



# Standard Specification for Niobium-Hafnium Alloy Bar, Rod, and Wire<sup>1</sup>

This standard is issued under the fixed designation B 655/B 655M; 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.

## 1. Scope

1.1 This specification covers hafnium alloyed niobium bar, rod, and wire.

1.2 The material covered by this specification is R04295, niobium-base alloy containing approximately 10 % hafnium and 1 % titanium.

1.3 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.4 The following safety hazards caveat pertains only to the test methods portion, Section 14, 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 establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

B 652/B 652M Specification for Niobium-Hafnium Alloy Ingots

E 8 Test Methods for Tension Testing of Metallic Materials

E 21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials

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

## 3. Terminology

### 3.1 Definitions:

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee B10 on Reactive and Refractory Metals and Alloys and is the direct responsibility of Subcommittee B10.03 on Niobium and Tantalum.

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<sup>2</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.

3.1.1 *bar, n*—material less than 6 in. [150 mm] in width and 0.187 in. [4.8 mm] or greater in thickness, with a rectangular or square cross section, supplied in straight lengths.

3.1.2 *lot, n*—a lot is defined as that material produced from one ingot and heat treated at the same conditions.

3.1.3 *rod, n*—material 0.125 to 2½ in. [3.2 to 64 mm] in diameter in round, hexagonal, or octagonal cross section supplied in straight lengths.

3.1.4 *wire, n*—material 0.020 to 0.124 in. [0.50 to 3.2 mm] in diameter furnished in coils, spools, or on reels. Material less than 0.020 in. [0.50 mm] in diameter is not covered in this specification.

## 4. Ordering Information

4.1 Orders for material under this specification should include the following information as applicable:

4.1.1 General alloy description (see 1.2) and ASTM designation and year of issue,

4.1.2 Quantity in weight or pieces,

4.1.3 Size, diameter, and length,

4.1.4 Chemical Composition (Section 6),

4.1.5 Temper (Section 7),

4.1.6 Mechanical test temperature and limits (Sections 8 and 14),

4.1.7 Permissible dimensional tolerances and weight or quantity variations (see 9.2 and 9.4),

4.1.8 Quality and finish (see 10.2),

4.1.9 Sampling (see 13.2),

4.1.10 Inspection witnessing (see 15.2),

4.1.11 Certification requirements (Section 18), and

4.1.12 Packaging (Section 20),

## 5. Materials and Manufacture

5.1 Materials covered by this specification shall be made from ingots in accordance with Specification B 652/B 652M.

5.2 The various niobium-hafnium alloy products covered by this specification are formed with the conventional extrusion, forging, swaging, rolling, and drawing equipment normally available in metal working plants.

## 6. Chemical Composition

6.1 The chemical composition of niobium-hafnium alloy ingots and billets for conversion to finished products covered by this specification shall conform to the requirements prescribed in Table 1. Analysis for elements, not listed in Table 1 and not normally expected in niobium-hafnium alloy, shall not be required unless specified at time of purchase.

6.2 The manufacturer's ingot analysis shall be considered the chemical analysis for products supplied under this specification.

6.3 When specified in the purchase order, the manufacturer shall test the product for elements specified in Table 2. The results of the tests shall meet the limits shown in Table 2.

## 7. Temper Designations

7.1 Unless otherwise stated, the materials supplied under this specification shall be in the annealed condition, defined as at least 90 % recrystallized.

7.2 Other temper designations, such as cold-worked temper or a stress-relieved temper can be specified as agreed upon between purchaser and the manufacturer at the time of purchase.

## 8. Mechanical Requirements

8.1 Materials in the annealed condition supplied under this specification shall conform to the requirements for mechanical properties as prescribed in Table 3. Unless otherwise specified in the purchase, the materials shall conform to the requirements for room temperature mechanical properties. In lieu of or in addition to the room temperature properties, the purchaser may specify elevated temperature mechanical properties in the purchase order.

## 9. Permissible Variations

9.1 *Tolerances on Rounds*—Tolerances on niobium-hafnium alloy round products covered by this specification shall be as prescribed in Table 4.

9.2 *Tolerances for Square, Rectangular, or Other Shapes*—Tolerances for forged or rolled square, rectangular, or other shapes shall be as agreed upon between the purchaser and manufacturer at the time of purchase.

9.3 *Other Tolerances and Limitations:*

9.3.1 The permissible variation in cut lengths shall not exceed a total of ¼ in. [6.5 mm].

**TABLE 1 Chemical Requirements (Ingot)**

Niobium-Hafnium Alloy Grade R04295	
Element	Content, Maximum Weight %, (Except Where Otherwise Specified)
Carbon	0.015
Oxygen	0.025
Nitrogen	0.010
Hydrogen	0.0015
Hafnium	9–11
Titanium	0.7–1.3
Zirconium	0.700
Tungsten	0.500
Tantalum	0.500
Niobium by difference	

**TABLE 2 Additional Chemical Requirements for Finished Product (When Specified by Purchaser)**

Niobium-Hafnium Alloy Grade R04295	
Element	Content, Maximum Weight %
Oxygen	0.035
Carbon	0.015
Nitrogen	0.010
Hydrogen	0.0015

9.3.2 The permissible variation in straightness of rounds shall not exceed 0.050 in. [1.25 mm] per foot [300 mm] in any length.

9.4 *Quantity or Weight*—For orders up to 100 ft [30 m] the manufacturer may overship up to 20 %. For orders up to 1000 lb [450 kg] or 1000 ft [300 m], the manufacturer may overship up to 10 %. The permissible overshipment for orders larger than this quantity shall be negotiated at the time of purchase.

## 10. Quality and Finish

10.1 Niobium-hafnium alloy bar, rod, and wire shall be free of injurious external and internal imperfections of a nature that will interfere with the purpose for which it is intended. Material may be finished as forged, rolled, swaged, drawn; in a cleaned, machined, or ground condition. The manufacturer shall be permitted to remove minor surface imperfections provided such removal does not reduce the dimensions below the minimum permitted by the tolerances in accordance with Section 9.

10.2 Test methods for these defects and standards of acceptability shall be as agreed upon between the purchaser and the manufacturer at the time of purchase.

## 11. Retests

11.1 If any sample or specimen exhibits obvious surface contamination or improper preparation disqualifying it as a truly representative sample, it shall be discarded and a new sample or specimen substituted.

11.2 In case of a failure, two additional specimens shall be retested. If both retest specimens conform to this specification, the original values shall be discarded and the material accepted.

11.3 If the results of the tests are not in conformance with the requirements of this specification, the lot may be reworked at the option of the manufacturer. The lot shall be acceptable if the results of all tests, after reworking, conform to this specification.

## 12. Significance of Numerical Limits

12.1 The following applies to all specified limits in this standard for purposes of determining conformance with this specification. The observed value or a calculated value shall be rounded off to the nearest unit in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E 29.

## 13. Sampling

13.1 Samples shall be taken from the material to determine conformity to this specification. The samples shall be taken so as to be representative of the finished products.

**TABLE 3 Mechanical Properties for Material, Annealed Condition<sup>A</sup> (90 % Minimum Recrystallized)**

	Ultimate Tensile Strength, min, psi [MPa]	Yield Strength (0.2 % off- set), min, psi [MPa]	Elongation in 1- in. [25-mm] gage length, min, %
Material 0.050 in. [1.27 mm] and smaller in diameter:			
Room temperature:	56 000 [385]	40 000 [275]	20
2000± 25°F [1100 ± 15°C]:	21 000 [145]	16 000 [110]	20
Material 0.051 in. [1.20 mm] and larger in diameter:			
Room temperature:	54 000 [370]	38 000 [260]	20
2000± 25°F [1100 ± 15°C]:	21 000 [145]	16 000 [110]	20

<sup>A</sup> Refer to Section 9 for conditions of mechanical property tests.

**TABLE 4 Permissible Variations in Dimensions for Rolled, Swaged, or Drawn Round Bar, Rod, and Wire**

Diameter, in. [mm]	Tolerances, + or - , in. [mm]	
0.020–0.030 excl [0.50–0.75]	0.00075	[0.02]
0.030–0.060 excl [0.75–1.50]	0.001	[0.03]
0.060–0.090 excl [1.50–2.3]	0.0015	[0.04]
0.090–0.125 excl [2.3–3.2]	0.002	[0.05]
0.125–0.187 excl [3.2–4.8]	0.003	[0.08]
0.187–0.375 excl [4.8–9.5]	0.004	[0.10]
0.375–0.500 excl [9.5–12.7]	0.005	[0.13]
0.500–0.625 excl [12.7–17]	0.007	[0.18]
0.625–0.750 excl [17–19]	0.008	[0.20]
0.750–1.000 excl [19–25]	0.010	[0.25]
1.000–1.500 excl [25–40]	0.015	[0.38]
1.500–2.000 excl [40–50]	0.020	[0.50]
2.000–2.500 excl [50–63]	0.030	[0.8]

13.2 Care shall be exercised to ensure that the sample selected for testing is representative of the material, and that it is not contaminated by the sampling procedure. If there is any question relating to the sampling techniques or analysis thereof, the methods of sampling and analysis shall be as agreed upon between the manufacturer and the purchaser.

#### 14. Test Methods

14.1 The tensile limits shall apply to samples taken in either the longitudinal or transverse direction of processing.

14.2 *Room Temperature Tension Test*—Conduct room temperature tension tests in accordance with Test Methods E 8. Determine the yield strength by the 0.2 % offset method. Small size 1-in. [25-mm] gage length specimens, proportional to the standard specimen, can be used. Determine tensile properties using a strain rate of 0.003 to 0.007 in./in.·min [mm/mm·min] through the yield point. After the yield strength has been exceeded, increase the cross-head speed to approximately 0.05 in./in.·min [mm/mm·min] to failure.

14.3 *Elevated Temperature Tension Tests*—Conduct elevated temperature tension tests in accordance with Section 8 and Test Methods E 21. One inch [25 mm] gage lengths can be used. Strain rates shall be as agreed upon by purchaser and seller.

14.4 *Chemical Tests*—Conduct the chemical analyses by the standard techniques normally used by the manufacturer.

#### 15. Inspection

15.1 The manufacturer shall inspect the material covered by this specification prior to shipment.

15.2 If so specified on the purchase order, the purchaser or his representative may witness the testing and inspection of the material at the place of manufacture. In such cases, the purchaser shall state in his purchase order which tests he desires to witness. The manufacturer shall give ample notice to the purchaser as to the time and place of the designated test. If the purchaser's representative does not present himself at the agreed upon time for the testing, and if no new date is agreed upon, the manufacturer shall consider the requirement for the purchaser's inspection at the place of manufacturer to be waived. When the inspector representing the purchaser does appear at the appointed time and place, the manufacturer shall afford him, without charge, all reasonable facilities to see that the material is being furnished in accordance with this specification. This inspection shall be conducted so as not to interfere unnecessarily with production operations.

#### 16. Rejection and Rehearing

16.1 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 test, the producer or supplier may make claim for a rehearing.

#### 17. Referee

17.1 In the event of disagreement between the manufacturer and the purchaser of the conformance of the material to the requirements of this specification, or any special tests specified by the purchaser, a mutually acceptable referee shall perform the tests in question. The results of the referee's testing shall be used in determining conformance of the material to this specification.

#### 18. Certification

18.1 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.

#### 19. Product Marking

19.1 Each bar, rod, bundle, box, coil, or spool shall be marked or tagged legibly and conspicuously with the number of this specification; temper; heat number; manufacturer's

identification; nominal size; and the gross, net, and tare weights. If marking fluids are used, they shall be of such a nature as to be removed easily with cleaning solutions. The markings or their removal shall have no deleterious effect upon the material or its performance. The characters shall be sufficiently stable to withstand ordinary handling.

## **20. Packaging and Package Marking**

20.1 Unless otherwise specified, material purchased under this specification must be packed by box or suitable protective containers, and should be so marked as to indicate the nature of the best handling.

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## **21. Keywords**

21.1 niobium-hafnium alloy bar; niobium-hafnium alloy rod; niobium-hafnium alloy wire