



Designation: B393 – 18

# Standard Specification for Niobium and Niobium Alloy Strip, Sheet, and Plate<sup>1</sup>

This standard is issued under the fixed designation B393; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope

1.1 This specification covers five grades of wrought niobium and niobium alloy strip, sheet, and plate as follows:

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,

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

1.1.5 *R04220-Type 5*—RRR grade pure niobium.

NOTE 1—This grade of niobium is used in superconducting applications that require the ultra high purity. Because of the high purity the product is conducive to very large grains that can adversely affect formability. It is not recommended for other applications.

1.2 Except for dimensional tolerances in [Table 1](#), 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.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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.*

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee B10 on Reactive and Refractory Metals and Alloys and is the direct responsibility of Subcommittee B10.03 on Niobium and Tantalum.

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## 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

[B391 Specification for Niobium and Niobium Alloy Ingots E8/E8M Test Methods for Tension Testing of Metallic Materials](#)

[E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications](#)

[E2626 Guide for Spectrometric Analysis of Reactive and Refractory Metals \(Withdrawn 2017\)](#)<sup>3</sup>

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *lot, n*—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, n*—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, n*—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, n*—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 Quantity in weight, number of pieces, and dimensions,

4.1.4 Chemistry ([6.3](#)),

4.1.5 Temper designation ([Section 8](#)),

4.1.6 Permissible overshipment ([9.3](#)),

4.1.7 Quality and finish ([10.3](#)),

4.1.8 Sampling ([11.2](#)),

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

**TABLE 1 Dimensional Tolerances for Niobium Flat-Rolled Products**

Thickness of Material, in. (mm) in lower table	Tolerance on Thickness <sup>A</sup> plus or minus, in. (mm) in lower table		Tolerance on Width (slit) <sup>B</sup> plus or minus, in.(mm) in lower table		Tolerance on Sheared Lengths, in. (mm)			
	Width under 6 in. or 152.4 mm	Width 6 to 24 in. or 152.4 to 609.6 mm	Width under 6 in. or 152.4 mm	Width 6 to 24 in. or 152.4 to 609.6 mm	Length 12 in. or 304.8 mm and under		Length over 12 in. or 304.8 mm	
					Plus	Minus	Plus	Minus
Inches								
0.005 to 0.010 excl	0.0005	0.001	0.012	...	1/16	0	3/32	0
0.010 to 0.015 excl	0.0007	0.001	0.015	0.015	1/16	0	3/32	0
0.015 to 0.020 excl	0.0008	0.0015	0.015	0.015	1/16	0	3/32	0
0.020 to 0.030 excl	0.0015	0.0025	0.020	0.025	1/16	0	3/32	0
0.030 to 0.060 excl	0.0025	0.0035	0.025	0.030	1/16	0	3/32	0
0.060 to 0.090 excl	0.004	0.005	0.025	0.035	1/16	0	3/32	0
0.090 to 0.125 excl	0.006	0.007	...	...	1/16	0	3/32	0
0.125 to 0.187 excl	0.010	0.010	...	...	1/16	0	3/32	0
0.187 to 0.250 excl	0.015	0.015	...	...	1/8	0	5/32	0
0.250 to 0.312 excl	0.020	0.020	...	...	1/8	0	5/32	0
0.312 to 0.375 excl	0.025	0.025	...	...	3/16	0	7/32	0
Millimetres								
0.13 to 0.254 excl	0.013	0.025	0.30	...	1.59	0	2.38	0
0.254 to 0.381 excl	0.018	0.025	0.38	0.38	1.59	0	2.38	0
0.381 to 0.508 excl	0.020	0.038	0.38	0.38	1.59	0	2.38	0
0.508 to 0.762 excl	0.038	0.064	0.51	0.64	1.59	0	2.38	0
0.762 to 1.524 excl	0.064	0.089	0.64	0.76	1.59	0	2.38	0
1.524 to 2.286 excl	0.102	0.127	0.64	0.89	1.59	0	2.38	0
2.286 to 3.175 excl	0.15	0.18	...	...	1.59	0	2.38	0
3.175 to 4.75 excl	0.25	0.25	...	...	1.59	0	2.38	0
4.75 to 6.35 excl	0.38	0.38	...	...	3.18	0	3.97	0
6.35 to 7.925 excl	0.51	0.51	...	...	3.18	0	3.97	0
7.925 to 9.52 excl	0.64	0.64	...	...	4.76	0	5.56	0

<sup>A</sup> Tolerance on thickness of sheet over 24 in. (610 mm) wide shall be  $\pm 10\%$  of the thickness.

<sup>B</sup> Tolerance on width of sheared sheet shall be  $\pm 1/16$  in. ( $\pm 1.6$  mm) and on sheared plate shall be  $\pm 1/8$  in. ( $\pm 3.2$  mm) up to material thickness of 0.375 in. (9.5 mm).

- 4.1.9 Inspection (Section 15),
- 4.1.10 Required reports (Section 17),
- 4.1.11 Marking (Section 18), and
- 4.1.12 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 B391 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 as prescribed in Table 2.

6.2 The manufacturer's ingot analysis shall be considered the chemical analysis for products supplied under this specification, except for end product interstitials as specified in 6.3. Alternately, an analysis of a representative sample of in process or final product from the same ingot may be specified.

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) on end products

as prescribed in Table 3 for each lot of material supplied. End product interstitial samples must be taken after all thermal and chemical processing.

6.4 Guide E2626 is recommended as a guide, where applicable.

## 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, 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 1.

9.2 Flatness tolerance for sheet and plate products supplied under this specification shall be a maximum of 6 % (2 % for RRR grade sheet and strip) as determined by the following equation (see Fig. 1):

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

**TABLE 2 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	Type 5 (RRR Superconducting Grade Pure Niobium) R04220
	Max Weight % (Except Where Otherwise Specified)				
Each ingot:					
Carbon	0.01	0.01	0.01	0.01	0.0030
Nitrogen	0.01	0.01	0.01	0.01	0.0030
Oxygen	0.015	0.025	0.015	0.025	0.0040
Hydrogen	0.0015	0.0015	0.0015	0.0015	0.0005
Zirconium	0.02	0.02	0.8 to 1.2 (range)	0.8 to 1.2 (range)	0.010
Tantalum	0.1	0.3	0.1	0.5	0.1
Iron	0.005	0.01	0.005	0.01	0.005
Silicon	0.005	0.005	0.005	0.005	0.005
Tungsten	0.03	0.05	0.03	0.05	0.007
Nickel	0.005	0.005	0.005	0.005	0.003
Molybdenum	0.010	0.020	0.010	0.050	<sup>A</sup>
Hafnium	0.02	0.02	0.02	0.02	<sup>A</sup>
Titanium	0.02	0.03	0.02	0.03	0.005
When specified:					
Boron	2 ppm	...	2 ppm	...	
Aluminum	0.002	0.005	0.002	0.005	0.005
Beryllium	0.005	...	0.005	...	
Chromium	0.002	...	0.002	...	<sup>B</sup>
Cobalt	0.002	...	0.002	...	<sup>B</sup>

<sup>A</sup> The limits shown below are for information only when the RRR ratio is greater than 260.

<sup>B</sup> Total of these metals is 0.005 %.

**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	Type 5 (RRR Superconducting Grade Pure Niobium) R04220
	Max Weight %				
Oxygen	0.0250	0.0400	0.0250	0.0400	0.0040
Carbon	0.0100	0.0150	0.0100	0.0150	0.0030
Nitrogen	0.0100	0.0100	0.0100	0.0100	0.0030
Hydrogen	0.0015	0.0015	0.0015	0.0015	0.0005

**TABLE 4 Mechanical Properties<sup>A</sup> 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 in. or Greater	Less Than 0.010 in.
Types 1 and 2	18 000 (125)	10 500 (73)	20	15
Types 3 and 4	28 000 (195)	18 000 (125)	20	15
Type 5 (RRR grade) <sup>B</sup>	14 000 (95)	7 200 (50)	30	30

<sup>A</sup> Refer to Section 14 for conditions of mechanical tests.

<sup>B</sup> For RRR grade the difference between longitudinal and transverse samples shall not exceed 20 % of the average of the two.