Designation: B164 – 03 (Reapproved 2014)

Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire[1]

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 specification[2] covers nickel-copper alloys UNS N04400 and N04405[3] 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E76 Test Methods for Chemical Analysis of Nickel-Copper Alloys (Withdrawn 2003)[5]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 ⅛ 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.

Current edition approved Oct. 1, 2014. Published October 2014. Originally approved in 1941. Last previous edition approved in 2008 as B164 – 03 (2008). DOI: 10.1520/B0164-03R14.

[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 Hardness (or equivalent)
		UNS N04400		
Cold-worked (as worked):				
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]	—
Cold-worked (stress-relieved):				
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 3⅛ (79.4), incl	80 000 (552)	50 000 (345)	20	—
Hot-worked (as worked or stress-relieved):				
Rounds, squares, and rectangles up to 12 (305), incl, and hexagons 2⅛ (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 2⅛ (54) to 4 (102), incl	75 000 (517)	30 000 (207)	25	—
Rings and disks	—	—	—	B75 to B95
Hot-worked (annealed) or cold-worked (annealed):				
Rod and bar, all sizes	70 000 (480)	25 000 (170)	35	—
Rings and disks	—	—	—	B60 to B75
Forging quality:[E]				
All sizes	—	—	—	—
		UNS N04405		
Cold-worked (as worked or stress-relieved):				
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 3⅛ (79.4), incl	80 000 (552)	45 000 (310)	15	—
Hot-worked (as hot-worked or stress-relieved):				
Rounds 3 (76.2) and less	75 000 (517)	35 000 (241)	30	—
Hexagons and squares, 2⅛ (54) and less	75 000 (517)	35 000 (241)	30	—
Hexagons and squares, over 2⅛ (54) to 4 (101.6), incl	70 000 (480)	30 000 (207)	25	—
Hot-worked (annealed) or cold-worked (annealed):				
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 3⁄32 in. (2.4 mm).
[C] For sections under ½ in. (12.7 mm), the elongation shall be 10 % min.
[D] For hot-worked flats 5⁄16 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.

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.

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 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 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 and wire 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 and wire ½ 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.

TABLE 7 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 Surfaces, 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 7/8 (22.2 to 47.6), incl	1/8 (3.2)	3/16 (4.8)	1/8 (3.2)	3/16 (4.8)
Over 1 7/8 to 2 7/8 (47.6 to 73.0), incl	3/16 (4.8)	1/4 (6.4)	—	3/16 (4.8)
Over 2 7/8 to 3 13/16 (73.0 to 96.8), incl	1/4 (6.4)	—	—	3/16 (4.8)
Over 3 13/16 (96.8)	1/4 (6.4)	—	—	3/8 (9.5)
Hot-worked rods:				
Rough-turned or rough-ground:[C]				
15/16 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.
[B] 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 in 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.
[C] Applicable to 3 ft (0.91 m) max length.

TABLE 8 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).
Multiple lengths	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.
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 plus 1/8 in. (3.2 mm), minus 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.

[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 9 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. 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	E76, E1473
Tension	E8
Rockwell Hardness	E18
Hardness Conversion	E140
Rounding Procedure	E29

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, tested by the purchaser, 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 10 Permissible Variations in Straightness of Precision-Straightened Cold-Worked Shafting UNS N04400 Only

Specified Diameter of Shafting, in.	Standard Distance Between Supports	Permissible Variations (Throw in One Revolution) from Straightness, in.
½ to 15⁄16, incl	42 in.	0.005
Over 15⁄16 to 1 15⁄16, incl	42 in.	0.006
Over 1 15⁄16 to 2½, incl	42 in.	0.007
Over 2½ to 4, incl	42 in.	0.008
¾ to 15⁄16, incl	Specified lengths of 3 to 10 ft.	0.004 plus 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 plus 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	specified lengths of 914 to 3050 mm	10.2 plus 0.2 for each metre or fraction thereof in excess of 914 mm
Over 23.8 to 101.6, incl	specified lengths of 6100 mm and less	12.7 plus 0.13 for each metre or fraction thereof in excess of 914 mm

TABLE 11 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]
Round—hot-worked, rough-ground, or rough-turned	0.050 (4.2)[C]

[A] Not applicable to forging quality.
[B] Material under ½ 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 producer's or supplier's certification shall be furnished to the purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the 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 B164, 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; wire; N04400

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order, for agencies of the U. S. Government.

S1. Scope

S1.1 The requirements for annealed, hot finished, and cold rolled and stress relieved rod and bar shall apply for shapes in the same conditions except as modified herein for chemistry and ultrasonic inspection.

S2. Referenced Documents

S2.1 The following documents of the issue in effect on date of material purchased form a part of this specification to the extent referenced herein:

S2.1.1 *Federal Standards:*

Fed. Std. No. 102 Preservation, Packaging and Packing Levels[6]

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[6]

Fed. Std. No. 182 Continuous Identification Marking of Nickel and Nickel-Base Alloys[6]

S2.1.2 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[6]

S3. Chemical Composition

S.3.1 The material shall conform to the composition limits specified in Table 3 except as specified in Table S3.1 or Table S3.2.

S4. Mechanical Properties

S.4.1 UNS N04400 cold worked bar and rod shall be supplied in the stress relieved condition.

TABLE S3.1 Chemical Requirements

Element	Composition Limits, % UNS N04400
Carbon	0.2 max.
Sulfur	0.015 max.
Aluminum	0.5 max.
Lead	0.006 max.
Tin	0.006 max.
Zinc	0.02 max.
Phosphorus	0.02 max.

TABLE S3.2 Chemical Requirements

Element	Composition Limits, % UNS N04405
Aluminum	0.5 max.
Lead	0.006 max.
Tin	0.006 max.
Zinc	0.02 max.
Phosphorus	0.02 max.

S5. Number of Tests

S.5.1 For wire, the number of samples for tension and wrapping tests shall be as specified in Table S5.1.

TABLE S5.1 Required Samples for Tension and Wrapping Tests of Wire

Lot Size, lbs	Number of Samples for Each Test
¼ in. diameter and less:	
180 and under	1
181 to 500	2
501 to 800	3
801 to 1300	5
1301 to 3200	7
3201 to 5000	10
Over ¼ in. diameter:	
For each 500 lbs. or fraction thereof	1

S6. Specimen Preparation

S6.1 Tensile specimens for rod and bar up to 1-½ in. in diameter or minimum thickness shall coincide with the central axis of the piece. Tensile specimens for rod and bar 1-½ in. and over in diameter or thickness shall be located midway between the center and the rolled or drawn surface of the piece.

S6.2 Tensile specimens for wire shall be of the full cross section and not less than 15 in. in length. Specimens shall be free from sharp bends or kinks. The distance between the jaws of the testing machine, with the specimen in place ready for testing, shall be not less than 10 in.

S7. Nondestructive Tests

S7.1 When specified by the purchaser, each piece of each lot shall be inspected. The purchaser shall specify if one or both tests are required.

S7.2 Ultrasonic Tests:

S7.2.1 General Requirements:

S7.2.1.1 Ultrasonic testing shall be performed in accordance with MIL-STD-271 as modified by the requirements specified herein. Testing shall be done by a longitudinal wave or shear wave technique as specified herein.

S7.2.1.2 Acoustic compatibility between the production material and the calibration standard material shall be within 75 %. If the acoustic compatibility is within 25 %, no gain compensation is required for the examination. If acoustic compatibility difference is between 25 % and 75 %, a change in the gain or dB controls shall be accomplished to compensate for the differences in acoustic compatibility. This method cannot be used if the ultrasonic noise level exceeds 50 % of the rejection value.

S7.2.2 Calibration:

S7.2.2.1 *Shear Wave*—The shear wave test shall be calibrated on two notches, one notch cut into the inside and one into the outside surface. The notches shall be cut axially and shall have a depth of 5 % of the material thickness or ¼ in. (6.4 mm), whichever is less. Notch length shall not exceed 1 in. (25.4 mm). Notches shall be made either in the piece to be examined or in a separate defect–free specimen of the same size (within ±⅛ in. (3.18 mm)), shape, material, and condition, or acoustically similar material. The position and amplitude of the response from each note shall be marked on the instrument screen or a transparent overlay, and these marks shall be used as the evaluation reference. Indications that appear between these points shall be evaluated on the basis of a straight line joining the two peak amplitudes.

S7.2.2.2 *Longitudinal Wave*–The longitudinal wave test shall be calibrated on a flat–bottomed reference hole of a given diameter in accordance with Table S7.1 for specified material thickness drilled either into the piece to be tested or into a separate defect–free specimen of the same size (within ±⅛ in. (3.18 mm)), shape, material, and condition, or acoustically similar material. Holes are to be drilled to midsection and the bottom of the hole shall be parallel to the entrant surface. The ultrasonic test instrument shall be adjusted so that the response from the reference hole shall not be less than 25 % and not more than 75 % of screen height.

TABLE S7.1 Ultrasonic Testing Reference Hole for Rod and Bar

Material Thickness, in. (mm)	Hole Diameter, in. (mm)
Up to and including 6 (152)	⅛ (3.18)
Over 6 (152) and including 16 (406)	¼ (6.4)
Over 16 (406)	As agreed upon

S7.2.3 *Recalibration*—During quality conformance inspection, any realignment of the search unit that will cause a decrease in the calibrated sensitivity and resolution, or both, or any change in search unit, couplant, instrument settings, or scanning speed from that used for calibration shall require recalibration. Recalibration shall be performed at least once per 8 h shift.

S7.2.3 *Procedure*—S7.2.3.1 and S7.2.3.2 describe the requirements for rod and bar. Wire shall be excluded from these requirements. Shapes other than those listed below shall be tested to the extent set forth in the approved procedure.

S7.2.3.1 Rod-Rod shall be tested using the longitudinal wave technique. The scanning path shall be circumferential or helical with the beam directed along a radius of the rod.

S7.2.3.2 Bar-Bar shall be tested using the longitudinal wave technique through one side of each pair of parallel sides (thickness and width only).

S7.2.4 Acceptance Criteria:

S7.2.4.1 *Shear Wave*—Any material that produces indications equal to or larger than the response from the reference notch or higher than the straight line joining the two peak amplitudes shall be rejected.

S7.2.4.2 *Longitudinal Wave*—Any material that produces indications equal to or larger than the response from the reference hole, or that produces a complete loss of back reflection shall be rejected. Material shall be tested using a square, rectangular, or circular transducer having an effective area of one square inch or less, but no dimension shall be smaller than the diameter of the reference hole. In the event of disagreement on the degree of back reflection loss, it shall be determined by the contact method using a 1 to 1⅛ in. (25.4 to 28.6 mm) diameter transducer or one whose area falls within this range.

S7.2.4.3 *Reference Notch Removal*—If reference notches or flat–bottomed holes are made in the material to be tested, they shall be so located than their subsequent removal will not impair the suitability of the material for its intended use.

S7.3 Liquid Penetrant Inspection:

S7.3.1 *Procedure*—Liquid penetrant inspection shall be in accordance with MIL-STD-271.

S7.3.2 *Surface Requirements*—The surface produced by hot working is not suitable for liquid penetrant testing. Therefore, liquid penetrant testing will not be applicable to products ordered with a hot finished surface.

S7.3.3 *Acceptance Criteria*—Linear defects revealed by liquid penetrant inspection shall be explored by grinding or other suitable means. Depth of defects shall not exceed the dimensional tolerance of the material.

S8. Quality Assurance

S8.1 *Responsibility for Inspection:*

S8.1.1 Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection and test requirements specified. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own or any other suitable facilities for the performance of the inspection and test requirements unless disapproved by the purchaser at the time the order is placed. The purchaser shall have the right to perform any of the inspections or tests set forth when such inspections and tests are deemed necessary to ensure that the material conforms to prescribed requirements:

S9. Identification Marking

S9.1 All material shall be properly marked for identification in accordance with Fed. Std. No. 182, except that the ASTM Specification number and the alloy number shall be used.

S10. Preparation for Delivery

S10.1 *Preservation, Packaging, Packing:*

S10.1.1 *Military Agencies*—The material shall be separated by size, composition, grade, or class and shall be preserved and packaged, level A or C, packed level A, B, or C as specified in the contract or purchase order.

S10.1.2 *Civil Agencies*—The requirements of Fed. Std. No. 102 shall be referenced for definitions of the various levels of packaging protection.

S10.2 *Marking:*

S10.2.1 *Military Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with MIL-STD-129.

S10.2.2 *Civil Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with Fed. Std. No. 123.

APPENDIX

(Nonmandatory Information)

X1. CONDITIONS AND FINISHES NORMALLY SUPPLIED

X1.1 The various conditions and finishes in which rod and bar are procurable are as follows:

X1.1.1 *Hot-Worked*—With a tightly adherent, black, mill oxide surface.

X1.1.2 *Hot-Worked, Rough-Ground*—Similar to X1.1.1 except rough-ground.

X1.1.3 *Hot-Worked, Rough-Turned*—Similar to X1.1.1 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 over-hauled surface is desired, essentially for machined step down shafts or parts machined in short lengths of 3 ft (910 mm) or less.

X1.1.3.1 Where material is intended for shafting for diameters over 4 in. (101.6 mm) the “stress-relieved” temper is recommended.

X1.1.4 *Hot-Worked, Forging Quality*—Rough turned and spot ground, as necessary, for sizes 1 in. in diameter and over; rough ground and spot ground for sizes under 1 in. (25.4 mm) in diameter. Material is selected from heats of known, good hot malleability.

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

X1.1.5 *Forging Quality, Bolt Tolerance*—Hot-worked, of known good hot malleability, but not overhauled prior to skin pass, cold-working to tolerances specified herein, which tolerances conform to the major diameter tolerances of Class 3 fit of American Standard screw threads. No mechanical properties are offered since material is to be subsequently hot worked. Intended primarily for hot heated bolts but is of somewhat inferior quality, as to surface seams and cracks compared to forging quality, see X1.1.4.

X1.1.6 *Hot-Worked, Annealed*—Soft with a tightly adherent oxide that may vary from dark to light.

X1.1.7 *Hot-Worked, Annealed, and Pickled*—Same as X1.1.6 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.

X1.1.8 *Cold-Worked, Stress-Relieved*—Hot worked, overhauled, cold-worked, and straightened. Material is thermally treated to relieve the major portion of the internal stresses resulting from cold-working and may have a very thin light to medium oxide. Intended primarily for shafting and for machined parts where minimum "walking" or distortion after metal removal is desired.

X1.1.9 *Cold-Worked, Annealed*—Hot-worked, overhauled, cold-worked, and straightened. Annealed for softness and with a dull matte finish.

NOTE X1.3—*UNS N04405 Material*—This is the machining grade and is preferred generally to UNS N04400 for intricately machined parts, particularly for parts that are to be machined on automatics or require drilling.