Designation: B446 – 03 (Reapproved 2008)\(^1\)

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) 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.

\(^1\) 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 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:

3.1.1 bar, n—material of rectangular (flats) 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.

**NOTE 1**—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.

\(^1\) 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. Current edition approved March 1, 2008. Published March 2008. Originally approved in 1966. Last previous edition approved in 2003 as B446 – 03. DOI: 10.1520/B0446-03R08E01.

\(^*\) 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 2 Chemical Requirements

<table>
<thead>
<tr>
<th>Element</th>
<th>Limits, %</th>
<th>N06625</th>
<th>N06219</th>
<th>N06650</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.10 max</td>
<td>0.05 max</td>
<td>0.03 max</td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td>0.50 max</td>
<td>0.50 max</td>
<td>0.50 max</td>
<td></td>
</tr>
<tr>
<td>Silicon</td>
<td>0.50 max</td>
<td>0.70-1.10</td>
<td>0.50 max</td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.015 max</td>
<td>0.020 max</td>
<td>0.020 max</td>
<td></td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.015 max</td>
<td>0.010 max</td>
<td>0.010 max</td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>20.0 min</td>
<td>18.0-22.0</td>
<td>19.0-21.0</td>
<td></td>
</tr>
<tr>
<td>Columbium + tantalum</td>
<td>3.15 min</td>
<td>...</td>
<td>0.05-0.50</td>
<td></td>
</tr>
<tr>
<td>Cobalt (if determined)</td>
<td>1.0 max</td>
<td>1.0 max</td>
<td>1.0 max</td>
<td></td>
</tr>
<tr>
<td>Molybdenum</td>
<td>8.0 min</td>
<td>7.0-9.0</td>
<td>9.5-12.5</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>10.0 max</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>5.0 max</td>
<td>2.0-4.0</td>
<td>12.0-16.0</td>
<td></td>
</tr>
<tr>
<td>Titanium</td>
<td>0.40 max</td>
<td>0.50 max</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>...</td>
<td>0.50 max</td>
<td>0.30 max</td>
<td></td>
</tr>
<tr>
<td>Nickel²</td>
<td>58.0 min</td>
<td>Bal.</td>
<td>Bal.</td>
<td></td>
</tr>
<tr>
<td>Tungsten</td>
<td>...</td>
<td>...</td>
<td>0.50-2.50</td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>...</td>
<td>...</td>
<td>0.05-0.20</td>
<td></td>
</tr>
</tbody>
</table>

²Element shall be determined arithmetically by difference.

Table 3 Permissible Variations in Diameter of Cold-Worked Rod

<table>
<thead>
<tr>
<th>Specified Dimension, in. (mm)</th>
<th>Permissible Variations from Specified Dimension, in. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plus</td>
</tr>
<tr>
<td>1/4 (1.6) to 3/8 (4.8), excl</td>
<td>0</td>
</tr>
<tr>
<td>3/8 (4.8) to 1/2 (12.7), excl</td>
<td>0</td>
</tr>
<tr>
<td>1/2 (12.7) to 5/8 (23.8), incl</td>
<td>0.001 (0.03)</td>
</tr>
<tr>
<td>Over 5/8 (23.8) to 1 (49.2), incl</td>
<td>0.0015 (0.04)</td>
</tr>
<tr>
<td>Over 1 (49.2) to 2 1/2 (63.5), incl</td>
<td>0.002 (0.05)</td>
</tr>
</tbody>
</table>

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,
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 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 as determined by the departure from straightness shall be as prescribed in Table 5.

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.

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 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 E8 shall be used. Longitudinal strip specimens shall be prepared in accordance with Test Methods E8 for rectangular bar up to ½ in. (12.7 mm), inclusive, in thicknesses that are too wide to be pulled full size.

12. Test Methods

12.1 The chemical composition and mechanical and other properties of the material as enumerated in this specification shall be determined, in case of disagreement, in accordance with the following ASTM standards:

<table>
<thead>
<tr>
<th>TABLE 5 Normal Machining Allowances for Hot-Worked Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finished-Machined Dimensions for Finishes As Indicated below, in. (mm)</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>On Diameter Between Parallel Surfaces of Square Bars</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>Hot-worked:</td>
</tr>
<tr>
<td>Up to ½ (22.2), incl</td>
</tr>
<tr>
<td>Over ½ to 1½ (22.2 to 47.6), incl</td>
</tr>
<tr>
<td>Over 1½ to 2½ (47.6 to 73.0), incl</td>
</tr>
<tr>
<td>Over 2½ to 3½ (73.0 to 96.8), incl</td>
</tr>
<tr>
<td>Over 3½ (96.8)</td>
</tr>
<tr>
<td>Hot-worked rods, rough-turned or rough ground:</td>
</tr>
<tr>
<td>1½ to 4 (23.8 to 101.6), incl in diameter</td>
</tr>
<tr>
<td>Over 4 to 12 (101.6 to 304.8), incl in diameter</td>
</tr>
</tbody>
</table>

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.
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 tested by the purchaser 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 test, the producer or supplier may make claim for a rehearing.

15. Certification

15.1 When specified in the purchase order or contract, a manufacturer’s certification shall be furnished to the purchaser stating that the material was manufactured, tested, and inspected in accordance with this specification and that test results on representative samples meet specification 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 number; 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 bar; rod; UNS N06625; UNS N06219; UNS N06650
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 Finished, Annealed, or Solution-Annealed*—Soft, with a tightly adherent dark oxide.

X1.1.2 *Hot Finished, Annealed or Solution 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 or solution 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 parts 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 and over; 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 2.5 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 defects 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-Drawn, Annealed, or Solution-Annealed, and Pickled*—Hot finished, overhauled, cold-drawn, annealed or solution-annealed, descaled, and straightened.