



Standard Specification for Niobium and Niobium Alloy Ingots¹

This standard is issued under the fixed designation B391; 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.

^{ε1} NOTE—Editorial corrections were made throughout in January 2010.

1. Scope

1.1 This specification covers unalloyed and alloyed niobium ingots prepared by vacuum- or plasma-arc melting or electron-beam melting to produce consolidated metal for processing to various mill shapes.

1.2 The materials covered by this specification are:

1.2.1 *R04200-Type 1*—Reactor grade unalloyed niobium,

1.2.2 *R04210-Type 2*—Commercial grade unalloyed niobium,

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

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

1.3 Unless a single unit is used, 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.

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards*:²

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

[E2626 Guide for Spectrometric Analysis of Reactive and Refractory Metals](#)

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 B10.03 on Niobium and Tantalum.

Current edition approved Oct. 1, 2009. Published December 2009. Originally approved in 1962. Last previous edition approved in 2003 as B391–03. DOI: 10.1520/B0391-09E01.

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.

3. Ordering Information

3.1 Orders for material under this specification shall include the following information, as applicable:

3.1.1 ASTM standard number and year of issue,

3.1.2 Type (see 1.2),

3.1.3 Quantity in weight or pieces,

3.1.4 Size, diameter and length,

3.1.5 Chemistry (see 5.2),

3.1.6 Permissible overshipment (see 6.1),

3.1.7 Quality and finish (see 7.2 and 7.6),

3.1.8 Sampling (Section 8)

3.1.9 Packaging (Section 15), and

3.1.10 Required reports (Section 13).

4. Materials and Manufacture

4.1 The ingot metal for all four types may be vacuum or plasma arc melted, vacuum electron-beam melted, or any combination of these three methods.

5. Chemical Requirements

5.1 The finished ingot shall conform to the requirements for chemical composition as prescribed in Table 1.

5.2 Analysis for elements not listed in Table 1 and not normally expected in niobium shall not be required unless specified at time of purchase.

6. Permissible Variations

6.1 *Quantity*—For orders requiring up to 100 lb (45.4 kg) of ingots, the manufacturer may overship up to a maximum of 20 %. For orders up to and including 1000 lb (454 kg), the manufacturer may overship up to a maximum of 10 %. The permissible overshipment shall be negotiated for orders larger than 1000 lb (454 kg).

7. Quality and Finish

7.1 The manufacturer shall use care to have each lot of ingot material as uniform in quality as possible.

7.2 When specified, the ingots shall be conditioned on the surface to standards agreed upon between the manufacturer and the purchaser.

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	...

7.3 Subsequent fabrication will be permitted. The difference between the maximum and minimum radius of the conditioned ingot shall not exceed 20 % of the maximum radius. Lands, grooves, and local depressions shall be blended to a maximum angle of 30° to the axis of the ingot.

7.4 Each ingot shall be tested for soundness by nondestructive test methods, such as dye penetrant or ultrasonic tests. Methods and acceptance standards shall be as mutually agreed upon between the purchaser and the manufacturer.

7.5 Defects in the ingots that exceed the acceptance standards shall be removed by cropping or surface conditioning, whichever is appropriate. The manufacturer shall be permitted to remove surface imperfections provided that after such removal the requirements of conditioning are met (7.2).

7.6 The ingots shall be free of imperfections that would be deemed injurious by the standards of acceptability agreed upon between the purchaser and the manufacturer.

8. Sampling

8.1 Care shall be exercised to ensure that the sample selected for testing is representative of the material and that it is not contaminated by the sampling procedure. If there is any question relating to the sampling techniques or to the analysis thereof, the methods for sampling and analysis shall be as agreed upon between the purchaser and the manufacturer.

8.2 Sampling is typically performed at the top, middle and bottom of the ingot.

9. Number of Tests and Retests

9.1 Each ingot shall be tested for chemical composition.

9.2 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.

9.3 In case of failure, retest two additional specimens. If both specimens conform to this specification, discard the original values and consider the material acceptable; otherwise the ingot shall be rejected or reworked and retested.

10. Significance of Numerical Limits

10.1 For the purpose of determining compliance with the specified limits for requirements of the properties listed in the following tables, an observed value or a calculated value shall be rounded as indicated in accordance with the rounding method of Practice E29.

11. Test Method

11.1 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.

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

12. Rejection and Rehearing

12.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection shall be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

12.2 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 purchaser, 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.

13. Certification

13.1 A producer's or supplier's certification shall be furnished to the purchaser that the material was manufactured, sampled, tested, and inspected in accordance with the specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

14. Product Marking

14.1 Each ingot shall be marked for identification by metal die stamping the manufacturer's ingot number on the top of the ingot. Each box or skid shall be marked or tabbed legibly and

conspicuously with the number, type of material, ingot number(s), manufacturer's identification, nominal size, and the gross, net, and tare weights.

15. Packaging and Package Marking

15.1 Unless otherwise specified, material purchased under this specification must be boxed or banded on skids in such a manner as to secure safe delivery to their destination when properly transported by any common carrier.

16. Keywords

16.1 niobium; niobium alloy ingots

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org). Permission rights to photocopy the standard may also be secured from the ASTM website (www.astm.org/COPYRIGHT/).