



Designation: B164 – 03 (Reapproved 2014)

Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire¹

This standard is issued under the fixed designation B164; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This specification² covers nickel-copper alloys UNS N04400 and N04405³ in the form of hot-worked and cold-worked rod and bar in the conditions shown in **Table 1** and cold-worked wire in the conditions shown in **Table 2**.

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:*⁴

B127 Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip

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

E18 Test Methods for Rockwell Hardness of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to

Determine Conformance with Specifications

E76 Test Methods for Chemical Analysis of Nickel-Copper Alloys (Withdrawn 2003)⁵

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

2.2 *Military Standards:*⁶

MIL-STD-129 Marking for Shipment and Storage

MIL-STD-271 Nondestructive Testing Requirements for Metals

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 1/8 in. (3.2 mm) and over in thickness in straight lengths.

3.1.2 *rod, n*—material of round solid section furnished in straight lengths.

3.1.3 *wire, n*—a cold-worked solid product of uniform round cross section along its whole length, supplied in coiled form.

NOTE 1—Hot-worked rectangular bar in widths 10 in. and under may be furnished as hot-rolled plate with sheared or cut edges in accordance with Specification **B127**, provided the mechanical property requirements of Specification B164 are met.

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 ASTM designation and year of issue.

4.1.2 UNS number.

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-164 in Section II of that Code.

³ New designations established in accordance with ASTM E527 and SAE J1086, Recommended 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.

⁵ The last approved version of this historical standard is referenced on www.astm.org.

⁶ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

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

TABLE 1 Mechanical Properties of Rod and Bar

Condition and Diameter or Distance Between Parallel Surfaces, in. (mm)	Tensile Strength min, psi (MPa)	Yield Strength (0.2 % offset) ^A min. psi (MPa)	Elongation in 2 in. or 50 mm (or 4D), min, %	Rockwell Hard- ness (or equivalent)
UNS N04400				
<i>Cold-worked (as worked):</i>				
Rounds under ½ (12.7)	110 000 (760)	85 000 (585)	8 ^B	—
Squares, hexagons, and rectangles under ½ (12.7)	85 000 (585)	55 000 (380)	10 ^B	—
<i>Cold-worked (stress-relieved):</i>				
Rounds under ½ (12.7)	84 000 (580)	50 000 (345)	10 ^B	—
Rounds, ½ to 3½ (12.7 to 88.9), incl	87 000 (600)	60 000 (415)	20	—
Rounds, over 3½ to 4 (88.9 to 101.6), incl	84 000 (580)	55 000 (380)	20	—
Squares, hexagons and rectangles, 2 (50.8) and under	84 000 (580)	50 000 (345)	20 ^{B,C}	—
Squares, hexagons and rectangles, over 2 (50.8) to 3½ (79.4), incl	80 000 (552)	50 000 (345)	20	—
<i>Hot-worked (as worked or stress-relieved):</i>				
Rounds, squares, and rectangles up to 12 (305), incl, and hexagons 2½ (54) and under	80 000 (552)	40 000 (276)	30 ^D	—
Rounds, squares, and rectangles over 12 (305) to 14 (356), incl	75 000 (517)	40 000 (276)	30	—
Hexagons over 2½ (54) to 4 (102), incl	75 000 (517)	30 000 (207)	25	—
Rings and disks	—	—	—	B75 to B95
<i>Hot-worked (annealed) or cold-worked (annealed):</i>				
Rod and bar, all sizes	70 000 (480)	25 000 (170)	35	—
Rings and disks	—	—	—	B60 to B75
<i>Forging quality:^E</i>				
All sizes	—	—	—	—
UNS N04405				
<i>Cold-worked (as worked or stress-relieved):</i>				
Rounds, under ½ (12.7)	85 000 (585)	50 000 (345)	8 ^B	—
Rounds, ½ (12.7) to 3 (76.2), incl	85 000 (585)	50 000 (345)	15	—
Rounds, over 3 (76.2) to 4 (101.6), incl	80 000 (552)	50 000 (345)	15	—
Hexagons and squares 2 (50.8) and under	85 000 (585)	50 000 (345)	15 ^{B,C}	—
Hexagons and squares over 2 (50.8) to 3½ (79.4), incl	80 000 (552)	45 000 (310)	15	—
<i>Hot-worked (as hot-worked or stress-relieved):</i>				
Rounds 3 (76.2) and less	75 000 (517)	35 000 (241)	30	—
Hexagons and squares, 2½ (54) and less	75 000 (517)	35 000 (241)	30	—
Hexagons and squares, over 2½ (54) to 4 (101.6), incl	70 000 (480)	30 000 (207)	25	—
<i>Hot-worked (annealed) or cold-worked (annealed):</i>				
Rod and Bar, All sizes	70 000 (480)	25 000 (170)	35	—

^A See 12.2.

^B Not applicable to diameters or cross sections under ⅜ in. (2.4 mm).

^C For sections under ½ in. (12.7 mm), the elongation shall be 10 % min.

^D For hot-worked flats ⅝ in. (7.9 mm) and under in thickness the elongation shall be 20 % min.

^E Forging quality is furnished to chemical requirements and surface inspection only. No tensile properties are required.

TABLE 2 Mechanical Properties of Cold-Worked Wire in Coil^A

Alloy Condition and Size, in. (mm)	Tensile Strength, psi (MPa)		Wrapping Test
	Min	Max	
UNS N04400 and N04405:			
Annealed, all sizes	70 000 (483)	85 000 (586)	All wire shall wrap around a rod of the same diameter as the wire without cracking
No. 0 temper, under ½ (12.7)	80 000 (552)	95 000 (655)	
No. 1 temper, under ½ (12.7)	90 000 (621)	110 000 (758)	
UNS N04400:			
Regular temper, under ½ (12.7)	110 000 (758)	140 000 (965)	All wire up to 0.2294 in. (5.84 mm), inclusive, shall wrap around a rod of the same diameter as the wire without cracking. Wire over 0.2294 in. diameter shall wrap around a rod of twice the wire diameter without cracking.
Regular temper, ½ (12.7) and over	90 000 (621)	130 000 (896)	
Spring temper			
0.028 (0.71) and less	165 000 (1138)	...	
Over 0.028 (0.71) to 0.057 (1.45), incl	160 000 (1103)	...	
Over 0.057 (1.45) to 0.114 (2.90), incl	150 000 (1034)	...	
Over 0.114 (2.90) to 0.312 (7.92), incl	140 000 (965)	...	
Over 0.312 (7.92) to 0.375 (9.53), incl	135 000 (931)	...	
Over 0.375 (9.53) to 0.500 (12.7), incl	130 000 (896)	...	
Over 0.500 (12.7) to 0.563 (14.3), incl	120 000 (827)	...	

^A Properties are not applicable to wire after straightening and cutting.

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

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 is required.

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 3](#).

5.2 If a product (check) analysis is performed by the purchaser, the material shall conform to the product (check) analysis variations in Specification [B880](#).

6. Mechanical Properties

6.1 *Mechanical Properties*—The material shall conform to the mechanical properties specified in [Table 1](#) for rod or bar, or in [Table 2](#) for wire.

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 4](#), and of hot-worked rod and bar as prescribed in [Table 5](#). The permissible variations in diameter of cold-worked wire shall be as prescribed in [Table 6](#).

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 [Table 4](#) and [Table 5](#), 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 5](#). Wire shall not be out-of-round by more than one-half the total permissible variations shown in [Table 6](#).

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 7](#) 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 8](#).

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 9](#).

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 10](#).

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 10](#), the rod shall be placed on a precision table equipped with ball-bearing 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 10](#). 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 11](#).

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*:

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

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

9.1.2.1 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.

9.2 *Test Material Selection*:

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

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

TABLE 3 Chemical Requirements

Element	Composition Limits, %	
	UNS N04400	UNS N04405
Nickel ^A	63.0 min	63.0 min
Copper	28.0 min 34.0 max	28.0 min 34.0 max
Iron	2.5 max	2.5 max
Manganese	2.0 max	2.0 max
Carbon	0.3 max	0.3 max
Silicon	0.5 max	0.5 max
Sulfur	0.024 max	0.025 min 0.060 max

^A Element shall be determined arithmetically by difference.

TABLE 4 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)
(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 15/16 (49.2), incl	0.0015 (0.04)	0.003 (0.08)
over 1 15/16 (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 5 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 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.

TABLE 6 Permissible Variations in Diameter of Cold-Worked Wire

Diameter, in. (mm)	Permissible Variations, in. (mm), ±
Under 0.0044 (0.11)	0.0002 (0.005)
0.0044 (0.11) to 0.0079 (0.20), incl	0.00025 (0.006)
Over 0.0079 (0.20) to 0.0149 (0.38), incl	0.0003 (0.008)
Over 0.0149 (0.38) to 0.0199 (0.51), incl	0.0004 (0.010)
Over 0.0199 (0.51) to 0.031 (0.79), incl	0.0005 (0.013)
Over 0.031 (0.79) to 0.045 (1.14), incl	0.0006 (0.015)
Over 0.045 (1.14) to 0.079 (2.01), incl	0.0007 (0.018)
Over 0.079 (2.01) to 0.1875 (4.76), incl	0.001 (0.025)
Over 0.1875 (4.76) to 0.3125 (7.93), incl	0.002 (0.051)
Over 0.3125 (7.93)	0.003 (0.076)

9.2.2 *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.

10.4 *Wrapping*—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, bar, and wire 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 shall be used. Longitudinal strip specimens shall be prepared in accordance with Test Methods E8 for rectangular bar up to 1/2 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 and wire under 1/2 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 and wire 1/2 in. 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.