



Designation: B446 – 23

# Standard Specification for Nickel-Chromium-Molybdenum-Niobium Alloy, Nickel-Chromium-Molybdenum-Silicon Alloy, and Nickel-Chromium-Molybdenum-Tungsten Alloy Rod and Bar<sup>1</sup>

This standard is issued under the fixed designation B446; 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 ( $\epsilon$ ) 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 covers nickel-chromium-molybdenum-niobium alloy (UNS N06625), nickel-chromium-molybdenum-silicon alloy (UNS N06219), and Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06650)<sup>2</sup> in the form of both hot-worked and cold-worked rod and bar in the conditions shown in [Table 1](#).

1.1.1 UNS N06625 products are furnished in three grades of different heat-treated conditions:

1.1.1.1 *Grade 1 (Annealed)*—Material is normally employed in service temperatures up to 1100 °F (593 °C).

1.1.1.2 *Grade 2 (Solution Annealed)*—Material is normally employed in service temperatures above 1100 °F (593 °C) when resistance to creep and rupture is required.

NOTE 1—Hot-working or reannealing may change properties significantly, depending on working history and temperatures.

1.1.1.3 *Grade 3 (Solution Annealed and Cold Worked)*—Material is normally employed in services where higher strengths are needed.

1.1.2 Alloys UNS N06219 and UNS N06650 are supplied in solution annealed condition only.

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 The following precautionary caveat pertains only to the test methods portion, Section 12, of this specification: *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*

<sup>1</sup> 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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<sup>2</sup> Designation (UNS N06650) was established in accordance with Practice E527 and SAE J 1086, Practice for Numbering Metals and Alloys (UNS).

*those identified in the appropriate Safety Data Sheet (SDS) for this product/material as provided by the manufacturer; to establish appropriate safety, health, and environmental practices, and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

[B443](#) Specification for Nickel-Chromium-Molybdenum-Columbium Alloy and Nickel-Chromium-Molybdenum-Silicon Alloy Plate, Sheet, and Strip

[B880](#) Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys

[B899](#) Terminology Relating to Non-ferrous Metals and Alloys

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

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

[E1473](#) Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys

## 3. Terminology

### 3.1 Definitions:

3.1.1 For definitions of terms used in this specification, refer to Terminology [B899](#).

### 3.2 Definitions of Terms Specific to This Standard:

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

**TABLE 1 Conditions for Hot-Worked and Cold-Worked Rod and Bar<sup>A</sup>**

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, %
UNS N06625 Grade 1 (Annealed) <sup>B</sup>			
Up to 4 (102), incl	120 (827)	60 (414)	30
Over 4 (102) to 10 (254), incl	110 (758)	50 (345)	25
UNS N06625 Grade 2 (Solution Annealed) <sup>C</sup>			
All sizes	100 (690)	40 (276)	30
UNS N06625 Grade 3 (Solution Annealed and Cold-Worked)			
Up to 2.5 in. (63 mm)	135 (930)	100 (690)	25
UNS N06219 All (Solution Annealed)			
All sizes	96 (660)	39 (270)	50
UNS N06650 All (Solution Annealed)			
All sizes	116 (800)	58 (400)	45

<sup>A</sup> Forging quality is furnished to chemical requirements and surface inspection only. No tensile properties are required. Forging stock is typically supplied in the hot worked condition, (see X1.1.5).

<sup>B</sup> Annealed 1600 °F (871 °C) minimum.

<sup>C</sup> Solution annealed at 2000 °F (1093 °C) minimum, with or without subsequent stabilization anneal at 1800 °F (982 °C) minimum to increase resistance to sensitization.

3.2.1 *bar, n*—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.

3.2.1.1 *Discussion*—Hot-worked rectangular bar in widths 10 in. (254 mm) and under may be furnished as hot-rolled plate with sheared or cut edges in accordance with Specification B443, provided the mechanical property requirements of this specification are met.

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

#### 4. Ordering Information

4.1 It shall be the responsibility of the purchaser to specify all requirements that are necessary for the safe and satisfactory

**TABLE 2 Chemical Requirements<sup>A,B</sup>**

Element	Composition Limits, %		
	N06625	N06219	N06650
Carbon	0.10	0.05	0.03
Manganese	0.50	0.50	0.50
Silicon	0.50	0.70–1.10	0.50
Phosphorus	0.015	0.020	0.020
Sulfur	0.015	0.010	0.010
Chromium	20.0–23.0	18.0–22.0	19.0–21.0
Niobium + tantalum <sup>C</sup>	3.15–4.15	...	0.05–0.50
Cobalt (if determined)	1.0	1.0	1.0
Molybdenum	8.0–10.0	7.0–9.0	9.5–12.5
Iron	5.0	2.0–4.0	12.0–16.0
Aluminum	0.40	0.50	0.05–0.50
Titanium	0.40	0.50	...
Copper	...	0.50	0.30
Nickel <sup>D</sup>	58.0 min	Bal.	Bal.
Tungsten	...	...	0.50–2.50
Nitrogen	...	...	0.05–0.20

<sup>A</sup> All values are maximums unless specified as a minimum or a range is provided.

<sup>B</sup> Where ellipses (...) appear in this table there is no requirement and the element need neither be analyzed for or reported.

<sup>C</sup> Columbium and Niobium are interchangeable names for the same element and both names are acceptable for use in B02.07 specifications.

<sup>D</sup> Nickel shall be determined arithmetically by difference.

**TABLE 3 Permissible Variations in Dimension of Cold-Worked Rod and Bar**

Specified Dimension <sup>A</sup> , in. (mm)	Permissible Variations from Specified Dimension, in. (mm)	
	Plus	Minus
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 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)

<sup>A</sup> Dimensions apply to diameter of rods, to distance between parallel surfaces of squares and hexagonals, and separately to width and thickness of rectangles.

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

Specified Dimension, in. (mm) <sup>A</sup>	Permissible Variations from Specified Dimensions, in. (mm)	
	Plus	Minus
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 and bar, 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: <sup>B</sup>		
Under 1 (25.4)	0.005 (0.13)	0.005 (0.13)
1 (25.4) and over	0.031 (0.79)	0

<sup>A</sup> Dimensions apply to diameter of rods, to distance between parallel surfaces of squares and hexagonals, and separately to width and thickness of rectangles.

<sup>B</sup> 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.

performance of material ordered under this specification. Examples of such requirements include, but are not limited to, the following:

4.1.1 ASTM specification designation and year date to which the product is to be furnished and be certified as meeting,

4.1.2 UNS number,

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

4.1.4 *Dimensions*, including length,

4.1.5 Condition (see 1.1.1, 1.1.2, and Appendix),

4.1.6 Grade designation,

4.1.6.1 If no grade of N06625 is specified, Grade 1 will be supplied.

4.1.7 Shape and finish characteristics (Section 8),

4.1.8 *Quantity*—Feet (or metres) or number of pieces,

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

4.1.10 *Product Marking* (see Section 16)—State product marking requirements, and

4.1.11 *Purchaser Inspection* (see Section 13)—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 2**.

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 and Other Requirements

6.1 *Mechanical Properties*—The material shall conform to the heat treatment and room temperature tensile properties prescribed 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 and bar 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 **Tables 3 and 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.

7.5 *Straightness*:

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

7.5.2 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 (227 kg) 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.

**TABLE 5 Normal Machining Allowances for Hot-Worked Material**

Finished-Machined Dimensions for Finishes As Indicated below, in. (mm) <sup>A</sup>	On Diameter, For Rods	Normal Machining Allowance, in. (mm)		
		Distance Between Parallel Surfaces of Square and Hexagonal Bars	For Rectangular Bar	
			On Thickness	On Width
Hot-worked: <sup>B</sup>				
Up to ⅞ (22.2), incl	⅛ (3.2)	⅛ (3.2)	⅛ (3.2)	⅜ (4.8)
Over ⅞ to 1⅞ (22.2 to 47.6), incl	⅛ (3.2)	⅜ (4.8)	⅛ (3.2)	⅜ (4.8)
Over 1⅞ to 2⅞ (47.6 to 73.0), incl	⅜ (4.8)	¼ (6.4)	...	⅜ (4.8)
Over 2⅞ to 3⅞ (73.0 to 96.8), incl	¼ (6.4)	...	...	⅜ (4.8)
Over 3⅞ (96.8)	¼ (6.4)	...	...	⅝ (9.5)
Hot-worked rods, rough-turned or rough ground: <sup>C</sup>				
⅞ to 4 (23.8 to 101.6), incl in diameter	⅞ (1.6)	...	...	...
Over 4 to 12 (101.6 to 304.8), incl in diameter	⅛ (3.2)	...	...	...

<sup>A</sup> Dimensions apply to diameter of rods, to distance between parallel surfaces of square and hexagonal bar, and separately to width and thickness of rectangular bar.  
<sup>B</sup> 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.

<sup>C</sup> Applicable to 3 ft (0.91 m) max length.