



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 (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 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*

*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>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).

<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<br>Between Parallel Surfaces,<br>in. (mm) | Tensile<br>Strength<br>min, ksi<br>(MPa) | Yield<br>Strength<br>(0.2 % offset),<br>min, ksi (MPa) | Elongation<br>in 2 in. or<br>50 mm or<br>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),<br>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<br>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> ,<br>in. (mm) | Permissible Variations from Specified<br>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 1 1/16 (23.8), incl              | 0.001 (0.03)                                                 | 0.002 (0.05) |
| Over 1 1/16 (23.8) to 1 1/8 (49.2), incl       | 0.0015 (0.04)                                                | 0.003 (0.08) |
| Over 1 1/8 (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,<br>in. (mm) <sup>A</sup> | Permissible Variations from<br>Specified Dimensions, in.<br>(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<br>(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<br>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.