Designation: B352/B352M – 17

Standard Specification for Zirconium and Zirconium Alloy Sheet, Strip, and Plate for Nuclear Application[1]

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 and health 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.*

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

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 to the product of an 8 h period for final continuous anneal, or to a single furnace load for final batch anneal.

[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] 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.

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).

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.

TABLE 2 Mechanical Properties[A]

Grade	Condition	Direction of Test	Test Temperature[B]	Tensile Strength, min, ksi [MPa]	Yield Strength (0.2 % Offset), min, ksi [MPa]	Elongation in 2 in. or 50 mm, min, %
R60001	annealed	longitudinal	RT	42 [290]	20 [140]	18
		transverse	RT	42 [290]	30 [205]	18
R60802		longitudinal	RT	58 [400]	35 [240]	25
or	annealed	transverse	RT	56 [385]	44 [300]	25
R60804						
R60802		longitudinal	550°F [290°C]	27 [185]	15 [100]	30
or	annealed	transverse	550°F [290°C]	26 [180]	17.5 [120]	30
R60804						
R60901	cold worked	longitudinal	RT	74 [510]	50 [345]	15
		transverse	RT	74 [510]	56 [385]	15
R60901	annealed	longitudinal	RT	65 [450]	45 [310]	20
		transverse	RT	65 [450]	50 [345]	20

[A] When a sub-size specimen is used, the gauge length shall be as specified in Test Methods E8/E8M for that specimen.
[B] "RT" represents room temperature; Note 4 in Test Methods E8/E8M indicates that RT shall be considered to be 50 to 100°F [10 to 38°C] unless otherwise specified. Paragraph 9.4.4 in Test Methods E21 states that for the duration of the test, the difference between the indicated temperature and the nominal test temperature is not to exceed ±5°F [3°C] for tests at 1800°F [1000°C] and lower, and ±10°F [6°C] for tests at higher temperatures.

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.

6. Condition

6.1 Sheet, strip, or plate shall be furnished in one of the following conditions as designated on the purchase order:

Form	Condition
Sheet	hot-rolled
	hot-rolled, annealed
	cold-rolled, annealed
	cold-rolled, annealed, followed by a final light cold-rolled pass, generally on polished rolls.
Strip	hot-rolled
	hot-rolled, annealed
	cold-rolled
	cold-rolled, annealed
	cold-rolled, annealed, followed by a final light cold-rolled pass, generally on polished rolls.
Plate	hot-rolled
	hot-rolled, annealed

7. Chemical Composition

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

7.2 The analysis of the material produced to this specification shall be the one made by the manufacturer on the ingot in accordance with Specification B350/B350M. This analysis can be performed by the manufacturer on the ingot itself, or on intermediate or final products with the same frequency and in the same positions relative to the ingot as required in Specification B350/B350M. The chemical analysis of hydrogen, oxygen, and nitrogen shall be determined on the finished product.

7.3 Analysis shall be made using the manufacturer's standard methods. In the event of disagreement as to the chemical composition of the metal, methods of chemical analysis for reference purposes shall be determined by a mutually acceptable laboratory.

7.4 *Product Analysis*—Product analysis is an analysis made by the purchaser or the manufacturer for the purpose of verifying the composition of the lot. The product analysis tolerances reflect the variation between laboratories in the measurement of chemical composition. The permissible variation of the product analysis from the specified range is as prescribed in Table 3.

7.5 *Number of Tests*—Two random samples for each 4000 lb [1800 kg] or fraction thereof shall be analyzed for hydrogen, nitrogen, and oxygen.

8. Mechanical Properties

8.1 The material shall conform to the requirements prescribed in Table 2 for longitudinal room-temperature mechanical properties. Transverse and elevated temperature properties shall be used to determine compliance only when specified in the purchase order. When material is ordered in a condition other than those given in Table 2, the specimens shall be heat treated as referenced in Table 2 prior to test.

8.2 The yield strength shall be determined by the offset method using 0.2 % criterion as prescribed in Test Methods E8/E8M.

8.3 The tensile properties shall be determined using a strain rate of 0.003 to 0.007 in./in. [mm/mm]/min through the yield strength. After the yield strength has be exceeded, the cross

TABLE 3 Permissible Variations in Product Analysis

Alloying Elements	Permissible Variation from the Specified Range (Table 1), %
Tin	0.050
Iron	0.020
Chromium	0.010
Nickel	0.010
Iron + chromium	0.020
Iron + chromium + nickel	0.020
Niobium	0.050
Oxygen	0.020
Each Impurity Element	20 ppm or 20 % of the specified limit, whichever is smaller

head speed should be increased to approximately 0.05 in./in. [mm/mm]/min to failure.

8.4 The tensile properties shall be determined in accordance with Test Methods E8/E8M or E21.

8.5 *Number of Tests*—For each lot, two random samples for each 4000 lb [1800 kg] or fraction thereof shall be tested for mechanical properties.

9. Corrosion Properties

9.1 Two samples chosen at random from each 4000 lb [1800 kg] or fraction thereof shall be corrosion tested in steam at 750°F [399°C], 1500 psi [10.3 MPa] for 72 h or 336 h at the option of the manufacturer in accordance with Test Method G2/G2M.

9.2 *Acceptance Criterion:*

9.2.1 *Grades R60802 and R60804*—All coupons thus tested shall exhibit a continuous, black, lustrous oxide film and be free of white or brown corrosion product in excess of standards previously agreed upon between manufacturer and purchaser. Coupons shall exhibit a weight gain of not more than 22 mg/dm^2 in a 72-h test or 38 mg/dm^2 in a 336-h test.

9.2.2 *Grade R60901*—All coupons shall exhibit a continuous, uniform, dark gray oxide film. Coupons shall exhibit a weight gain of not more than 35 mg/dm^2 in a 72-h test or 60 mg/dm^2 in a 336-h test.

10. Permissible Variations in Dimensions

10.1 Sheet, strip, or plate shall conform to the permissible variations in dimensions prescribed in the applicable Tables 4-12, incl.

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 E29.

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

12. Special Tests

12.1 *Ultrasonic Inspection:*

TABLE 4 Permissible Variations in Thickness of Hot-Rolled Zirconium Sheet[A]

Specified Thickness, in. [mm]	Permissible Variations in Thickness, plus and minus, in. [mm]
0.145–0.188 [3.7–5], incl	0.014 [0.35]
0.130–0.145 [3.3–3.7], excl	0.012 [0.30]
0.115–0.130 [2.9–3.3], incl	0.010 [0.25]
0.1–0.115 [2.5–2.9], excl	0.009 [0.23]
0.084–0.098 [2.13–2.5], incl	0.008 [0.20]

[A] Thickness measurements are taken at least ⅜ in. [10 mm] in from edge.

TABLE 5 Permissible Variations in Length of Hot- and Cold-Rolled Zirconium Sheet

Specified Length, ft [m]	Permissible Variations in Length, in. [mm]
Up to 10 [3]	+½ [+13], –0
Over 10 to 20 [3 to 6]	+1 [+25], –0

TABLE 6 Permissible Variations in Thickness of Hot-Rolled Zirconium Strip

Specified Width, in. [mm]	Variation from Specified Thickness for Widths Given, Over and Under, in. [mm]	
	0.187–0.1180 [4.8–3.0], incl.	0.1197–0.0830 [3.0–2.1], incl
To 3½ [90]	0.006 [0.15]	0.005 [0.13]
Over 3½ –12 [90–300]	0.007 [0.18]	0.006 [0.15]
Over 12–18 [300–460]	0.008 [0.20]	0.008 [0.20]
Over 18–24 [460–610]	0.010 [0.25]	0.010 [0.25]

12.1.1 In lieu of the ultrasonic test of the ingot as specified in B350/B350M, the manufacturer may alternatively perform ultrasonic inspection at an intermediate size in accordance with Practices E114 or E1001, with the approval of the purchaser.

12.1.2 Unless otherwise approved by the purchaser, the reference standard shall consist of a 0.06 in. [1.5 mm] flat bottom hole drilled perpendicular to the longitudinal product axis to a depth of 0.5 in. [13 mm].

12.1.3 Any defect reflections greater than the indication from the reference standard should be rejected.

12.2 Additional tests may be specified in the purchase order. The test method and standards shall be agreed upon in advance between manufacturer and purchaser.

13. Workmanship and Appearance

13.1 Sheet, strip, or plate shall be free of cracks, seams, slivers, blisters, and other injurious imperfections in accordance with standards of acceptability agreed upon between the manufacturer and the purchaser.

14. Finish

14.1 Hot-rolled sheet, strip, or plate shall be furnished with one of the following finishes as designated in the purchase order:

14.1.1 Not descaled,

14.1.2 Conditioned (spot grinding to remove imperfections within the thickness tolerance),

14.1.3 Mechanically descaled, or

14.1.4 Mechanically descaled, conditioned and pickled.

14.2 Cold-rolled sheet or strip shall be furnished with one of the following as designated in the purchase order:

14.2.1 Cold-rolled,

14.2.2 Ground 32 µin. [0.8 µm] rms or better, or

14.2.3 Pickled.

15. Edge

15.1 *Hot-Rolled Strip*—The following types of edges are available on hot-rolled strip:

15.1.1 Mill edge,

15.1.2 Slit edge,

TABLE 7 Permissible Variations in Width of Hot-Rolled Zirconium Strip

Specified Width, in. [mm]	Permissible Variations in Width, in. [mm]					
	Mill Edge		Slit Edge		Sheared Edge	
	Plus	Minus	Plus	Minus	Plus	Minus
To 3½ [90]	⅛ [3.2]	0	1/32 [.8]	1/32 [.8]	1/16 [1.6]	1/16 [1.6]
Over 3½ –12 [90–300]	¼ [6.4]	⅛ [3.2]	1/32 [.8]	1/32 [.8]	⅛ [3.2]	0
Over 12–18 [300–460]	⅜ [9.5]	⅛ [3.2]	3/64 [1.2]	3/64 [1.2]	⅛ [3.2]	0
Over 18–24 [460–610]	½ [12.7]	¼ [6.4]	3/64 [1.2]	3/64 [1.2]	3/16 [4.8]	0

TABLE 8 Permissible Variations in Thickness of Cold-Rolled Zirconium Strip

NOTE 1—For thicknesses under 0.010 in. [0.25 mm]: in widths to 16 in. [400 mm] a tolerance of ±10 % of the thickness shall apply; in widths over 16 to 24 in. [400 to 610 mm] incl, a tolerance of ±15 % of the thickness shall apply.

NOTE 2—Thickness measurements shall be taken ⅜ in. [9.5 mm] in from the edge of the strip, except on widths less than 1 in. [25 mm] where tolerances are applicable for measurements at all locations.

Specified Thickness, in. [mm]	Permissible Variations in Thickness, for Widths Given, plus and minus in. [mm]		
	3/16 to 3 in. [4.8 to 75 mm]	Over 3 to 12 in. [75 to 300 mm]	Over 12 to 24 in. [300 to 610 mm]
Under 3/16 –0.160 [4.75–4.01], incl	0.003 [0.08]	0.004 [0.10]	0.006 [0.15]
0.160–0.100 [4.0–2.5], incl	0.002 [0.05]	0.004 [0.10]	0.005 [0.13]
0.099–0.069 [2.5–1.71], incl	0.002 [0.05]	0.003 [0.08]	0.004 [0.10]
0.068–0.035 [1.7–0.91], incl	0.002 [0.05]	0.003 [0.08]	0.004 [0.10]
0.034–0.020 [0.9–0.51], incl	0.0015 [0.04]	0.002 [0.05]	0.0025 [0.06]
0.019–0.010 [0.5–0.25], incl	0.001 [0.02]	0.0015 [0.02]	0.002 [0.05]

TABLE 9 Permissible Variations in Width of Cold-Rolled Zirconium Strip (Slit Edge)

Specified Thickness, in. [mm]	Permissible Variations in Width, for Widths Given, plus and minus in. [mm]		
	½ to 6 in. [12.7 to 152 mm], incl	Over 6 to 12 in. [152 to 305 mm], incl	Over 12 to 24 in. [305 to 610 mm], excl
Under 3/16 –0.161 [4.75–4.01], incl	0.016 [0.41]	0.020 [0.5]	0.031 [0.8]
0.160–0.100 [4.01–2.5], incl	0.010 [0.25]	0.016 [0.4]	0.020 [0.5]
0.099–0.069 [2.50–1.71], incl	0.008 [0.20]	0.010 [0.25]	0.020 [0.5]
0.068 [1.7] and under	0.005 [0.13]	0.010 [0.25]	0.020 [0.5]

TABLE 10 Permissible Variations in Length of Hot- and Cold-Rolled Zirconium Strip

Specified Length, ft [m]	Permissible Variations in Length, in. [mm]
To 5 [1.5] incl	+⅜ [9.5], –0
Over 5–10 [1.5–3.0], excl	+½ [13], –0
Over 10–20 [3.0–6.1], incl	+⅝ [16], –0

15.1.3 Sheared edge, and

15.1.4 Machined edge.

15.2 *Cold-Rolled Strip*—A slit edge is normally furnished on cold-rolled strip. A machined edge is available for weld preparation.

15.3 *Sheet and Plate*—Both hot- and cold-rolled sheet and plate are furnished with a sheared edge.

16. Retests

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

16.2 If the results of the inspection of a lot are not in conformance with the requirements of this specification, the lot may be reworked at the option of the manufacturer, providing the rework steps are within the previously approved specifications and procedures used for the original fabrication. Deviations must be approved by the purchaser.

16.3 If the result of any test does not meet the specification requirements, retests may by performed on twice as many samples as originally tested for the characteristic, or using retest procedures mutually agreed upon between the manufacturer and the purchaser.

16.3.1 All test results including the original test results shall be reported to the purchaser. Retest results shall be indicated with the suffix "R."

16.3.2 Only one set of retests is permitted and all retest results shall conform to the specification requirements for the retested characteristic. Following a failed test, 100 % testing is not considered to be a retest.

17. Inspection

17.1 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

TABLE 11 Permissible Variations from a Flat Surface for Annealed Zirconium Plate

NOTE 1—Variations in flatness apply to plates up to 15 ft [4.5 m] in length, or to any 15 ft [4.5 m] of longer plates.

NOTE 2—If the longer dimension is under 36 in. [0.9 m], the variation is not greater than ¼ in. [6.4 mm].

NOTE 3—The shorter dimension specified is considered the width and the variation in flatness across the width does not exceed the tabular amount for that dimension.

NOTE 4—The maximum deviation from a flat surface does not customarily exceed the tabular tolerance for the longer dimension specified.

Specified Thickness, in. [mm]	48 in. or Under [120 cm]	48-60 in., excl [120–150 cm]	60-72 in., incl [150–180 cm]	Over 72 in. [180 cm]
3/16 –¼ [4.75–6.4], incl	¾ [19.0]	1 1/16 [27.0]	1¼ [32]	1⅜ [35]
¼ –⅜ [6.4–9.5], excl	11/16 [18]	¾ [19.0]	15/16 [25]	1⅛ [29]
⅜ –½ [9.5–13], incl	½ [13]	9/16 [14]	11/16 [18]	¾ [19]
½ –¾ [13–19.0], excl	½ [13]	9/16 [14]	⅝ [16]	⅝ [16]
¾ –1 [19.0–25], excl	½ [13]	9/16 [14]	⅝ [16]	⅝ [16]
Over 1 [25]	½ [13]	9/16 [14]	9/16 [14]	9/16 [14]

TABLE 12 Camber Tolerance for Zirconium Sheet And Plate[A]

Tolerance:	$\frac{1}{8}\times\frac{\text{Length in Feet}}{5}$	(result in inch)
	$3.2\times\frac{\text{Length in Meters}}{1.5}$	[result in mm]

[A] Camber is the greatest deviation of a side edge from a straight line. The measurement is taken by placing a straightedge on the concave side and measuring the greatest distance between the plate edge and the straightedge.

testing, the manufacturer shall consider the requirement for purchaser's inspection at place of manufacture to be waived.

17.2 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.

18. Rejection

18.1 Rejection for failure of the material to meet the requirements of this specification shall be reported to the manufacturer promptly and in writing but not later than 60 calendar days from the receipt of the material by the purchaser. Unless otherwise specified, rejected material may be returned to the manufacturer at the manufacturer's expense, unless the purchaser receives, within three weeks of the notice of rejection, other instructions for disposition.

19. Referee

19.1 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 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.

20. Certification

20.1 The manufacturer shall supply at least one copy of the report certifying that the material has been manufactured, inspected, sampled, and tested in accordance with the requirements of this specification and that the results of chemical analysis, tensile, and other tests meet the requirements of this specification for the grade specified. The report shall include results of all chemical analysis, tensile tests, and all other tests required by the specification.

21. Packaging and Package Marking

21.1 Each bundle, box, or coil shall be legibly and conspicuously marked or tagged with the following information:

21.1.1 Purchase order or contract number,
21.1.2 Name of material,
21.1.3 Grade,
21.1.4 Size,
21.1.5 Lot, heat, or ingot number,
21.1.6 Condition,
21.1.7 Gross, net and tare weights, and
21.1.8 ASTM specification number.

21.2 All material shall be packaged in such a manner as to assure safe delivery to its destination when properly transported by any common carrier.

22. Keywords

22.1 nuclear application; plate; sheet; strip; zirconium; zirconium alloy