



Designation: B776 – 12 (Reapproved 2024)

Standard Specification for Hafnium and Hafnium Alloy Strip, Sheet, and Plate¹

This standard is issued under the fixed designation B776; 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 two grades of wrought hafnium and hafnium alloy strip, sheet, and plate as follows:

- 1.1.1 Grade R1 for nuclear applications, and
- 1.1.2 Grade R3 for commercial applications.

1.2 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.

1.3 The following precautionary caveat pertains only to the test method portions 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

- E8/E8M 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

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. Terminology

3.1 *Lot Definition:*

3.1.1 *lot, n*—a lot shall consist of a material of the same size, shape, condition, and finish produced from the same ingot by the same reduction schedule and the same heat treatment parameters. Unless otherwise agreed upon 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.

3.2 *Forms:*

3.2.1 *strip, n*—a flat product, may be supplied in coil, less than 6 in. (150 mm) in width and from 0.005 in. to 0.188 in. (0.13 mm to 4.8 mm) in thickness.

3.2.2 *sheet, n*—a flat product 6 in. (150 mm) or more in width and from 0.005 in. to 0.188 in. (0.13 mm to 4.8 mm) in thickness.

3.2.3 *plate, n*—a flat product more than 0.125 in. (3.2 mm) in thickness.

4. Classification

4.1 The strip, sheet, or plate is to be furnished in two grades as follows:

- 4.1.1 Grade R1 (Nuclear)—Unalloyed.
- 4.1.2 Grade R3 (Commercial)—Unalloyed.

5. Ordering Information

5.1 Purchase orders for materials under this specification shall include the following information as applicable:

- 5.1.1 Quantity (weight or number of pieces),
- 5.1.2 Form (3.2) and dimensions,
- 5.1.3 Grade (4.1),
- 5.1.4 Lot definition for continuous anneal, if applicable (3.1),
- 5.1.5 Metallurgical condition, if not in the recrystallized annealed condition (6.3),
- 5.1.6 Chemical analysis of elements not listed (7.1.3),
- 5.1.7 Product analysis (7.1.1.1 and 7.1.3),
- 5.1.8 Tensile test temperatures (8.1),
- 5.1.9 Mechanical properties, for Grade R3 (8.1),
- 5.1.10 Corrosion properties and testing, (9.1 and 9.1.3),
- 5.1.11 Material condition and finish (12.1 – 12.5),
- 5.1.12 Workmanship standards and methods of inspection (Section 13),

- 5.1.13 Purchaser inspection (16.1),
- 5.1.14 Rejection and referee (17.2),
- 5.1.15 Certification report (Section 18),
- 5.1.16 Product marking (Section 19), and
- 5.1.17 Packaging and package marking (Section 20).

NOTE 1—A typical ordering description is as follows: 28 pieces hafnium plate, annealed; mechanically descaled and pickled; 0.158 in. by 6.000 in. thick by 18 in. long lengths; Grade R1; ASTM B776 – 07.

6. Materials and Manufacture

6.1 Material covered by this specification shall be made from ingots that are produced by vacuum or plasma arc melting, vacuum electron-beam melting, a combination of these three methods, or other melting processes conventionally used for reactive metals. All processes to be done in furnaces usually used for reactive metals.

6.2 The various mill products covered by this specification shall be formed with the conventional extrusion, forging, or rolling equipment normally found in primary ferrous and nonferrous plants.

6.3 The sheet, strip, and plate shall be supplied in the recrystallized annealed condition unless otherwise specified in the purchase order.

7. Chemical Composition

7.1 The grades of R1 and R3 metal covered by this specification shall conform to the chemical composition requirements prescribed in Table 1.

7.1.1 The elements listed in Table 1 are intentional alloy additions or elements which are inherent to the manufacture of sponge, ingot, or mill product.

7.1.1.1 Elements other than those listed in Table 1 are deemed to be capable of occurring in the grades listed in Table 1 by and only by way of unregulated or unanalyzed scrap additions to the ingot melt. Therefore, product analysis for

TABLE 2 Check Analyses Limits

Element	Variations Under Min. or Over Max. %
Hydrogen	0.002
Nitrogen	0.01
Carbon	0.01
Zirconium	0.02
Iron and Chromium	0.025
Tin	0.05
Niobium	0.05
Oxygen	0.02

elements not listed in Table 1 shall not be required unless specified and shall be considered to be in excess of the intent of this specification.

7.1.2 Elements intentionally added to the melt must be identified, analyzed, and reported in the chemical analysis.

7.1.3 When agreed upon by producer and purchaser and requested by the purchaser in his written purchase order, chemical analysis shall be completed for specific residual elements not listed in this specification.

7.2 The manufacturer's ingot analysis shall be considered the chemical analysis, except for certain cases where tests on product are required, as specified in 14.1.1.

7.2.1 The ingot shall be sampled in sufficient places along the side wall so that the top sample is within 5 in. (125 mm) of the top face and the distance between samples or between the bottom face and a sample does not exceed one ingot diameter. A minimum of three samples per ingot is required.

7.2.2 These samples shall be analyzed for the alloying and impurity elements given in Table 1.

7.2.3 Alternatively, the manufacturer may sample an intermediate or final size during processing with the same frequency and in the same positions relative to the ingot as specified in 7.2.1 to determine the composition, except for hydrogen and nitrogen, which shall be determined on the finished product.

7.3 Check Analysis:

7.3.1 Check analysis is an analysis made by the purchaser or the manufacturer of the metal after it has been processed into finished mill forms, and is either for the purpose of verifying the composition of a heat or lot or to determine variations in composition within a heat or lot. Acceptance or rejection of a lot of material may be made by the purchaser on the basis of this check analysis.

7.3.2 Check analysis limits shall be as specified in Table 2. These limits are the amounts an individual result for a given element may vary under or over the specified limits shown in Table 1.

7.3.3 Check analysis tolerances do not broaden the specified heat analysis requirements but cover variations between laboratories in the measurement of chemical content.

7.3.4 The manufacturer shall not ship material that is outside the limits specified in Table 1 for the applicable grade.

8. Mechanical Properties

8.1 Grade R1 shall conform to the requirements prescribed in Table 3 for room temperature mechanical properties. Elevated temperature properties shall be used to determine

TABLE 1 Chemical Requirements

Elements	Composition, Weight	
	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	0.015
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	balance	balance

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