



Designation: B495 – 22

Standard Specification for Zirconium and Zirconium Alloy Ingots¹

This standard is issued under the fixed designation B495; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope

1.1 This specification covers six grades of zirconium ingots.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 The following precautionary caveat pertains only to the test method portion, Section 10, 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

E114 Practice for Ultrasonic Pulse-Echo Straight-Beam Contact Testing

E2626 Guide for Spectrometric Analysis of Reactive and Refractory Metals (Withdrawn 2017)³

3. Terminology

3.1 *Lot Definitions:*

3.1.1 *ingot, n*—a quantity of metal cast into a shape suitable for subsequent processing to various mill products.

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 The last approved version of this historical standard is referenced on www.astm.org.

4. Classification

4.1 The ingots are furnished in nine grades as follows:

4.1.1 *Grade R60700*—Low oxygen unalloyed zirconium.

4.1.2 *Grade R60702*—Unalloyed zirconium.

4.1.3 *Grade R60703*—Unalloyed zirconium, metallurgical grade.

4.1.4 *Grade R60704*—Zirconium-tin alloy.

4.1.5 *Grade R60705*—Zirconium-niobium alloy.

4.1.6 *Grade R60706*—Zirconium-niobium alloy.

4.1.7 *Grade R61702*—Unalloyed zirconium, casting application.

4.1.8 *Grade R61704*—Zirconium-tin alloy, casting application.

4.1.9 *Grade R61705*—Zirconium-niobium alloy, casting application.

5. Ordering Information

5.1 Orders for materials under this specification shall include the following information:

5.1.1 Quantity (weight),

5.1.2 Name of material (zirconium ingot),

5.1.3 Grade number (Section 4),

5.1.4 ASTM designation and year of issue,

5.1.5 Finish (Section 8), and

5.1.6 Additions to the specification and supplementary requirements, if required.

NOTE 1—A typical ordering description is as follows: 10 000-lb zirconium ingot, machine conditioned, ASTM B495, dated __, Grade R60702.

6. Materials and Manufacture

6.1 The ingots covered by this specification shall be manufactured by electron beam, vacuum, or inert atmosphere melting in furnaces conventionally used for reactive metals.

7. Chemical Composition

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

7.2 When requested by the purchaser, a check analysis shall be performed for any elements listed in Table 1.

7.2.1 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 1 Chemical Requirements^A

Element	Composition, %								
	UNS Grade Designation								
	R60700	R60702	R60703	R60704	R60705	R60706	R61702	R61704	R61705
Zirconium + hafnium, min	99.2	99.2	98.0	97.5	95.5	95.5	98.8	97.1	95.1
Hafnium, max	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Iron + chromium	0.2 max	0.2 max	...	0.2 to 0.4	0.2 max	0.2 max	0.3 max	0.3 max	0.3 max
Tin	...	...	...	1.00 to 2.00	...	...	...	1.0 to 2.0	...
Hydrogen, max	0.004	0.004	...	0.005	0.005	0.005	0.005	0.005	0.005
Nitrogen, max	0.020	0.020	...	0.025	0.025	0.025	0.03	0.03	0.03
Carbon, max	0.05	0.05	...	0.05	0.05	0.05	0.1	0.1	0.1
Niobium	...	...	...	...	2.0 to 3.0	2.0 to 3.0	...	...	2.0 to 3.0
Phosphorus, max	...	...	...	...	...	...	0.01	0.01	0.01
Oxygen, max	0.10	0.16	...	0.18	0.18	0.16	0.25	0.3	0.3

^A By agreement between the purchaser and the manufacturer, analysis may be acquired and limits established for elements and compounds not specified in the table of chemical compositions.

TABLE 2 Permissible Variation in Check Analysis Between Different Laboratories

Element	Permissible Variation in Check Analysis, %
Hydrogen	0.005
Nitrogen	0.01
Carbon	0.02
Hafnium	0.1
Iron + chromium	0.03
Tin	0.05
Niobium	0.05
Oxygen	0.02

8. Workmanship, Finish, and Appearance

8.1 Ingots shall be conditioned by machining, grinding, or surface fusion to remove gross surface and subsurface defects detrimental to subsequent fabrication.

8.2 After conditioning has been completed, no abrupt changes in diameter or local depressions that will impair subsequent fabrication shall be permitted. The difference between the maximum and minimum radii of the conditioned ingot shall not exceed 20 % of the maximum radius, except within 6 in. (150 mm) of the ends of the ingot where rounding is permissible. Lands, grooves, and local depressions shall be blended to a maximum angle of 30° to the axis of the ingot. Each end of the ingot shall be chamfered or radiused. The minimum chamfer or radius shall be ½ in. (12 mm).

9. Number of Tests and Retests

9.1 At least one sample from the top, middle, and bottom of each ingot shall be analyzed chemically.

9.2 An ultrasonic test shall be conducted on each ingot.

9.3 Retests:

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

9.3.2 If the results of any test are not in conformance with the requirements of this specification, the ingot may be retested at the option of the manufacturer. The ingot shall be acceptable if results of all retests following the initial test conform to this specification.

10. Test Methods

10.1 *Ultrasonic Test*—Inspect the ingots ultrasonically by the methods described in 10.1.1 and 10.1.2 unless otherwise agreed upon between the manufacturer and the purchaser.

10.1.1 *Standardization*—Conduct the test in accordance with Practice E114. The search unit shall be a longitudinal beam transducer, operated at a frequency of 2¼ MHz using a suitable couplant with the piece being tested. Standardize the search unit on a test block, setting the back-reflection equal to 100 %. The test block shall be of the same approximate diameter and surface condition as the ingot. Standardization is required before the inspection begins on the ingot. Make two traverses along the length of the cylindrical ingot surface 90° apart.

10.1.2 *Acceptance Standards*—Use an acceptance standard containing a minimum of three holes, each 0.093 in. (2.36 mm) in diameter, at locations approximating the center, the mid-radius, and within 10 % of the back surface. If an indication greater than the indication from the 0.093 in. (2.36 mm) hole at the nearest approximate depth is observed, remove the ingot defect. Note that the mid-radius hole can represent both the ¼ and ¾ diameter depths. If the back reflection is between 50 and 95 %, increase the gain to bring the back reflection up to 100 % and inspect the trace indication to observe any internal reflections greater than the indication from the reference standard. Again, remove such defects. Following such amplitude adjustment and inspection, recalibrate the search unit on the test block to continue testing. A maximum of 10 % of the length of the ingot may consist of nonparallel sides such that the back reflection is not at least 50 %, provided each increment is not more than 3 in. (75 mm) in length and each increment is separated by an increment at least 3 in. (75 mm) long in which