Designation: B495 – 10

Standard Specification for Zirconium and Zirconium Alloy Ingots[1]

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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

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

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.

4. Classification

4.1 The ingots are furnished in six 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.

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.

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.

[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.

TABLE 1 Chemical Requirements[A]

Element	Composition, %					
	UNS Grade Designation					
	R60700	R60702	R60703	R60704	R60705	R60706
Zirconium + hafnium, min	99.2	99.2	98.0	97.5	95.5	95.5
Hafnium, max	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
Tin	...	...	...	1.00 to 2.00	...	...
Hydrogen, max	0.004	0.004	...	0.005	0.005	0.005
Nitrogen, max	0.020	0.020	...	0.025	0.025	0.025
Carbon, max	0.05	0.05	...	0.05	0.05	0.05
Niobium	...	...	...	...	2.0 to 3.0	2.0 to 3.0
Oxygen, max	0.10	0.16	...	0.18	0.18	0.16

[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

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 the back reflection is a minimum of 50 % when calibrated in accordance with 10.1.1.

10.2 *Chemical Tests*—Conduct the chemical analysis by the standard techniques normally used by the manufacturer. Guide E2626 may be used as a guide for chemical analysis techniques.

11. Inspection

11.1 The manufacturer shall inspect the material covered by this specification prior to shipment. If so specified in the purchase order, the purchaser or his representative may witness the testing and inspection of the material at the place of manufacture. In such cases, the purchaser shall state in his purchase order which tests he desires to witness. The manufacturer shall give ample notice to the purchaser as to the time and place of the designated tests. If the purchaser's representative does not present himself at the time agreed upon for the testing, the manufacturer shall consider the requirement for the purchaser's inspection at the place of manufacture to be waived.

11.2 The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to

satisfy him that the material is being furnished in accordance with this specification. This inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

12. Rejection and Rehearing

12.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

13. Certification

13.1 A producer's or supplier's certification shall be furnished to the purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. A report of the test results shall be furnished.

14. Referee

14.1 In the event of disagreement between the manufacturer and the purchaser on the conformance of the material to the requirements of this specification or any special test specified by the purchaser, a mutually acceptable referee shall perform the tests in question. The results of the referee's testing shall be used in determining conformance of the material to this specification.

15. Packaging and Package Marking

15.1 Each ingot shall be metal die stamped on the top with the manufacturer's ingot number. Each box or skid shall be marked or tagged legibly and conspicuously with the following information: name; brand or trademark of the manufacturer; name of the material; gross, net, and tare weights; nominal diameter; and ASTM designation.

15.2 Ingots shall be boxed or banded on skids in such a manner as to ensure safe delivery to their destination when properly transported by any common carrier.

16. Keywords

16.1 ingot; zirconium; zirconium alloy