



Designation: B160 – 05 (Reapproved 2019)

Standard Specification for Nickel Rod and Bar ¹

This standard is issued under the fixed designation B160; 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 specification² covers nickel (UNS N02200),³ low-carbon nickel (UNS N02201),³ and solution-strengthened nickel (UNS N02211) 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 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 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:⁴

[B162 Specification for Nickel Plate, Sheet, and Strip](#) [B880 Specification for General Requirements for Chemical](#)

[Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys](#)

[E8/E8M Test Methods for Tension Testing of Metallic Materials](#)

[E18 Test Methods for Rockwell Hardness of Metallic Materials](#)

[E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications](#)

[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 of Terms Specific to This Standard:

3.1.1 *bar, n*—material of rectangular (flats), hexagonal, or square solid section up to and including 10 in. (254 mm) in width and $\frac{1}{8}$ 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 [B162](#), provided the mechanical property requirements of Specification B160 are met.

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 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.

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.

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

³ New designations established in accordance with ASTM E527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

⁴ 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.



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 4D, 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) and Solution Strengthened Nickel (UNS N02211)			
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.

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 Specification B880 and the material shall conform to the product (check) analysis variations defined in Check Analysis Variation table of Specification B880.

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

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 1/2 (12.7), excl	0	0.003 (0.08)
1/2 (12.7) to 15/16 (23.8), incl	0.001 (0.03)	0.002 (0.05)
Over 15/16 (23.8) to 1 1/16 (49.2), incl	0.0015 (0.04)	0.003 (0.08)
Over 1 1/16 (49.2) to 2 1/2 (63.5), incl	0.002 (0.05)	0.004 (0.10)
Over 2 1/2 (63.5) to 3 (76.2), incl	0.0025 (0.06)	0.005 (0.13)
Over 3 (76.2) to 3 1/2 (88.9), incl	0.003 (0.08)	0.006 (0.15)
Over 3 1/2 (88.9) to 4 (101.6), incl	0.0035 (0.09)	0.007 (0.18)
Hexagons, squares, rectangles:		
1/2 (12.7) and less	0	0.004 (0.10)
Over 1/2 (12.7) to 7/8 (22.2), incl	0	0.005 (0.13)
Over 7/8 (22.2) to 1 1/4 (31.8), incl	0	0.007 (0.18)
Over 1 1/4 (31.8) to 2 1/4 (57.2), incl	0	0.009 (0.23)
Over 2 1/4 (57.2) to 3 (76.2), incl	0	0.011 (0.28)
Over 3 (76.2) to 3 1/2 (88.9), incl	0	0.015 (0.38)
Over 3 1/2 (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.

TABLE 2 Chemical Requirements

Element	Composition Limits, %		
	Nickel (UNS N02200)	Low-Carbon Nickel (UNS N02201)	Solution-Strengthened Nickel (UNS N02211)
Nickel, min ^A	99.0	99.0	93.7
Copper, max	0.25	0.25	0.25
Iron, max	0.40	0.40	0.75
Manganese, max	0.35	0.35	4.25 – 5.25
Carbon, max	0.15†	0.02	0.20†
Silicon, max	0.35	0.35	0.15
Sulfur, max	0.01	0.01	0.015

^A Element shall be determined arithmetically by difference.

† Carbon max value for UNS N02200 was corrected editorially. † Carbon max value for UNS N02211 was corrected editorially.

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 1/2 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.

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

Specified Dimension, in. (mm)	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.

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.

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 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 or 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 **E8/E8M** shall be used. Longitudinal strip specimens shall be prepared in accordance with Test Methods **E8/E8M** 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 reasonably 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 ⅓ 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	E1473
Tension	E8/E8M
Rockwell Hardness	E18
Hardness Conversion	E140
Rounding Procedure	E29

TABLE 5 Normal Machining Allowances for Hot-worked Material

Finished-Machined Dimensions for Finishes as Indicated Below, in. (mm) ^A	Normal Machining Allowance, in. (mm)			
	On Diameter, for Rods	Distance Between Parallel Surface, for Hexagonal and Square Bar	For Rectangular Bar	
			On Thickness	On Width
Hot-worked: ^B				
Up to 7/8 (22.2), incl	1/8 (3.2)	1/8 (3.2)	1/8 (3.2)	3/16 (4.8)
Over 7/8 to 1 1/8 (22.2 to 47.6), incl	1/8 (3.2)	3/16 (4.8)	1/8 (3.2)	3/16 (4.8)
Over 1 1/8 to 2 1/8 (47.6 to 73.0), incl	3/16 (4.8)	1/4 (6.4)	—	3/16 (4.8)
Over 2 1/8 to 3 1/16 (73.0 to 96.8), incl	1/4 (6.4)	—	—	3/16 (4.8)
Over 3 1/16 (96.8) ^C	1/4 (6.4)	—	—	3/8 (9.5)
Hot-worked rods:				
Rough-turned or Rough-ground: ^C				
1 5/16 to 4 (23.8 to 101.6), incl in diameter	1/16 (1.6)	—	—	—
Over 4 to 12 (101.6 to 304.8), incl in diameter	1/8 (3.2)	—	—	—

^A Dimensions apply to diameter of rods, to distance between parallel surfaces of hexagonal and square bar, and separately to width and thickness of rectangular bar. The allowances for hot-worked material in Table 5 are recommended for rods machined in lengths of 3 ft (0.91 m) or less and for bars machined in lengths of 2 ft (0.61 m) or less. Hot-worked material to be machined longer lengths should be specified showing the finished cross-sectional dimension and the length in which the material will be machined in order that the manufacturer may supply material with sufficient oversize, including allowance for out-of-straightness.

^B Applicable to 3 ft (0.91 m) max length.

TABLE 6 Permissible Variations in Length of Rods and Bars

Random mill lengths:	
Hot-worked	6 to 24 ft (1.83 to 7.31 m) long with not more than 25 weight % between 6 and 9 ft (1.83 and 2.74 m). ^A
Cold-worked	6 to 20 ft (1.83 to 6.1 m) long with not more than 25 weight % between 6 and 10 ft (1.83 and 3.05 m). Furnished in multiples of a specified unit length, within the length limits indicated above. For each multiple, an allowance of 1/4 in. (6.4 mm) will be made for cutting, unless otherwise specified. At the manufacturer's option, individual specified unit lengths may be furnished.
Multiple lengths	
Nominal lengths	Specified nominal lengths having a range of not less than 2 ft (610 mm) with no short lengths allowed. ^B
Cut lengths	A specified length to which all rods and bars will be cut with a permissible variation of + 1/8 in. (3.2 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 + 1/4 in. (6.4 mm), - 0. ¹

^A For hot-worked sections weighing over 25 lb/ft (37 kg/m) and for smooth forged products, all sections, short lengths down to 2 ft (610 mm) may be furnished.

^B For cold-worked rods and bars under 1/2 in. (12.7 mm) in diameter or distance between parallel surfaces ordered to nominal or stock lengths with a 2-ft (610 mm) range, at least 93 % of such material shall be within the range specified; the balance may be in shorter lengths but in no case shall lengths less than 4 ft (1220 mm) be furnished.

TABLE 7 Permissible Variations in Straightness Of Cold-Worked Rods And Bars

Specified Diameter or Distance Between Parallel Surfaces, in. (mm) ^A	Permissible Variations in Lengths Indicated, in. (mm)
Rounds:	Depth of Chord:
1/2 (12.7) to 4 (101.6), incl	0.030 (0.76) per ft (305 mm) of length
Hexagons, squares, rectangles:	
1/2 (12.7) to 4 (101.6), incl	0.030 (0.76) per ft (305 mm) of length

^A Material under 1/2 in. (12.7 mm) shall be reasonably straight and free of sharp bends and kinks.

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 E29:

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 dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

TABLE 8 Permissible Variations in Straightness of Precision-Straightened, Cold-Worked Nickel (UNS N02200) Shafting

Specified Diameter of Shafting, in.	Standard Distance Between Supports	Permissible Variations (Throw in One Revolution) from Straightness, in.
1/2 to 15/16, incl	42 in.	0.005
Over 15/16 to 1 5/16, incl	42 in.	0.006
Over 1 5/16 to 2 1/2, incl	42 in.	0.007
Over 2 1/2 to 4, incl	42 in.	0.008
3/4 to 15/16, incl	Specified lengths of 3 to 10 ft	0.004 + 0.0025 for each foot or fraction thereof in excess of 3 ft.
Over 15/16 to 4, incl	Specified lengths of 20 ft and less	0.005 + 0.0015 for each foot or fraction thereof in excess of 3 ft.

Specified Diameter of Shafting, mm	Standard Distance Between Supports	Permissible Variations (Throw in One Revolution) from Straightness, mm
12.7 to 23.8 incl	1067 mm	0.13
Over 23.8 to 49.2, incl	1067 mm	0.15
Over 49.2 to 63.5, incl	1067 mm	0.18
Over 63.5 to 101.6, incl	1067 mm	0.20
19.1 to 23.8 incl Over	specified lengths of 914 to 3050 mm	10.2 + 0.2 for each metre or fraction thereof in excess of 914 mm
23.8 to 101.6, incl	specified lengths of 6100 mm and less	0.13 for each metre or fraction thereof in excess of 914 mm

TABLE 9 Permissible Variations in Straightness of Hot-Worked Rods and Bars^A

Finish	Permissible Variations, in./ft. (mm/m) ^B
Rods and bars, hot-worked	0.050 (4.2) ^C
Rounds—hot-worked, rough-ground, or rough-turned	0.050 (4.2) ^C

^A Not applicable to forging quality.

^B Material under 1/2 in. (12.7 mm) shall be reasonably straight and free of sharp bends and kinks.

^C The maximum curvature (depth of chord) shall not exceed the values indicated multiplied by the length in feet.

15. Certification

15.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the purchaser stating that material has been manufactured, tested, and inspected in accordance with this specification, and that the test results on representative samples meet specification requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

16. Product Marking

16.1 The following information shall be marked on the material or included on the package, or on a label or tag

attached thereto: the name of the material or UNS Number, heat number, condition (temper), ASTM Specification B160, the size, gross, tare, and net weight, consignor and consignee address, contract or order number, or such other information as may be defined in the contract or order.

17. Keywords

17.1 bar; rod; N02200; N02201; N02211

APPENDIX

(Nonmandatory Information)

X1. CONDITIONS AND FINISHES

X1.1 The various conditions and finishes in which nickel (UNS N02200) and low-carbon nickel (UNS N02201) rods and bars are procurable are as indicated below.

X1.2 Low-carbon nickel (UNS N02201) is intended essentially for fused caustic and other fused salts and for temperatures above 600 °F (316 °C). For such applications, the manufacturer should be consulted.

X1.2.1 *Hot-Worked*—With a tightly adherent, black, mill oxide surface.

X1.2.2 *Hot-Worked, Rough-Ground*—Similar to X1.2.1 except rough-ground.

X1.2.3 *Hot-Worked, Rough-Turned*—Similar to X1.2.1 except rough-turned with a broad-nosed tool similar to a bar peeling operation and thus may not be straight. Intended generally for machining where an overhauled surface is desired, essentially for machined step down shafts or parts machined in short lengths of 3 ft (914 mm) or less.



X1.2.4 Hot-Worked, Forging Quality—Rough-turned and spot-ground, as necessary, for sizes 1 in. (25.4 mm) in diameter and over; rough-ground and spot-ground for sizes under 1 in. in diameter. Material is selected from heats of known, good hot malleability.

NOTE X1.1—For sizes 4 in. (101.6 mm) in diameter and less, cold-worked rod may be used also for forging by virtue of the fact such rod have been overhauled for removal of mechanical surface defects prior to cold drawing. In such cases, the user should run pilot forging tests to ensure himself that such material has the desired hot-malleability range.

X1.2.5 Hot-Worked, Annealed—Soft with a tightly adherent oxide that may vary from dark to light.

X1.2.6 Hot-Worked, Annealed and Pickled—Same as **X1.2.5** except descaled for removal of mill oxide. Provides for

better surface inspection than does hot-worked material and often employed where welding is involved where removal of mill oxide is desired.

NOTE X1.2—Annealing prior to pickling may be required in order to reduce the mill oxide since uniform pickling of an unreduced oxide is difficult.

X1.2.7 Cold-Worked, As-worked—Hot-worked overhauled, cold-worked, and straightened with a smooth, bright finish.

X1.2.8 Cold-Worked, Annealed—Hot-worked overhauled, cold-worked, and straightened. Annealed for softness and with a dull, matte finish.

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