0035 (0.09)	0.007 (0.18)
Hexagons, squares, rectangles:		
½ (12.7) and less	0	0.004 (0.10)
Over ½ (12.7) to 7⁄8 (22.2), incl	0	0.005 (0.13)
Over 7⁄8 (22.2) to 1¼ (31.8), incl	0	0.007 (0.18)
Over 1¼ (31.8) to 2¼ (57.2), incl	0	0.009 (0.23)
Over 2¼ (57.2) to 3 (76.2), incl	0	0.011 (0.28)
Over 3 (76.2) to 3½ (88.9), incl	0	0.015 (0.38)
Over 3½ (88.9) to 4 (101.6), incl	0	0.017 (0.43)

[A] Dimensions apply to diameter of rounds, to distance between parallel surfaces of hexagons and squares, and separately to width and thickness of rectangles.

7.6 *Straightness*:

7.6.1 The permissible variations in straightness of cold-worked rod and bar as determined by the departure from straightness shall be as prescribed in Table 7.

7.6.2 The permissible variations in straightness of precision straightened cold-worked rod as determined by the departure from straightness shall be as prescribed in Table 8.

7.6.2.1 In determining straightness in the standard 42-in. (1.07-m) distance between supports or, when specified, in determining straightness in lengths not in excess of those shown in Table 8, the rod shall be placed on a precision table equipped with ballbearing rollers and a micrometer or dial indicator. The rod shall then be rotated slowly against the

TABLE 4 Permissible Variations in Diameter or Distance Between Parallel Surfaces of Hot-Worked Rod and Bar

Specified Dimension, in. (mm)[A]	Permissible Variations from Specified Dimensions, in. (mm)	
	+	−
Rod and bar, hot-worked:		
1 (25.4) and under	0.016 (0.41)	0.016 (0.41)
Over 1 (25.4) to 2 (50.8), incl	0.031 (0.79)	0.016 (0.41)
Over 2 (50.8) to 4 (101.6), incl	0.047 (1.19)	0.031 (0.79)
Over 4 (101.6)	0.125 (3.18)	0.063 (1.60)
Rod, rough-turned or rough-ground:		
Under 1 (25.4)	0.005 (0.13)	0.005 (0.13)
1 (25.4) and over	0.031 (0.79)	0
Forging quality rod:[B]		
Under 1 (25.4)	0.005 (0.13)	0.005 (0.13)
1 (25.4) and over	0.031 (0.79)	0

[A] Dimensions apply to diameter of rods, to distance between parallel surfaces of hexagons and squares, and separately to width and thickness of rectangles.
[B] Spot grinding is permitted to remove minor surface imperfections. The depth of these spot ground areas shall not exceed 3 % of the diameter of the rod.

indicator, and the deviation from straightness in any portion of the rod between the supports shall not exceed the permissible variations prescribed in Table 8. The deviation from straightness (throw in one revolution) is defined as the difference between the maximum and minimum readings of the dial indicator in one complete revolution of the rod.

7.6.3 The permissible variations in straightness of hot-worked rod and bar as determined by the departure from straightness shall be as specified in Table 9.

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:*

9.2 A lot for chemical analysis shall consist of one heat.

9.2.1 A lot for mechanical properties testing shall consist of all material from the same heat, nominal diameter of thickness, and condition.

9.2.1.1 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.

9.3 *Test Material Selection*:

9.3.1 *Chemical Analysis*—Representative samples from each lot shall be taken during pouring or subsequent processing.

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

9.3.2 *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.

11. Specimen Preparation

11.1 Tension test specimens shall be taken from material in the final condition and tested in the direction of fabrication.

11.1.1 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 E 8 shall be used. Longitudinal strip specimens shall be prepared in accordance with Test Methods E 8 for rectangular bar up to ½ in. (12.7 mm), inclusive, in thicknesses that are too wide to be pulled full size.

11.2 Hardness test specimens shall be taken from material in the final condition.

11.3 In order that the hardness determinations may be in reasonable close agreement, the following procedure is suggested:

11.3.1 For rod, under ½ in. (12.7 mm) in diameter, hardness readings shall be taken on a flat surface prepared by filing or grinding approximately 1⁄16 in. (1.6 mm) from the outside surface of the rod.

11.3.2 For rod, ½ in. (12.7 mm) in diameter and larger, and for hexagonal, square, and rectangular bar, all sizes, hardness readings shall be taken on a cross section midway between the surface and center of the section.

12. Test Methods

12.1 The chemical composition, mechanical, and other properties of the material as enumerated in this specification shall be determined, in case of disagreement, in accordance with the following methods:

Test	ASTM Designation
Chemical Analysis	E 39
Tension	E 8
Rockwell Hardness	E 18
Hardness Conversion	E 140
Rounding Procedure	E 29

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 as indicated below, in accordance with the rounding method of Practice E 29:

Test	Rounded Unit for Observed Or Calculated Value
Chemical composition, hardness, and tolerances (when expressed in decimals)	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 %

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 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