



Designation: B164-98 Designation: B 164 - 03 (Reapproved 2008)

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

This standard is issued under the fixed designation B 164; 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 Department of Defense.

1. Scope

1.1 This specification² covers nickel-copper alloys UNS N04400 and N04405* 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 the standard. The values given in parentheses are for information only.

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:³

B 127 Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip

B 880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys

E 8 Test Methods for Tension Testing of Metallic Materials

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials⁴

E 18 Test Methods for Rockwell Hardness of Metallic Materials

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

E 76 Test Methods for Chemical Analysis of Nickel-Copper Alloys

E 140 Hardness Conversion Tables for Metals⁴

E 76 Test Methods for Chemical Analysis of Nickel-Copper Alloys

E 140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness (008)

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

2.2 Military Standards:⁴

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 $\frac{1}{8}$ 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.

¹ This specification is under the jurisdiction of ASTM Committee B-2B02 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.

* New designations established in accordance with ASTM E 527 and SAE J1086, Recommended Practice for Numbering Metals and Alloys (UNS).

³ Annual Book of ASTM Standards, Vol 02.04.

³ 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.

⁴ Annual Book of ASTM Standards, Vol 03.01.

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



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) |
|---|------------------------------------|---|---|--|
| | | | | |
| <i>Cold-worked (as worked):</i> | | | | |
| Rounds under 1/2 (12.7) | 110 000 (760) | 85 000 (585) | 8 ^B | — |
| Squares, hexagons, and rectangles under 1/2 (12.7) | 85 000 (585) | 55 000 (380) | 10 ^B | — |
| <i>Cold-worked (stress-relieved):</i> | | | | |
| Rounds under 1/2 (12.7) | 84 000 (580) | 50 000 (345) | 10 ^B | — |
| Rounds, 1/2 to 3 1/2 (12.7 to 88.9), incl | 87 000 (600) | 60 000 (415) | 20 | — |
| Rounds, over 3 1/2 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 3 1/8 (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 2 1/8 (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 2 1/8 (54) to 4 (102), incl | 75 000 (517) | 30 000 (207) | 25 | — |
| Rings and disks | — | — | — | B 75 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 | — | — | — | B 60 to B75 |
| <i>Forging quality:^E</i> | | | | |
| All sizes | — | — | — | — |
| UNS N04405 | | | | |
| <i>Cold-worked (as worked or stress-relieved):</i> | | | | |
| Rounds, under 1/2 (12.7) | 85 000 (585) | 50 000 (345) | 8 ^B | — |
| Rounds, 1/2 (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 3 1/8 (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, 2 1/8 (54) and less | 75 000 (517) | 35 000 (241) | 30 | — |
| Hexagons and squares, over 2 1/8 (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 3/32 in. (2.4 mm).^C For sections under 1/2 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 1/2 (12.7) | 80 000 (552) | 95 000 (655) | |
| No. 1 temper, under 1/2 (12.7) | 90 000 (621) | 110 000 (758) | |
| UNS N04400: | | | |
| Regular temper, under 1/2 (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, 1/2 (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.

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 B 127, provided the mechanical property requirements of Specification B 164 are met.

4. Ordering Information

4.1 Orders for material to this specification shall include information as follows: 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.
- 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 Table 3 Specification B 880.

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 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 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.

TABLE 3 Chemical Requirements

| Element | Composition Limits, %Product (Check) Analysis | | |
|---------------------|--|---------------|-------|
| | Variations, under min or over max, of the Specified Limit of Element | | |
| | UNS N04400 | UNS N04405 | |
| Nickel ^A | 63.0 min | 63.0 min | 0-45 |
| Copper | 28.0 min | 28.0 min | 0-15 |
| | 34.0 max | 34.0 max | 0-20 |
| Iron | 2.5 max | 2.5 max | 0-05 |
| Manganese | 2.0 max | 2.0 max | 0-04 |
| Carbon | 0.3 max | 0.3 max | 0-02 |
| Silicon | 0.5 max | 0.5 max | 0-03 |
| Sulfur | 0.024 max | 0.025 min | 0-005 |
| | | 0.060 max | 0-005 |

^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) |

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.

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 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 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 | | | | |
| 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.

^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.

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.

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.

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. |
|-------------------------------------|-------------------------------------|---|
| 1/2 to 15/16, incl | 42 in. | 0.005 |
| Over 15/16 to 1 1/16, incl | 42 in. | 0.006 |
| Over 1 1/16 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 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 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.

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 E 8 shall be used. Longitudinal strip specimens shall be prepared in accordance with Test Methods E 8 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.

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 |
|--------------------------|------------------|
| <u>Chemical Analysis</u> | E 76 |
| <u>Chemical Analysis</u> | E 76, E 1473 |
| <u>Tension</u> | E 8 |