



Designation: B 776 – 01

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

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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 Materials²

E 21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials²

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications³

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 thickness, shape, and condition produced from the same ingot by the same reduction schedule and the same final heat-treating conditions.

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:

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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

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

† Editorially corrected.

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 B776– ____.

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.

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.

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/dm².

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,

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

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.

11.2 Flat-rolled product in the hot-rolled condition shall be furnished with one of the following finishes as designated on the order.

11.2.1 Not descaled,

11.2.2 Mechanically descaled, and

TABLE 4 Permissible Variation in Thickness of Cold-Rolled Hafnium Sheet^A

Specified Thickness, in.	Permissible Variations In Thickness, ± in.
0.146 – 0.1875, excl	0.007
0.131 – 0.145	0.006
0.115 – 0.130	0.005
0.099 – 0.114	0.0045
0.084 – 0.098	0.004
0.073 – 0.083	0.0035
0.059 – 0.072	0.003
0.041 – 0.058	0.0025
0.027 – 0.040	0.002
0.017 – 0.026	0.0015
0.008 – 0.016	0.001
0.006 – 0.007	0.0008
0.005	0.0005

^AThickness measurements are taken at least 3/8 in. from edge.

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