



Designation: B 737 – 90 (Reapproved 2000)

## Standard Specification for Hot-Rolled and/or Cold-Finished Hafnium Rod and Wire<sup>1</sup>

This standard is issued under the fixed designation B 737; 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 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 1.0 in. (9.5 to 25.4 mm) in diameter.

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

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

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:*

E 8 Test Methods for Tension Testing of Metallic Materials<sup>2</sup>

E 21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials<sup>2</sup>

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>3</sup>

### 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *lot*—a lot shall consist of all material of the same mill size, shape, and condition produced from the same ingot by the same reduction schedule and the same final heat treating conditions.

### 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 Metallurgical condition (Section 6),

4.1.5 Finish (Section 12),

4.1.6 Applicable dimensions (diameter and length),

4.1.7 Grade (Table 1), and

4.1.8 ASTM designation and year of issue.

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 B 737.

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 Tolerances (Section 10),

4.2.3 Workmanship standards (Section 13),

4.2.4 Special tests (Section 11),

4.2.5 Inspection (Section 16),

4.2.6 Zirconium analysis requirements (Table 1), and

4.2.7 The isotopic hafnium composition and its analysis, if required, shall be mutually agreed upon by the purchaser and producer.

### 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.

<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 B10.02 on Zirconium and Hafnium.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 03.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 14.02.

**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             | <sup>A</sup>  | <sup>A</sup>   |
| Hafnium               | balance       | balance        |

<sup>A</sup> Zirconium shall be reported. Acceptable levels shall be established by mutual agreement between purchaser and producer.

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 2 for room temperature mechanical properties. Elevated temperature properties shall be used to determine compliance only when specified in the purchase order (see Test Methods E 21).

8.2 The yield strength shall be determined by the offset (0.2 %) method as prescribed in Test Methods E 8.

8.3 The tensile properties shall be determined using a strain rate of 0.003 to 0.007 in./in.·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.·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<sup>2</sup>.

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 Tables 3-5.

## 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.

## 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 E 29.

**TABLE 2 Mechanical Properties**

| Grade | Condition | Test Temperature | Tensile Strength, min | Yield Strength, min | Elongation in 2 in. or 50 mm, min, % |
|-------|-----------|------------------|-----------------------|---------------------|--------------------------------------|
|       |           |                  | ksi (MPa)             | ksi (MPa)           |                                      |
| R1    | annealed  | RT               | 58 (400)              | 22 (151)            | 22                                   |
|       | annealed  | 600°F (316°C)    | 25 (172)              | 11 (83)             | 32                                   |