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Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625), Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219), and Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06650)*N06650 Rod and Bar ¹

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 (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.

^{ε1} NOTE—Table 1 was corrected editorially in October 2010.

1. Scope

1.1 This specification covers nickel-chromium-molybdenum-columbium (UNS N06625), nickel-chromium-molybdenum-silicon alloy (UNS N06219), and Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06650)* in the form of hot-worked rod and bar and cold-worked rod in the conditions shown in Table 1.

1.1.1 UNS N06625 products are furnished in two 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.

1.1.2 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 the standard. The values given in parentheses are for information 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 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:*²

B443 Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625) and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) 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

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 of Terms Specific to This Standard:*

¹ This specification is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.07 on Refined Nickel and Cobalt and Their Alloys.

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* New designation (UNS N06650) was established in accordance with Practice E527 and SAE J 1086, Practice for Numbering Metals and Alloys (UNS).

² 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.

TABLE 1 Conditions for Hot-Worked Rod and Bar and Cold-Worked Rod^A

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) ^B			
Up to 4 (102), incl	120	60	30
Over 4 (102) to 10 (254), incl	110	50	25
UNS N06625 Grade 2 (Solution Annealed) ^C			
All sizes	100	40	30
UNS N06219 All (Solution Annealed)			
All sizes	96 (600)	39 (270)	50
All sizes	96 (660) †	39 (270)	50
UNS N06650 All (Solution Annealed)			
All sizes	116 (800)	58 (400)	45

^A 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).

^B Annealed 1600°F (871°C) minimum.

^C 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.

† MPA was corrected editorially.

3.1.1 *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.

3.1.1.1 *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.

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

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*, including length,

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

4.1.5.1 If neither grade of N06625 is specified, Grade 1 will be supplied,

TABLE 2 Chemical Requirements

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

^A Element shall be determined arithmetically by difference.

**TABLE 3 Permissible Variations in Diameter of Cold-Worked Rod**

Specified Dimension, 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)

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)	
	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, 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.

4.1.6 Finish (Section 8),

4.1.7 *Quantity*—Feet (or metres) or number of 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), and

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

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 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 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 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.