



Designation: B 550/B 550M – 02

Standard Specification for Zirconium and Zirconium Alloy Bar and Wire¹

This standard is issued under the fixed designation B 550/B 550M; 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 specification² covers three grades of zirconium and zirconium alloy bar and wire.

1.2 Unless a single unit is used, for example corrosion mass gain in mg/dm^2 , the values stated in either inch-pound or SI units are to be regarded separately as standard. The values stated in each system are not exact equivalents; therefore each system must be used independently of the other. SI values cannot be mixed with inch-pound values.

1.3 The following precautionary caveat pertains only to the test methods portions 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:*

E 8 Test Methods for Tension Testing of Metallic Materials³

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁴

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *annealed*—denotes material that exhibits a recrystallized grain structure.

3.2 *Lot Definitions:*

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

3.2.2 *ingot*—no definition required.

3.2.3 *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 same 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.

3.2.4 *sponge*—a lot shall consist of a single blend produced at one time.

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

4. Classification

4.1 The bar or wire is to be furnished in three grades as follows:

4.1.1 *Grade R60702*—Unalloyed zirconium.

4.1.2 *Grade R60704*—Zirconium-tin.

4.1.3 *Grade R60705*—Zirconium-niobium.

5. Ordering Information

5.1 Orders for material under this specification should include the following information:

5.1.1 Quantity (weight or number of pieces),

5.1.2 Name of material (zirconium bar or wire) (Table 1),

5.1.3 Grade number (see 4.1),

5.1.4 ASTM designation and year of issue, and

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

NOTE 1—A typical ordering description is as follows: 1000 lb (500 kg) zirconium cold drawn bar, 0.35 in. (10 mm) in diameter by 10 ft (3 m) in length, ASTM B 550 - 01, Grade R60702.

6. Materials and Manufacture

6.1 Bar and wire covered by this specification shall be formed with conventional fabrication methods and equipment found in primary ferrous and nonferrous metal plants.

6.2 Bar and wire will be supplied in the conditions prescribed in Table 2.

6.3 The products covered include the sections and sizes shown in Table 1.

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.

Current edition approved Oct. 10, 2002. Published December 2002. Originally published as B 550 – 71. Last previous edition B 550/B 550M – 01.

² For ASME Boiler and Pressure Vessel Code applications, see related Specification SB-550 in Section II of that Code.

³ *Annual Book of ASTM Standards*, Vol 03.01.

⁴ *Annual Book of ASTM Standards*, Vol 14.02.

TABLE 1 Product Sections and Size

Product	Section	Size
Bars:	Hot-finished round, squares, octagons, and hexagons	¼ in. (6.4 mm) and over in diameter or size
	Hot-finished flats	¼ in. (6.4 mm) to 10 in. (250 mm), incl, in width, and ⅛ in. (3.2 mm) and over in thickness
	Cold-finished rounds, squares, octagons, hexagons, and shapes	Over ½ in. (13 mm) in diameter or size ^A
Wire:	Cold-finished flats	⅜ in. (9.5 mm) and over in width, ^B and ⅛ in. (3.2 mm) and over in thickness ^C
	Cold-finished rounds, squares, octagons, hexagons, and shapes	½ in. (13 mm) and under in diameter or size
	Cold-finished flats	⅛ in. (1.6 mm) to under ⅜ in. (9.5 mm) in width, and 0.010 in. (.25 mm) to under ⅜ in. (4.8 mm) in thickness

^ASizes ½ in. (13 mm) and under are wire when in coils, and cut wire when finished in straight lengths.

^BWidths less than ⅜ in. (9.5 mm) and thicknesses less than ⅜ in. (4.8 mm) are generally described as flat wire.

^CThickness ⅛ in. (3.2 mm) to under ⅜ in. (4.8 mm) can be cold-rolled strip as well as bar.

TABLE 2 Condition

Form	Condition
Bars	hot finished
	hot finished and annealed
	cold finished
Wire	cold finished and annealed
	cold finished
	cold finished and annealed

TABLE 4 Permissible Variation in Check Analysis Between Different Laboratories

Element	Permissible Variation in Product Analysis, %
Hydrogen	0.002
Nitrogen	0.01
Carbon	0.01
Hafnium	0.1
Iron + chromium	0.025
Tin	0.05
Niobium	0.05
Oxygen	0.02

7. Chemical Composition

7.1 The material shall conform to the requirements as to chemical composition prescribed in **Table 3**.

7.2 The manufacturer's ingot analysis shall be considered the chemical analysis for bar and wire, 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 3** 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 4**.

8. Mechanical Properties

8.1 The annealed material shall conform to the requirements for mechanical properties, at room temperature, as prescribed in **Table 5**. Wire supplied for welding applications shall be

furnished with a temper suitable for uniform feeding in semiautomatic or automatic welding equipment.

TABLE 5 Tensile Requirements^A

	Grades		
	R60702	R60704	R60705
Tensile Strength, min, ksi (MPa)	55 (380)	60 (415)	80 (550)
Yield Strength, min, ksi (MPa)	30 (205)	35 (240)	55 (380)
Elongation in 2 in. or 50 mm min, % ^B	16	14	16

^AFor bar only.

^BWhen a sub-size specimen is used, the gage length shall be as specified in Test Methods **E 8** for the specimen.

TABLE 3 Chemical Requirements^A

Element	Composition, %		
	Grades R60702	Grades R60704	Grades R60705
Zirconium + hafnium, min	99.2	97.5	95.5
Hafnium, max	4.5	4.5	4.5
Iron + chromium	0.2 max	0.2 to 0.4	0.2 max
Tin	...	1.0 to 2.0	...
Hydrogen, max	0.005	0.005	0.005
Nitrogen, max	0.025	0.025	0.025
Carbon, max	0.05	0.05	0.05
Niobium	2.0 to 3.0
Oxygen, max	0.16	0.18	0.18

^ABy agreement between the purchaser and the manufacturer, analysis may be required and limits established for elements and compounds not specified in the table of chemical composition.

9. Permissible Variations in Dimensions

9.1 Unless otherwise specified, all bar or wire shall conform to the permissible variations in dimensions prescribed in the applicable Tables 6-14, inclusive.

10. Workmanship, Finish and Appearance

10.1 Bars in the hot-finished condition which will conform to the tolerances prescribed in Tables 6 and 7, shall be furnished with one of the following finishes as designated on the purchase order:

- 10.1.1 Not descaled,
- 10.1.2 Mechanically descaled,
- 10.1.3 Mechanically descaled and pickled, and
- 10.1.4 Turned (round bars only).

10.2 Bars and wire in cold-finished condition, that will conform to the tolerances prescribed in Tables 8-12, shall be furnished with one of the following finishes as designated on the purchase order.

- 10.2.1 Cold drawn or cold rolled, or swaged,
- 10.2.2 Turned (round bars only),
- 10.2.3 Centerless ground (round bars only), and
- 10.2.4 Polished (round bars only).

10.3 Bars or wire shall be free of cracks, seams, slivers, blisters, burrs, and other injurious imperfections in accordance with standards of acceptability agreed upon between the manufacturer and the purchaser.

11. Significance of Numerical Limits

11.1 For the purpose of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value or a calculated value shall be rounded as indicated in accordance with the rounding methods of Practice E 29.

Property	Rounded Unit for Observed or Calculated Value
Chemical composition and tolerances (when expressed as decimals)	nearest unit in the last right-hand place of figures of the specified limit
Tensile strength and yield strength	nearest 1000 psi (10 MPa)
Elongation	nearest 1 %

12. Number of Tests and Retests

12.1 One longitudinal tension test shall be made from each lot of bar and rod, see 13.1.

12.2 One chemistry test for hydrogen and nitrogen content shall be made from each lot of finished product, see 13.2.

12.3 Retests:

12.3.1 If any sample or specimen exhibits obvious surface contamination or improper preparation disqualifying it as a truly representative sample, it shall be discarded and a new sample or specimen substituted.

TABLE 6 Dimensional Tolerances for Hot-Finished Rounds, Squares, Octagons, and Hexagons

Specified Size, in. (mm)	Variation in Size, in. (mm)	Out of Round, Out of Square, in. (mm)
Up-0.500 (13)	+0.030 -0 (+0.75)	0.025 (0.64)
Over 0.500-1.000 (13-25)	+0.050 -0 (+1.3)	0.040 (1)
Over 1.000-2.000 (25-50)	+0.070 -0 (+1.8)	0.060 (1.5)
Over 2.000-4.000 (50-100)	+0.150 -0 (+3.8)	0.080 (2)
Over 4.000-6.000 (100-150)	+0.250 -0 (+6.4)	0.100 (2.5)

TABLE 7 Dimensional Tolerances in Hot-Rolled Flat Bars

Thickness, in. (mm)	Variation in Thickness, in. (mm)	Variation in Width, ^A in. (mm)
Up-0.150 (3.8)	+0.020 -0 (+0.5)	1/8 -0 (3.2)
Over 0.150-0.250 (3.8-6.3)	+0.030 -0 (+0.75)	5/32 -0 (4.0)
Over 0.250-0.350 (6.3-8.9)	+0.040 -0 (+1.0)	3/16 -0 (4.8)
Over 0.350-0.450 (8.9-11.4)	+0.050 -0 (+1.3)	7/32 -0 (5.6)
Over 0.450-0.550 (11.4-14)	+0.070 -0 (+1.8)	B
Over 0.550-1.500 (14-38)	+0.080 -0 (+2.0)	B
Over 1.500 (38)	B	B

^AFor bars sheared from plate, width tolerances shall be as follows:

^BDepends on size and quantity ordered.

Specified Thickness, in. (mm)	Width Tolerances, in. (mm)	
	Over	Under
Over 0.100-0.150	1/16 (1.6)	1/16 (1.6)
Over 0.150-0.250	5/64 (2.0)	5/64 (2.0)
Over 0.250-0.350	3/32 (2.4)	3/32 (2.4)
Over 0.350-0.450	7/64 (2.8)	7/64 (2.8)
Over 0.450-0.550	1/8 (3.2)	1/8 (3.2)
Over 0.550-0.650	5/32 (4.0)	5/32 (4.0)

TABLE 8 Permissible Variations in Sectional Dimensions for Cold-Finished Bars in Rounds, Hexagons, Octagons, and Squares

Specified Size, in. (mm)	Permissible Variation, in. ^A (mm)	
	Over	Under
	Rounds	
Over 1/2 -1, incl (13-25)	0.002 (0.05)	0.002 (0.05)
1-1 1/2, excl (25-38)	0.0025 (0.06)	0.0025 (0.06)
1 1/2 -4, incl ^B (38-100)	0.003 (0.08)	0.003 (0.08)
Hexagons, Octagons, and Squares		
Over 1/2 -1, incl (13-25)	0	0.004 (0.10)
Over 1-2, excl (25-50)	0	0.006 (0.15)
Over 2-3, incl (50-75)	0	0.008 (0.20)
Over 3 (75)	0	0.010 (0.25)

^AWhen it is necessary to heat treat or heat treat and pickle after cold finishing, because of special hardness or mechanical property requirements, tolerances are double those shown in the table.

^BFor permissible variations on sizes over 4 in. (100 mm) the manufacturer should be consulted.

12.3.2 If the results of any tests of any lot do not conform to the requirements specified, retests shall be made on additional samples from the same lot, each of which shall conform to the requirements specified.

13. Test Methods

13.1 Tension Tests—Conduct the tension test in accordance with Test Methods E 8. Determine the yield strength by the offset (0.2 %) method. Determine the tensile properties using a strain rate of 0.003 to 0.007 in./in. (mm/mm)/min through the yield strength. After the yield strength has been exceeded, the cross-head speed may be increased to approximately 0.05 in./in. (mm/mm)/min to failure.

13.2 Chemical Tests—Conduct the chemical analysis by the standard techniques normally used by the manufacturer.

14. Inspection

14.1 The manufacturer shall inspect the material covered by this specification prior to shipment and, on request, shall furnish the purchaser with certificates of test. 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