



Designation: B737 – 05

Standard Specification for Hot-Rolled and/or Cold-Finished Hafnium Rod and Wire¹

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1. Scope

1.1 This specification covers hot- or cold-worked hafnium rod and wire, or both.

1.2 This specification contains two material grades, one specifically for nuclear applications (Grade R1) and one for commercial applications for alloying (Grade R3).

1.3 The products covered include the following:

1.3.1 Rod $\frac{3}{8}$ to 1 in. (9.5 to 25 mm) in diameter.

1.3.2 Wire less than $\frac{3}{8}$ in. (9.5 mm) in diameter.

1.4 Unless a single unit is used, for example, corrosion mass gain in mg/dm^2 , the values stated in either inch-pound or SI units are to be regarded separately as standard. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. SI values cannot be mixed with inch-pound values.

1.5 *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:*²

E8 Test Methods for Tension Testing of Metallic Materials

E21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

3. Terminology

3.1 *Lot Definitions:*

¹ This specification is under the jurisdiction of ASTM Committee B10 on Reactive and Refractory Metals and Alloys and is the direct responsibility of Subcommittee B10.02 on Zirconium and Hafnium.

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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.

3.1.1 *castings, n*—a lot shall consist of all castings produced from the same pour.

3.1.2 *ingot, n*—no definition required.

3.1.3 *rounds, flats, tubes, and wrought powder metallurgical products (single definition, common to nuclear and non-nuclear standards), n*—a lot shall consist of a material of the same size, shape, condition, and finish produced from the same ingot or powder blend by the same reduction schedule and the same heat treatment parameters. Unless otherwise agreed between manufacturer and purchaser, a lot shall be limited to the product of an 8 h period for final continuous anneal, or to a single furnace load for final batch anneal.

3.1.4 *sponge, n*—a lot shall consist of a single blend produced at one time.

3.1.5 *weld fittings, n*—definition is to be mutually agreed upon between manufacturer and the purchaser.

4. Ordering Information

4.1 Purchase orders for material under this specification shall include the following information as required to adequately describe the desired material:

4.1.1 Quantity (weight or number of pieces),

4.1.2 Name of material,

4.1.3 Form (rod, wire),

4.1.4 Finish (Section 12),

4.1.5 Applicable dimensions (diameter and length),

4.1.6 Grade (Table 1),

4.1.7 ASTM designation and year of issue,

4.1.8 Zirconium analysis requirements (Table 1), and

4.1.9 Workmanship standards (Section 13).

NOTE 1—A typical ordering description is as follows: 500 lb hafnium rod, annealed; mechanically descaled and pickled; 0.375 in. diameter by 6 in. minimum random lengths; Grade R1; ASTM Specification B737 - 01.

4.2 In addition to the data specified in 4.1, the following options and points of agreement between the manufacturer and the purchaser shall be specified on the purchase order if required:

4.2.1 Mechanical test temperature (see 8.1),

4.2.2 Straightness (Table 2),

4.2.3 Special tests (Section 11),

4.2.4 Inspection (Section 16),

TABLE 1 Chemical Requirements

Composition, Weight %			
Element	Nuclear Grade		Alloying Grade
	Grade R1	Grade R3	
Aluminum	0.010	0.050	
Carbon	0.015	0.025	
Chromium	0.010	0.050	
Copper	0.010	...	
Hydrogen	0.0025	0.0050	
Iron	0.050	0.0750	
Molybdenum	0.0020	...	
Nickel	0.0050	...	
Niobium	0.010	...	
Nitrogen	0.010	0.0150	
Oxygen	0.040	0.130	
Silicon	0.010	0.050	
Tantalum	0.020	...	
Tin	0.0050	...	
Titanium	0.010	0.050	
Tungsten	0.0150	0.0150	
Uranium	0.0010	...	
Vanadium	0.0050	...	
Zirconium	A	A	
Hafnium ^B	balance	balance	

^A Zirconium shall be reported. Acceptable levels shall be established by mutual agreement between purchaser and producer.

^B Hafnium isotopic composition and analytical methods, if required, shall be mutually agreed upon by the purchaser and producer.

TABLE 2 Permissible Variations in Straightness for Straight Lengths Hot- or Cold-Finished Rod and Wire^A

Diameter, in. (mm)	Permissible Variations
Up to 3/8 (9.5), incl	3/32 in. (2.4 mm) in any 5 ft (1.5 m) but may not exceed 3/32 in. (2.4 mm) × (number of feet in length/5)
Over 3/8 to 1.0 (9.5 to 25)	1/16 in. (1.6 mm) in any 5 ft (1.5 m) but may not exceed 1/16 in. (1.6 mm) × (number of feet in length/5)

^A The measurement is taken on the concave side of the bar with a straight-edge. Unless otherwise specified, hot- or cold-finished bars for machining purposes are furnished machine straightened to the tolerances specified in the table.

- 4.2.5 Hafnium isotopic composition and its analysis, ([Table 1](#)),
- 4.2.6 Metallurgical condition ([Section 6](#)),
- 4.2.7 Corrosion test Grade 3 ([9.3](#)),
- 4.2.8 Rejected material return ([Section 17](#)), and
- 4.2.9 Certification requirements ([Section 19](#)).

5. Materials and Manufacture

5.1 Material covered by this specification shall be made by conventional hot and cold working procedures, from ingots produced by vacuum melting in electron beam or consumable arc furnaces, or both, of a type conventionally used for reactive metals.

6. Metallurgical Condition

6.1 All grades furnished under this specification shall be in the recrystallization annealed condition unless otherwise specified.

7. Chemical Composition

7.1 The material shall conform to the requirements for chemical composition as prescribed in [Table 1](#).

7.2 The manufacturer's ingot analysis shall be considered the chemical analysis for material produced to this specification except for hydrogen and nitrogen content which shall be determined on the finished product.

7.3 Analysis shall be made using the manufacturer's standard methods. In the event of disagreement as to the chemical composition of the metal, methods of chemical analysis for reference purposes shall be determined by a mutually acceptable laboratory.

7.4 Sampling for chemical composition shall consist of samples taken at top, middle, and bottom of the ingot. Samples for hydrogen and nitrogen shall be taken as two random samples from each lot at final size.

8. Mechanical Properties

8.1 Grade R1 in rod form shall conform to the requirements prescribed in [Table 3](#) for room temperature mechanical properties. Elevated temperature properties shall be used to determine compliance only when specified in the purchase order (see [Test Methods E21](#)).

8.2 The yield strength shall be determined by the offset (0.2 %) method as prescribed in [Test Methods E8](#).

8.3 The tensile properties shall be determined using a strain rate of 0.003 to 0.007 in./in.[mm/mm]-min through the yield strength. After the yield strength has been exceeded, the cross-head speed shall be increased to approximately 0.05 in./in.[mm/mm]-min to failure.

8.4 Requirements for mechanical properties do not apply to wire.

9. Corrosion Properties

9.1 Two samples chosen at random from each lot shall be corrosion tested in water at 680°F (360°C), 2690 psi (18.5 MPa) for 672 + 8 – 0 h using the manufacturer's standard procedure.

9.2 *Grade R1*—Coupons shall exhibit a weight gain of not more than 10 mg/dm².

9.3 *Grade R3*—Test for information only, if required by purchase order.

10. Permissible Variations in Dimensions

10.1 Rod and wire shall conform to the dimensional requirements for the specified product as prescribed in [Table 2](#), [Table 4](#), and [Table 5](#).

11. Special Tests

11.1 Additional tests may be specified in the purchase order. The test method and standards shall be agreed upon in advance between manufacturer and purchaser.

TABLE 3 Mechanical Properties

Grade	Condition	Test Temperature	Tensile Strength, min ksi (MPa)	Yield Strength, min ksi (MPa)	Elongation in 2 in. or 50 mm, min, %
R1	annealed	RT	58 (400)	22 (150)	22
	annealed	600°F (315°C)	25 (170)	11 (75)	32