



Standard Specification for Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06110) Rod and Bar¹

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1. Scope

1.1 This specification covers nickel-chromium-molybdenum-tungsten (UNS N06110)² in the form of hot-worked rod and bar and cold-worked rod in the conditions shown in Table 1.

1.2 The values stated in inch-pound units are to be regarded as the standards. The SI units in parentheses are provided for information only.

2. Referenced Documents

2.1 ASTM Standards:

B 755 Specification for Nickel-Chromium-Molybdenum-Tungsten Alloys (UNS N06110) Plate, Sheet, and Strip³

B 880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys, and Cobalt Alloys³

E 8 Test Methods for Tension Testing of Metallic Materials⁴

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁵

E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys⁶

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *bar*—material of rectangular (flats) 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.

DISCUSSION — 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, provided the mechanical property requirements of Specification B are met.

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

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² New designation established in accordance with ASTM E527 and SAE J1086, Recommended Practice for Numbering Metals and Alloys (UNS).

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

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

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

⁶ *Annual Book of ASTM Standards*, Vol 03.06.

TABLE 1 Mechanical Properties

Condition and Diameter or Distance Between Parallel Surfaces in. (mm)	Tensile Strength min, ksi (MPa)	Yield Strength (0.2% Offset), min, ksi (MPa)	Elongation in 2 in. or 50 mm or 4D, min, %
Cold-worked rods and hot-worked rod and bar, annealed:			
Up to 4 (102), incl	95 (655)	45 (310)	60
Over 4 (102) to 10 (254), incl	90 (621) ^A	40 (276) ^A	50 ^A
Forging quality (all sizes)			

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

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*.

4.1.2 *UNS Number*.

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

4.1.4 *Dimensions*—Dimensions including length.

4.1.5 *Condition* (see Appendix).

4.1.6 *Finish* (Section 8).

4.1.7 *Quantity*—Feet, (or metres) or number pieces.

4.1.8 *Certification*—State if certification is required (see Section 15).

4.1.9 *Samples for Product (Check) Analysis*—State whether samples for product (check) analysis should be furnished (see 5.2).

4.1.10 *Purchaser Inspection* (see Section 13)—If purchaser wishes to witness test or inspection of material at place of manufacture, the purchase order must so state indicating which test or inspections are to be witnessed.

5. Chemical Composition

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

5.2 If a product (check) analysis is performed by the purchaser, the material shall conform to the product (check) analysis variations per B 880.

TABLE 2 Chemical Requirements

Element	Composition Limits, %
C	0.15 max
Mn	1.0 max
Si	1.0 max
P	0.015 max
S	0.015 max
Cr	28.0 min 33.0 max
Cb	1.0 max
Co (if determined)	1.0 max
Mo	9.0 min 12.0 max
Fe	1.0 max
Al	1.0 max
Ti	1.0 max
W	1.0 min 4.0 max
Ni ^A	51.0 min
Cu	0.50 max

^A Element shall be determined arithmetically by difference.

6. Mechanical and Other Properties

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

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

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

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

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

TABLE 3 Permissible Variations in Diameter of Cold-Worked Rod

Specified Dimensions, in. (mm)	Permissible Variations from Specified Dimension, in. (mm)	
	+	–
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)

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

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

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

7.5.2 The permissible variations in straightness of hot-worked rod and bar as determined by the departure from straightness shall be as specified in Table 8.

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 except that a single piece weighing over 500 lb shall be considered as one lot.

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.

10. Number of Tests

10.1 *Chemical Analysis*—One test per lot.

10.2 *Tension*—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.

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 Surfaces of Square Bars	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				
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 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 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).

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 rod under 1/2 in. (12.7 mm) in diameter 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

Specified Diameter, in. (mm) ^A	Permissible Variations, in. (mm)
	Depth of Chord: 0.030 (0.76) per ft (305 mm) of length
1/2 (12.7) to 2 1/2 (63.5), incl	

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

11.1.1 All rod and bar shall be tested in full cross section size when possible. When a full cross section size test cannot be performed, the largest possible round specimen shown in Test Methods E 8 shall be used. Longitudinal strip specimens shall be prepared in accordance with Test Methods E 8 for rectangular bar up to 1/2 in. (12.7 mm), inclusive, in thicknesses that are too wide to be pulled full size.

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:

TABLE 8 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.

Test	ASTM Designation
Chemical analysis	E 1473
Tension	E 8
Rounding procedure	E 29

12.2 For purposes of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value or a calculated value shall be rounded as indicated below, in accordance with the rounding method of Practice E 29:

Test	Rounded Unit for Observed Or Calculated Value
Chemical composition and tolerance (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 de- fined 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 tests, the producer or supplier may make the claim for a rehearing.

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, heat number, condition (temper), this specification number, 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 rod; bar; N06110

APPENDIX

(Nonmandatory Information)

X1. PROCURABLE CONDITIONS AND FINISHES

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

X1.1.1 Hot-worked, annealed—soft, with a tightly adherent dark oxide.

X1.1.2 Hot-worked, annealed, and pickled—Same as X1.1.1 except descaled for removal of mill oxide. Provides for better surface inspection than does hot-worked, annealed material and often employed where welding is involved where removal of mill oxide is desired.

NOTE X1.1—Annealing prior to pickling may be required in order to reduce the mill oxide since uniform pickling of an unreduced oxide is difficult.

X1.1.3 Hot-worked, annealed, and rough ground—Similar to X1.1.1 except rough ground.

X1.1.4 Hot-worked, annealed, and 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 overhauled surface is desired, essentially for machined step down shafts or part machined in short lengths of 3 ft (0.91 m) or less.

X1.1.5 Hot-worked, forging quality—Rough turned and spot ground, as necessary, for sizes 1 in. (25.4 mm) in diameter; rough ground and spot ground for sizes under 1 in. in diameter. Material is selected from heats of known, good hot malleability.

NOTE X1.2—For sizes 2½ in. (63.5 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 defect 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.

X1.1.6 Cold-worked, annealed, and pickled hot-worked, overhauled, cold-worked, annealed, descaled, and straightened. Annealed for softness and with a dull matte finish.

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