



Designation: B 393 – 99

Standard Specification for Niobium and Niobium Alloy Strip, Sheet, and Plate¹

This standard is issued under the fixed designation B 393; 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 four grades of wrought niobium and niobium alloy strip, sheet, and plate as follows:

NOTE 1—Committee B-10 has adopted “niobium” as the designation for Element No. 41, formerly named “columbium.”

1.1.1 *R04200-Type 1*—Reactor grade unalloyed niobium,
1.1.2 *R04210-Type 2*—Commercial grade unalloyed niobium,

1.1.3 *R04251-Type 3*—Reactor grade niobium alloy containing 1 % zirconium, and

1.1.4 *R04261-Type 4*—Commercial grade niobium alloy containing 1 % zirconium.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

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

B 391 Specification for Niobium and Niobium Alloy Ingots²

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 *lot*—a lot shall consist of all material produced from the same ingot at one time, with the same cross section, processed with the same nominal metallurgical parameters and heat treated at the same conditions.

3.1.2 *plate*—a flat product 6 in. (152.4 mm) or more in width and greater than $\frac{3}{16}$ in. (4.76 mm) in thickness.

3.1.3 *sheet*—a flat product 6 in. (152.4 mm) or more in width and from 0.005 in. (0.13 mm) to $\frac{3}{16}$ in. (4.76 mm) in thickness.

3.1.4 *strip*—a flat product, which may be supplied in coil, less than 6 in. (152.4 mm) in width and from 0.005 in. (0.13 mm) to $\frac{3}{16}$ in. (4.76 mm) in thickness.

4. Ordering Information

4.1 Orders for materials under this specification shall include the following information as applicable:

4.1.1 Type and grade (Section 1),

4.1.2 ASTM designation and year of issue,

4.1.3 Method of manufacture (Section 5),

4.1.4 Temper designation (Section 8),

4.1.5 Quantity in weight, number of pieces, and dimensions,

4.1.6 Chemistry (Section 6),

4.1.7 Mechanical properties (Section 7),

4.1.8 Quality and finish (Section 10),

4.1.9 Sampling (Section 11),

4.1.10 Marking (Section 18),

4.1.11 Packaging (Section 19),

4.1.12 Required reports (Section 17),

4.1.13 Disposition of rejected material (Section 16), and

4.1.14 Additions to the specification and supplementary requirements, as required.

5. Materials and Manufacture

5.1 Material covered by this specification shall be made from ingots that conform to Specification B 391 and that are produced by vacuum or plasma arc melting, vacuum electron-beam melting, or a combination of these three methods.

5.2 The various niobium mill products covered by this specification are formed with the conventional extrusion, forging, swaging, rolling, and drawing equipment normally available in metal working plants.

6. Chemical Requirements

6.1 The niobium and niobium alloy ingots and billets for conversion to finished products covered by this specification shall conform to the requirements for chemical composition and hardness as prescribed in Table 1 and Table 2.

6.2 The manufacturer's ingot analysis shall be considered

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² *Annual Book of ASTM Standards*, Vol 02.04.

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

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

TABLE 1 Chemical Requirements

Element	Type 1 (Reactor Grade Unalloyed Niobium) R04200	Type 2 (Commercial Grade Unalloyed Niobium) R04210	Type 3 (Reactor Grade Niobium- 1 % Zirconium) R04251	Type 4 (Commercial Grade Niobium- 1 % Zirconium) R04261
Max Weight % (Except Where Otherwise Specified)				
Each ingot:				
Carbon	0.01	0.01	0.01	0.01
Nitrogen	0.01	0.01	0.01	0.01
Oxygen	0.015	0.025	0.015	0.025
Hydrogen	0.0015	0.0015	0.0015	0.0015
Zirconium	0.02	0.02	0.8 to 1.2 (range)	0.8 to 1.2 (range)
Tantalum	0.1	0.3	0.1	0.5
Iron	0.005	0.01	0.005	0.01
Silicon	0.005	0.005	0.005	0.005
Tungsten	0.03	0.05	0.03	0.05
Nickel	0.005	0.005	0.005	0.005
Molybdenum	0.010	0.020	0.010	0.050
Hafnium	0.02	0.02	0.02	0.02
Titanium	0.02	0.03	0.02	0.03
When specified:				
Boron	2 ppm	...	2 ppm	...
Aluminum	0.002	0.005	0.002	0.005
Beryllium	0.005	...	0.005	...
Chromium	0.002	...	0.002	...
Cobalt	0.002	...	0.002	...

TABLE 2 Brinell Hardness

	Type 1	Type 2	Type 3	Type 4
Maximum average	90	125	125	135
Maximum per individual impression	105	150	140	150

the chemical analysis for products supplied under this specification, except for interstitials as specified in 6.3.

6.3 When requested by the purchaser at the time of purchase, the manufacturer shall furnish a report certifying the values of the interstitial elements (C, O, N, H) as prescribed in Table 3 for each lot of material supplied.

7. Mechanical Requirements

7.1 The annealed materials supplied under this specification shall conform to the requirements for mechanical properties as specified in Table 4.

8. Temper Designations

8.1 Unless otherwise stated, the materials supplied under these specifications shall be in the fully annealed condition,

TABLE 3 Additional Chemical Requirements for Finished Product (When Specified by Purchaser)

Element	Type 1 (Reactor Grade Unalloyed Niobium) R04200	Type 2 (Commercial Grade Unalloyed Niobium) R04210	Type 3 (Reactor Grade Niobium—1 % Zirconium) R04251	Type 4 (Commercial Grade Niobium—1 % Zirconium) R04261
Max Weight %				
Oxygen	0.0250	0.0400	0.0250	0.0400
Carbon	0.0100	0.0150	0.0100	0.0150
Nitrogen	0.0100	0.0100	0.0100	0.0100
Hydrogen	0.0015	0.0015	0.0015	0.0015

TABLE 4 Mechanical Properties^A for Material, Annealed Condition (90 % Minimum Recrystallized)

Grade	Ultimate Tensile Strength, min, psi (MPa)	Yield Strength (0.2 % offset), min, psi (MPa)	Elongation in 1-in. (25.4- mm) gage length, min, %	
			0.010 or Greater	Less Than 0.010
Types 1 and 2	18 000 (125)	10 500 (73)	20	15
Types 3 and 4	28 000 (195)	18 000 (125)	20	15

^ARefer to Section 14 for conditions of mechanical tests.

that is, at least 90 % recrystallized.

8.2 Other temper designations, such as cold-worked temper or stress-relieved temper, can be specified as agreed upon between the purchaser and the manufacturer at the time of purchase.

9. Permissible Variations in Dimensions and Weight

9.1 Tolerances for thickness, width, and length for flat-rolled products covered by this specification shall be as prescribed in Table 5.

9.2 Flatness tolerance for sheet and plate products supplied under this specification shall be a maximum of 6 % as determined by the following equation (see Fig. 1):

$$\text{Flatness, \%} = (H/L) \times 100 \quad (1)$$

where:

H = maximum vertical distance between a flat reference and the lower surface of the sheet, and

L = minimum horizontal distance between the highest point on a sheet and the point of contact with a flat reference surface. (Fig. 1 is included to illustrate the method for taking measurements for calculation of sheet flatness. However, a value of H less than $1/32$ in. (0.070 mm) shall not be cause for rejection.)

9.3 *Quantity or Weight*—For orders requiring up to 100 lb (45.4 kg) of finished product, the manufacturer may overshoot by 20 %. When the order is for quantities up to 1000 lb (453.6 kg), the manufacturer may overshoot by 10 %. The permissible overshoot shall be negotiated for orders larger than this quantity.

10. Quality and Finish

10.1 Finished niobium and niobium alloy strip, sheet, and plate shall be free of injurious internal and external imperfections of a nature that will interfere with the purpose for which it was intended. Material may be finished as rolled, as cleaned, or as ground. If shipped as hot-worked, cold-worked, cleaned, or ground, the manufacturer shall be permitted to remove minor surface imperfections, if such removal does not reduce the dimensions below the minimum permitted by the tolerances specified in Table 5.

10.2 The finished strip, sheet, or plate shall be visibly free of oxide, grease, oil, residual lubricants, and other extraneous materials.

10.3 Methods of testing for these defects and standards of acceptability shall be as agreed upon between the manufacturer and the purchaser.

11. Sampling

11.1 Samples for chemical and mechanical testing shall be