Designation: B737 – 10 (Reapproved 2015)

Standard Specification for Hot-Rolled and/or Cold-Finished Hafnium Rod and Wire[1]

This standard is issued under the fixed designation B737; 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.

1. Scope

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

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

1.3 The products covered include the following:

1.3.1 Rod ⅜ to 1 in. (9.5 to 25 mm) in diameter.

1.3.2 Wire less than ⅜ 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

E2626 Guide for Spectrometric Analysis of Reactive and Refractory Metals

3. Terminology

3.1 *Definitions:*

3.1.1 *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.

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 Mechanical test requirements for Grade R3 (Section 8),

4.2.3 Straightness (Table 2),

4.2.4 Special tests (Section 11),

4.2.5 Inspection (Section 16),

4.2.6 Hafnium isotopic composition and its analysis, (Table 1),

4.2.7 Metallurgical condition (Section 6),

4.2.8 Corrosion test Grade 3 (9.3),

4.2.9 Rejected material return (Section 17), and

4.2.10 Certification requirements (Section 19).

[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.

TABLE 1 Chemical Requirements — Maximum Impurity Level

Element	Composition, Weight %	
	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; number of meters in length / 1.52)
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; number of meters in length / 1.52)

[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.

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.

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/dm^2.

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.

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, %[A]
R1	annealed	RT	58 (400)	22 (150)	22
	annealed	600°F (315°C)	25 (170)	11 (75)	32

[A] When a sub-size specimen is used, the gage length shall be as specified in Test Methods E8.

TABLE 4 Permissible Variations in Diameter for Hot- or Cold-Finished Rod and Wire

Diameters, in. (mm)	Permissible Variations, in. (mm)[A]
Up to 3/16 (4.8), incl	±0.002 (0.05)
Over 3/16 to 5/8 (4.8 to 16), incl	±0.003 (0.08)
Over 5/8 to 3/4 (16 to 19), incl	±0.004 (0.10)
Over 3/4 to 1.0 (19 to 25), incl	±0.005 (0.13)

[A] When it is necessary to heat treat or heat treat and pickle after cold finishing, because of special hardness, surface or mechanical property requirements, tolerances are double those shown in the table.

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.

12. Finish

12.1 Rods shall be furnished with one of the following surface finishes as designated in the purchase order:

12.1.1 Mechanically descaled and pickled,

12.1.2 Centerless ground and pickled, or

12.1.3 Centerless ground, pickled, and oxidized.

12.2 Wire shall be furnished with one of the following surface finishes as designated in the purchase order:

12.2.1 Conditioned and pickled, or

12.2.2 Conditioned, pickled, and oxidized.

13. Workmanship

13.1 Cracks, seams, slivers, blisters, burrs, and other injurious imperfections shall not exceed standards of acceptability agreed upon by the manufacturer and the purchaser.

14. Number of Test and Retests

14.1 Two random samples shall be taken from each lot.

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

14.3 If the results of any test lot are not in conformance with the requirements of this specification, the lot may be retested at the option of the manufacturer. The frequency of the retest will be double the initial number of tests and if the results of the retest conform to the specification, then the retest values will become the test values for certification. All test values, original and retest, shall be reported to the purchaser.

15. Significance of Numerical Limits

15.1 For the purpose of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value or a calculated value shall be rounded as indicated in accordance with the rounding methods of Practice E29.

Property	Rounded Unit for Observed or Calculated Value
Chemical composition, and tolerances (when expressed as decimals)	nearest unit in the last right-hand place of figures of the specified limit
Tensile strength and yield strength	nearest 1000 psi (10 MPa)
Elongation	nearest 1 %

16. Inspection

16.1 The manufacturer shall inspect the material covered by this specification prior to shipment. If so specified in 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 test he desires to witness. The manufacturer shall give notice to the purchaser as to the time and place of the designated tests. If the purchaser's representative does not present himself at the time agreed upon for the testing, the manufacturer shall consider the requirement for purchaser's inspection at place of manufacture to be waived.

16.2 The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. This inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. Rejection

17.1 Rejection for failure of the material to meet the requirements of this specification shall be reported to the manufacturer within 60 calendar days from the receipt of the material by the purchaser. Unless otherwise specified, rejected material may be returned to the manufacturer at the manufacturer's expense, unless the purchaser receives, within 3 weeks of the notice of rejection, other instructions for disposition.

18. Referee

18.1 In the event of disagreement between the manufacturer and the purchaser on the conformance of the material to the requirements of this specification or any special test 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.

19. Certification

19.1 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. The certificate shall include a report of the test results.

20. Packaging and Package Marking

20.1 Each shipment shall be legibly and conspicuously marked or tagged with the following information:

20.1.1 Purchase order or contract number,

20.1.2 Name of material,

20.1.3 Grade,

20.1.4 Size,

20.1.5 Lot, heat or ingot number,

TABLE 5 Permissible Variations in Length for Hot- or Cold-Finished Rod and Wire

Diameter, in. (mm)	Permissible Variations, in. (mm)		
	Under 3 ft (1m)	3–12 ft (1–4m)	Over 12 ft (4m)
Up to ⅜ (9.5), incl	+ ¼, – 0 (+ 6.4, – 0)	+ ½, – 0 (+ 13, – 0)	+ ¾, – 0 (+ 19, – 0)
Over ⅜ to 1 (9.5 to 25)	+ ¼, – 0 (+ 6.4, – 0)	+ ⅜, – 0 (+ 9.5, – 0)	+ ½, – 0 (+ 13, – 0)

20.1.6 Condition,

20.1.7 Gross, net, and tare weights, and

20.1.8 ASTM specification designation number.

20.2 All material shall be packaged in such a manner as to ensure safe delivery to its destination when properly transported by any common carrier.

21. Keywords

21.1 hafnium; hafnium alloy; rod; wire