



Designation: B352/B352M – 26

Standard Specification for Zirconium and Zirconium Alloy Sheet, Strip, and Plate for Nuclear Application¹

This standard is issued under the fixed designation B352/B352M; 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 hot- and cold-rolled zirconium and zirconium alloy sheet, strip, and plate.

1.2 One unalloyed and three alloys for use in nuclear applications are described.

1.3 The products covered in this specification include the following forms and sizes:

1.3.1 *Sheet*, 24 in. [600 mm] or more in width; under 0.187 in. [4.8 mm] in thickness,

1.3.2 *Strip*, less than 24 in. [600 mm] in width; under 0.187 in. [4.8 mm] in thickness, and

1.3.3 *Plate*, over 10 in. [250 mm] in width; 0.187 in. [4.8 mm] and over in thickness.

NOTE 1—Material over 0.187 in. [4.8 mm] in thickness and less than 10 in. [250 mm] wide is covered as bar in Specification B351/B351M.

1.4 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.

1.5 The following precautionary caveat pertains only to the test method 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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.*

¹ This specification is under the jurisdiction of ASTM B10 on Reactive and Refractory Metals and Alloys and is the direct responsibility of B10.02 on Zirconium and Hafnium.

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2. Referenced Documents

2.1 ASTM Standards:²

B350/B350M Specification for Zirconium and Zirconium Alloy Ingots for Nuclear Application

B351/B351M Specification for Hot-Rolled and Cold-Finished Zirconium and Zirconium Alloy Bars, Rod, and Wire for Nuclear Application

E8/E8M Test Methods for Tension Testing of Metallic Materials

E21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

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

E127 Practice for Fabrication and Control of Flat Bottomed Hole Ultrasonic Standard Reference Blocks

E1001 Practice for Detection and Evaluation of Discontinuities by the Immersed Pulse-Echo Ultrasonic Method Using Longitudinal Waves

G2/G2M Test Method for Corrosion Testing of Products of Zirconium, Hafnium, and Their Alloys in Water at 680 °F [360 °C] or in Steam at 750 °F [400 °C]

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

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

3.2 Lot Definition:

3.2.1 Sheet, strip, and plate products (single definition, common to nuclear and non-nuclear standards), *n*—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 either to a single furnace load for final batch anneal, or to a change in annealing conditions

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.



for continuous annealing if sampling is distributed from each 4000 lb [1800 kg], or alternatively to an 8 h period.

4. Ordering Information

4.1 Purchase orders for material under this specification should include the following information as required to adequately describe the desired material:

- 4.1.1 Quantity (weight or number of pieces),
- 4.1.2 Name of material,
- 4.1.3 Condition (Section 6),
- 4.1.4 Finish (Section 14),
- 4.1.5 Form (Sheet, strip, plate),
- 4.1.6 Edge (Section 15),
- 4.1.7 Dimensions (size, thickness, width and length),
- 4.1.8 Grade designation (Table 1), and
- 4.1.9 ASTM designation and year of issue.
- 4.1.10 Transverse test requirements, if any (Section 8),
- 4.1.11 Ultrasonic test requirements (Section 12),
- 4.1.12 Standards of acceptability for cracks, seams, slivers, blisters, and other imperfections (Section 13), and
- 4.1.13 Special packaging and shipping requirements (Section 21).

NOTE 2—A typical ordering description is as follows: _ 5000 lb reactor grade zirconium alloy, cold-rolled, vacuum annealed strip, 4.750 by 0.065 by 72 in., ASTM Specification B352/B352M - 11, Grade R60804.

4.2 In addition to the data specified in 4.1, the following options and points of agreement between the manufacturer and the purchaser should be specified on the purchase order as required:

- 4.2.1 Temperature and direction of mechanical testing (see Section 8 and Table 2),
- 4.2.2 Workmanship standards (Section 13),
- 4.2.3 Special tests (Section 12),
- 4.2.4 Inspection (Section 17), and
- 4.2.5 Corrosion visual standards (Section 9).
- 4.2.6 Oxygen limits (see footnote A, Table 1).

5. Materials and Manufacture

5.1 Materials covered by this specification shall be produced in accordance with Specification B350/B350M; all processes to be done in furnaces usually used for reactive metals.

TABLE 1 Chemical Requirements

Element	Composition, Weight %			
	UNS R60001	UNS R60802	UNS R60804	UNS R60901
Tin	...	1.20–1.70	1.20–1.70	...
Iron	...	0.07–0.20	0.18–0.24	...
Chromium	...	0.05–0.15	0.07–0.13	...
Nickel	...	0.03–0.08	...	...
Niobium (columbium)	...	...	...	2.40–2.80
Oxygen	^A	^A	^A	0.09–0.15
Iron + chromium + nickel	...	0.18–0.38	...	...
Iron + chromium	...	...	0.28–0.37	...
Maximum Impurities, Weight %				
Aluminum	0.0075	0.0075	0.0075	0.0075
Boron	0.00005	0.00005	0.00005	0.00005
Cadmium	0.00005	0.00005	0.00005	0.00005
Calcium	...	0.0030	0.0030	...
Carbon	0.027	0.027	0.027	0.027
Chromium	0.020	...	...	0.020
Cobalt	0.0020	0.0020	0.0020	0.0020
Copper	0.0050	0.0050	0.0050	0.0050
Hafnium	0.010	0.010	0.010	0.010
Hydrogen	0.0025	0.0025	0.0025	0.0025
Iron	0.150	...	...	0.150
Magnesium	0.0020	0.0020	0.0020	0.0020
Manganese	0.0050	0.0050	0.0050	0.0050
Molybdenum	0.0050	0.0050	0.0050	0.0050
Nickel	0.0070	...	0.0070	0.0070
Niobium	...	0.0100	0.0100	...
Nitrogen	0.0080	0.0080	0.0080	0.0080
Phosphorus	...	...	...	0.0020
Silicon	0.0120	0.0120	0.0120	0.0120
Tin	0.0050	...	...	0.010
Tungsten	0.010	0.010	0.010	0.010
Titanium	0.0050	0.0050	0.0050	0.0050
Uranium	0.00035	0.00035	0.00035	0.00035

^A When so specified in the purchase order, oxygen shall be determined and reported. Maximum, minimum, or both, permissible values should be specified in the purchase order.