



Designation: B 654 – 03

## Standard Specification for Niobium-Hafnium Alloy Foil, Sheet, Strip, and Plate<sup>1</sup>

This standard is issued under the fixed designation B 654; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### 1. Scope

1.1 This specification covers niobium-hafnium-titanium alloy foil, sheet, strip, and plate.

NOTE 1—Committee B10 has adopted “niobium” as the designation for Element 41, formerly named “columbium.”

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

1.3 Except for dimensional tolerances in Table 4, the values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *The following safety hazards caveat pertains only to the test methods portion, Section 15, of this specification: This standard does not purport to address all of the safety problems, 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:*

B 652 Specification for Niobium-Hafnium Alloy Ingots<sup>2</sup>

E 8 Test Methods for Tension Testing of Metallic Materials<sup>3</sup>

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>4</sup>

### 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *foil*—a flat product less than 6 in. (152.4 mm) wide and less than 0.005 in. (0.13 mm) in thickness.

3.1.2 *sheet*—a flat product 6 in. (152.4 mm) or more in width and from 0.005 in. (0.13 mm) to  $\frac{3}{16}$  in. (4.76 mm) in thickness.

3.1.3 *strip*—a flat product, may be supplied in coil, less than 6 in. (152.4 mm) wide and from 0.005 in. (0.13 mm) to  $\frac{3}{16}$  in. (4.76 mm) in thickness.

3.1.4 *plate*—a flat product 6 in. (152.4 mm) or more in width and more than  $\frac{3}{16}$  in. (4.76 mm) in thickness.

### 4. Ordering Information

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

4.1.1 Type material (Section 1),

4.1.2 Quantity in number of pieces, dimensions, and weight,

4.1.3 Chemistry (see 6.3),

4.1.4 Temper designation (Section 8),

4.1.5 Permissible overshipments (see 10.3),

4.1.6 Quality and finish (see 12.2),

4.1.7 Sampling (see 13.2),

4.1.8 Elevated temperature mechanical properties (see 15.4),

4.1.9 Required reports (Section 16),

4.1.10 Inspection (Section 17), and

4.1.11 Packaging (Section 21).

### 5. Materials and Manufacture

5.1 Material covered by this specification shall be made from ingots conforming to Specification B 652, that are produced by vacuum-arc melting, or electron-beam furnace melting, or a combination of the two.

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

### 6. Chemical Composition

6.1 The niobium-hafnium alloy ingots and billets for conversion to finished products covered by this specification shall conform to the requirements for chemical composition as 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 Upon request of the purchaser at the time of purchase, the seller shall furnish a report certifying the values of the interstitial elements (carbon, oxygen, nitrogen, hydrogen) as specified in Table 2 for each lot of material supplied. A lot is defined as that material produced from one ingot, heat treated at the same time.

<sup>1</sup> This specification is under the jurisdiction of 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> *Annual Book of ASTM Standards*, Vol 02.04.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 03.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 14.02.

**TABLE 1 Chemical Requirements (Ingot)**

Niobium – Hafnium Alloy R04295	
Element	Content, Weight % <sup>A</sup>
C	0.015
O	0.025
N	0.010
H	0.0015
Hf	9–11
Ti	0.7–1.3
Zr	0.700
W	0.500
Ta	0.500
Nb by difference	

<sup>A</sup> Values are maximum unless otherwise shown.

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

Niobium – Hafnium Alloy R04295	
Element	Maximum Content, Weight %
O	0.035
C	0.015
N	0.010
H	0.0015

## 7. Methods of Chemical Analysis

7.1 The chemical compositions enumerated in this specification shall, in the case of disagreement, be determined in accordance with the methods as agreed upon between supplier and purchaser for referee purposes.

## 8. Temper Designations

8.1 Unless otherwise stated, the materials supplied under this specification shall be in the fully annealed condition.

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

## 9. Mechanical Properties

9.1 Materials in the annealed condition supplied under this specification shall conform to the requirements for mechanical properties as specified in Table 3 by test methods specified in Section 15.

## 10. Permissible Variations

10.1 Tolerances for thickness, width, and length for flat-rolled products covered by this specification shall be as shown in Table 4.

10.2 Flatness tolerance for sheet and plate products supplied under this specification shall be 6 % maximum, as determined by the following equation (see Fig. 1):

$$\text{Flatness, \%} = (H/L) \times 100 \quad (1)$$

where:

*H* = maximum vertical distance between a flat reference surface and the lower surface of the sheet, and

*L* = minimum horizontal distance between the highest point on the sheet and the point of contact with a flat reference surface. (The method for taking measurements for calculation of sheet flatness is shown in Fig. 1. However, a value of *H* less than 1/32 in. (0.07 mm) shall not be cause for rejection.)

10.3 *Quantity or Weight*—For orders requiring up to 100 lb (45.4 kg), the manufacturer may overship by 20 %. When the order is for quantities up to 1000 lb (454 kg), the manufacturer may overship by 10 %. The permissible overshipment for quantities larger than 1000 lb shall be negotiated between the purchaser and seller.

## 11. Significance of Numerical Limits

11.1 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.

## 12. Quality and Finish

12.1 Niobium-hafnium alloy foil, sheet, strip, and plate shall be free of injurious internal and external imperfections of a nature that will interfere with the purpose for which it was intended. Material may be supplied in the as-rolled and cleaned or ground finish. For material shipped in either condition, the manufacturer shall be permitted to remove minor surface imperfections, if such removal does not reduce the dimensions below the minimum permitted by the tolerances specified in Table 4.

12.2 Methods of testing for these defects, and the standards of acceptability, shall be as agreed upon between the purchaser and the manufacturer.

## 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 % offset), min, psi (MPa)	Elongation in 1 in. (25 mm) Gage Length, min, %	Bend Test Radius (t is material thickness)
Material 0.050 in. (1.27 mm) and thinner:				
Room temperature	56 000 (386)	40 000 (276)	20	2t
2000 ± 25°F (1093 ± 14°C)	21 000 (145)	16 000 (110)	20	2t
Material 0.051 in. (1.29 mm) and thicker:				
Room temperature	54 000 (372)	38 000 (262)	20	2½t
2000 ± 25°F (1093 ± 14°C)	21 000 (145)	16 000 (110)	20	2½t

<sup>A</sup> Refer to Section 15 for conditions of mechanical property tests.