Designation: B 776 – 01a

Standard Specification for Hafnium and Hafnium Alloy Strip, Sheet, and Plate[1]

This standard is issued under the fixed designation B 776; 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 hafnium strip, sheet, and plate, one specifically for nuclear applications (Grade R1) and one for commercial applications for alloying (Grade R3).

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

1.3 *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[2]

E 21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials[2]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[3]

3. Terminology

3.1 *Lot Definitions:*

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

3.1.2 *ingot*—no definition required.

3.1.3 *rounds, flats, tubes, and wrought powder metallurgical products (single definition, common to nuclear and non-nuclear standards)*—a lot shall consist of a material of the same size, shape, condition, and finish produced from the 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*—a lot shall consist of a single blend produced at one time.

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

4. Classification

4.1 The strip, sheet, or plate is to be furnished in one of the two grades shown in Table 1.

5. Ordering Information

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

5.1.1 Quantity (weight or number of pieces),

5.1.2 Number of material,

5.1.3 Form (strip, sheet, plate),

5.1.4 Metallurgical condition (6.2),

5.1.5 Finish (Section 11),

5.1.6 Applicable dimensions (thickness, width, and length),

5.1.7 Grade (Table 1), and

5.1.8 ASTM designation and year of issue.

NOTE 1—A typical ordering description is as follows: twenty-eight pieces hafnium plate, annealed; mechanically descaled and pickled; 0.158 in. by 6.000 in. thick by 18-in. long lengths; Grade R1; ASTM B 776 – ___.

5.2 In addition to the data specified in 5.1, the following options and points of agreement between the manufacturer and the purchaser shall be specified on the purchase order if required:

5.2.1 Mechanical test temperature (see 8.1),

5.2.2 Tolerances (Section 10),

5.2.3 Workmanship standards (Section 11),

5.2.4 Special or alternate tests (Sections 8 and 14),

5.2.5 Inspection (Section 16),

5.2.6 Corrosion testing (Section 9),

5.2.7 Zirconium analysis requirements (Table 1), and

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

[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] *Annual Book of ASTM Standards*, Vol 03.01.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

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.

6. Materials and Manufacture

6.1 The sheet, strip, or plate covered by this specification shall be formed with conventional forging and rolling equipment found in primary ferrous and nonferrous metal plants, and made from ingots produced by vacuum melting in electron beam or consumable arc furnaces, or both, of a type conventionally used for reactive metals.

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

7. Chemical Compositions

7.1 The material shall conform to the chemical composition requirements prescribed in Table 1.

7.2 The manufacturer's ingot analysis shall be considered the chemical analysis for sheet, strip, and plate, except for hydrogen and nitrogen, which shall be determined on the finished product.

7.3 When requested by the purchaser and stated in the purchase order, a product analysis for any elements listed in Table 1 shall be made on the finished product.

7.3.1 The manufacturer's analysis shall be considered as verified if the check analysis confirms the manufacturer's reported values within the tolerances prescribed in Table 2.

TABLE 2 Permissible Variation in Check Analysis Between Different Laboratories

Element	Permissible Variation in Product Analysis, %
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

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 compliance only when specified in the purchase order.

9. Corrosion Properties

9.1 When required by the purchaser and stated in the purchase order, the following corrosion testing shall be performed:

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

9.1.2 *Grade R1*—Coupons shall exhibit a weight gain of not more than 10 mg/dm^2.

9.1.3 Grade R3 will be tested for information only, if required by purchase order.

10. Permissible Variations in Dimensions

10.1 *Thickness*—The variation in thickness of strip, sheet, and plate are given in the following tables:

10.1.1 Cold-rolled sheet, Table 4.

10.1.2 Hot-rolled strip, Table 5,

10.1.3 Cold-rolled strip, Table 6.

10.2 *Width and Length*—The variation in width and length are given in the following tables:

10.2.1 Hot- and cold-rolled sheet, Table 7 and Table 8.

10.2.2 Hot-rolled strip, Table 9.

10.2.3 Cold-rolled strip, Table 10.

10.3 *Crown Tolerances*—The variations in crown tolerances are given in the following tables:

10.3.1 Hot-rolled strip, Table 11.

10.3.2 Cold-rolled strip, Table 12.

10.4 *Camber Tolerances*—The variations in camber tolerances are given in the following tables:

10.4.1 Hot- and cold-rolled sheet, Table 13.

10.4.2 Hot- and cold-rolled strip, Table 14.

10.4.3 Plate, Table 15.

10.5 Flatness tolerances permissible for plate are given in Table 16.

11. Workmanship, Finish, and Appearance

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

TABLE 3 Mechanical Properties

Grade	Condition	Test Temperature	Tensile Strength, min ksi (MPa)	Yield Strength, min ksi (MPa)	Elongation, (min %) in 2 in. (50 mm)
Longitudinal:					
R1	annealed	RT	58 (400)	22 (151)	20
	annealed	600°F (316°C)	25 (172)	11 (83)	25
Transverse:					
R1	annealed	RT	45 (310)	25 (172)	20
	annealed	600°F (316°C)	23 (158)	14 (96)	30