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Standard Specification for Castings, Zirconium-Base, Corrosion Resistant, for General Application[1]

This standard is issued under the fixed designation B752; 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.

ε[1] NOTE—Method E 142 was removed editorially from Section 2 and X1.1.2 was corrected in April 2011.
ε[2] NOTE—SI units were removed editorially from Elongation heading in Table S6.1 in March 2012.

1. Scope

1.1 This specification covers zirconium and zirconium-alloy castings for general corrosion-resistant and industrial applications.

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.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A802/A802M Practice for Steel Castings, Surface Acceptance Standards, Visual Examination
E8 Test Methods for Tension Testing of Metallic Materials
E10 Test Method for Brinell Hardness of Metallic Materials
E18 Test Methods for Rockwell Hardness of Metallic Materials
E23 Test Methods for Notched Bar Impact Testing of Metallic Materials
E94 Guide for Radiographic Examination
E165 Practice for Liquid Penetrant Examination for General Industry
E446 Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *pour, n*—shall consist of all material melted and cast at one time.

3.2 *Lot Definitions:*

3.2.1 *castings, n*—a lot shall consist of all castings produced from the same pour.

4. Ordering Information

4.1 Orders for castings to this specification shall include the following, as required to describe the requirements adequately.

4.1.1 Description of the castings by pattern number or drawing (dimensional tolerances shall be included on the casting drawing),

4.1.2 Quantity,

4.1.3 Grade Designation (see Table 1),

4.1.4 Options in the specification, and

4.1.5 Supplementary requirements desired, including the standards of acceptance.

5. Materials and Manufacture

5.1 Material for this specification shall be melted by conventional processes used for reactive metals. Typical methods include the consumable electrode and inductoslag melting processes.

6. Chemical Composition

6.1 *Pour Analysis*—An analysis of each pour shall be made by the producer from a sample such as a casting or test bar that is representative of the pour. The chemical composition determined shall conform to the requirements specified for the relevant grade in Table 1.

6.1.1 The elements listed in Table 1 are intentional alloying additions of elements which are inherent to the manufacture of primary zirconium, zirconium sponge, mill product or castings.

6.1.1.1 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 pour. Therefore, pour analysis for elements not listed in Table 1 shall be considered to be in excess of the intent of this specification.

6.2 When agreed upon by producer and purchaser and requested by the purchaser in his written purchase order,

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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]

	Grade Designation, Composition, %		
	702C	704C	705C
Zirconium and hafnium, min.	98.8	97.1	95.1
Hafnium, max	4.5	4.5	4.5
Iron and chromium, max	0.3	0.3	0.3
Hydrogen, max	0.005	0.005	0.005
Nitrogen, max	0.03	0.03	0.03
Carbon, max	0.1	0.1	0.1
Oxygen, max	0.25	0.3	0.3
Phosphorus, max	0.01	0.01	0.01
Tin	...	1.0 to 2.0	...
Niobium	...	...	2.0 to 3.0

[A] By agreement between the purchaser and the producer, analysis may be required and limits established for elements and compounds not specified in this table.

chemical analysis shall be completed for specific residual elements not listed in this specification.

6.3 *Product Analysis*—A product analysis may be made by the purchaser on a representative casting from any lot. Because of the possibility of oxygen or other interstitial contamination, samples for oxygen, carbon, hydrogen, and nitrogen analysis shall be taken no closer than ¼ in. (6.3 mm) to a cast surface except that castings too thin for this shall be analyzed on representative material. The chemical composition determined shall conform to the analysis in Table 1 within the check analysis variations shown in Table 2 or shall be subject to rejection by the purchaser.

6.4 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 purchase, 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.

7. Heat Treatment

7.1 Unless otherwise specified in the contract, all castings will be supplied in the as-cast condition except when post-weld heat treatment is required.

TABLE 2 Check Analysis Tolerances

Element	Maximum of Range, Weight, %	Permissible Variation in Check Analysis
Nitrogen	0.03	+0.006
Carbon	0.10	+0.02
Hydrogen	0.005	+0.001
Iron and chromium	0.30	+0.06
Oxygen	0.25	+0.05
Hafnium	4.50	+0.50
Phosphorus	0.010	+0.003
Tin	1.0 to 2.0	±0.02
Niobium	2.0 to 3.0	±0.015
Residuals	0.10	+0.02

7.2 If post-weld heat treatment is required, it shall consist of a stress relief performed at 1050 ± 50°F (565 ± 25°C) for a minimum of ½ h at temperature plus an additional ½ h at temperature per inch of thickness for section sizes greater than 1 in. (25 mm). After heat treatment, the castings should be cooled in air or in the furnace to ambient temperature unless otherwise agreed upon between the purchaser and producer.

8. Workmanship, Finish, and Appearance

8.1 All castings shall be made in a workmanlike manner and shall conform to the dimensions in drawings furnished by the purchaser before manufacturing is started. If the pattern is supplied by the purchaser, the dimensions of the casting shall be as predicted by the pattern.

8.2 The surface of the casting shall be free of adhering mold material, scale, cracks, and hot tears as determined by visual examination. Other surface discontinuities shall meet the visual acceptance standards specified in the order. Practice A802/A802M or other visual standards may be used to define acceptable surface discontinuities and finish. Unacceptable surface discontinuities shall be removed, and their removal verified by visual examination of the resultant cavities.

9. Repair by Welding

9.1 If repairs are required, these shall be made using a welding procedure and operators certified to quality requirements established by the producer. The procedures developed shall be consistent with standard practices recommended for reactive metal alloys. The producer shall maintain documentation on procedure and welder qualifications. Procedure modifications or special arrangements shall be as agreed upon between the producer and purchaser.

9.2 Weld repairs shall be considered major in the case of a casting that has leaked on a hydrostatic test or when the depth of the cavity after preparation for repair exceeds 20 % of the actual wall thickness or 1 in. (25 mm), whichever is smaller, or when the surface area of the cavity exceeds approximately 10 $in.^2$ (6500 mm^2). All other weld repairs shall be considered minor. Major and minor repairs shall be subject to the same quality standards as are used to inspect the castings.

9.3 The composition of the deposited weld metal shall be within the chemical requirements for each grade established in Table 1.

9.4 All castings with major weld repairs shall be stress relieved after repair in accordance with 7.2. Stress relief after minor repairs is not required for grades 702C and 704C except by agreement between the producer and the purchaser. Grade 705C must be stress relieved after any weld repair.

10. Inspection

10.1 The producer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being produced and furnished in accordance with this specification. Foundry inspection by the purchaser shall not interfere unnecessarily with the producer's operations. All tests and inspections, with the exception of product analysis (6.3),

shall be made at the place of manufacture, testing, or inspection unless otherwise agreed upon.

11. Rejection

11.1 Any rejection based on test reports shall be reported to the producer within 60 days from the receipt of the test reports by the purchaser.

11.2 Material that shows unacceptable discontinuities as determined by the acceptance standards specified on the order, subsequent to acceptance at the producer's works, will be rejected, and the producer shall be notified within 60 days, or as otherwise agreed upon.

12. Product Marking

12.1 Unless otherwise specified, the following shall apply:

12.1.1 Castings shall be marked for material identification with the ASTM specification number (B752) and grade symbol, that is, 702C, 704C, or 705C.

12.1.2 The producer's name or identification mark and the pattern number shall be cast or stamped using low stress stamps on all castings. Small size castings may be such that marking must be limited consistent with the available area.

12.1.3 The marking of lot numbers on individual castings shall be agreed upon between the producer and the purchaser.

12.1.4 Marking shall be in such a position as not to injure the usefulness of the casting.

13. Keywords

13.1 castings; corrosion-resistant; zirconium; zirconium alloys

SUPPLEMENTARY REQUIREMENTS

Supplementary requirements shall be applied only when specified by the purchaser. Details of the supplementary requirements shall be agreed upon between the producer and purchaser. The specified tests shall be performed by the producer prior to shipment of the castings.

S1. Radiographic Examination

S1.1 The castings shall be examined for internal defects by means of X rays or gamma rays. The procedure shall be in accordance with Guide E94 and types and degrees of discontinuities shall be judged by Reference Radiographs E446. The extent of examination and basis for acceptance shall be agreed upon between the producer and purchaser.

S2. Liquid Penetrant Examination

S2.1 The castings shall be examined for surface discontinuities by means of liquid penetrant examination. The examination shall be in accordance with Test Method E165. Areas to be inspected, methods and types of liquid penetrants to be used, developing procedure, and basis for acceptance shall be agreed upon between the producer and purchaser.

S3. Examination of Weld Preparation

S3.1 Cavities prepared for welding as a result of surface discontinuities, such as cracks, open porosity, and so forth shall be examined by means of liquid penetrant examination in order to verify removal of such discontinuities.

S3.2 Weld repairs that are made to eliminate discontinuities that are detected by radiography shall be re-radiographed to verify that unacceptable discontinuities have been removed.

S4. Certification

S4.1 A test report shall be furnished. The test report shall contain the results of the actual chemical analysis and other tests specified by the purchaser.

S4.2 Each test report shall be signed by an authorized agent of the seller or producer.

S4.3 The test report shall be furnished within 5 days of shipment of the castings.

S5. Prior Approval of Major Weld Repairs

S5.1 Major weld repairs as defined and agreed upon between the producer and purchaser shall be subject to the prior approval of the purchaser.

S6. Tension Test

S6.1 Tensile properties shall be determined on material representing each pour. Properties shall be determined in the as-cast condition unless the purchase order requires the properties be determined in the final condition after all heat treatments (including isostatic pressing) have been completed or unless otherwise specified in the purchase order. The results shall conform to the requirements specified in Table S6.1.

S6.2 Test bars may be obtained from special test blocks cast for that purpose or cut from castings processed with a lot.

TABLE S6.1 Tensile and Hardness Requirements

Grade	Tensile Strength, min		Yield Strength, 0.2 % Offset, min		Elongation in 1 in. length, min, %	Hardness, HB, max	Hardness, Rockwell, max
	ksi	MPa	ksi	MPa			
702C	55	(380)	40	(276)	12	210	B96
704C	60	(413)	40	(276)	10	235	B99
705C	70	(483)	50	(345)	12	235	B99

S6.3 Tensile tests shall be made in accordance with the requirements of Test Methods E8. Tensile properties shall be determined using a strain rate of 0.003 to 0.007 in./in./min (0.005 to 0.007 mm/mm/min) through the yield strength.

S6.4 If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted from the same pour.

S7. Hardness Test

S7.1 Hardness shall be determined on each lot. Hardness shall be determined in the as-cast condition unless the purchase order requires the hardness be determined in the final condition after all heat treatments (including isostatic pressing) have been completed or unless otherwise specified in the purchase order. The results shall conform to the requirements specified in Table S6.1.

S7.2 Hardness shall be determined on a sample cast for that purpose, or on a casting randomly selected from a lot. If a casting is used for a hardness sample, indentations shall be made in a surface that will not be subsequently machined. Hardness values reported shall be representative of the base metal of the castings and not of any surface contamination caused by mold-metal interactions.

S7.3 Hardness tests shall be made in accordance with the requirements of Test Methods E10 or E18.

S8. Hot Isostatic Pressing (HIP)

S8.1 Hot Isostatic Pressing (HIP) shall be used to improve as-cast properties or remove internal defects, or both. Temperature, time at temperature, and atmosphere shall be agreed upon between supplier and purchaser.

S8.2 HIP may be substituted for required thermal treatment provided all requirements for that treatment are met and temperatures detrimental to the material properties are not reached.

S9. Charpy Impact Test

S9.1 Charpy impact test properties shall be determined on material representing each lot. Three Charpy V-notch specimens shall be made from a test piece and tested in accordance with Test Methods E23. They shall be tested at room temperature unless otherwise agreed upon by the manufacturer and purchaser and reported as absorbed energy. The condition of the sample material and the acceptance limit shall be agreed to by both the purchaser and the supplier.

APPENDIX

(Nonmandatory Information)

X1. RATIONALE (COMMENTARY)

X1.1 This specification is intended for use by purchasers or producers, or both, of reactive metal castings for defining the requirements and ensuring the properties of castings for unique corrosion-resistant applications, that is, not for commodity items which must meet all potential purchasers' requirements.

X1.1.1 Users are advised to use the specification as a basis for obtaining castings that will meet minimum acceptance requirements established and revised by consensus of the members of the committee.

X1.1.2 User requirements considered more stringent may be met by the addition to the purchase order of one or more supplementary requirements, which may include, but are not limited to, those listed in Sections S1 through S9.