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Standard Specification for Niobium-Titanium Alloy Billets, Bar, and Rod for Superconducting Applications¹

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1. Scope

1.1 This specification covers niobium-titanium alloy billets, bars, and rods, at 46 to 48 % titanium. This material is used in the manufacture of wire for superconducting applications.

~~1.2 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 independent of the other; SI values cannot be mixed with inch-pound values. SI units are stated in parentheses.~~

1.2 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, Section 14, 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

E92 Test Method for Vickers Hardness of Metallic Materials

E112 Test Methods for Determining Average Grain Size

E165 Practice for Liquid Penetrant Examination for General Industry

E214 Practice for Immersed Ultrasonic Testing by the Reflection Method Using Pulsed Longitudinal Waves

~~E384 Test Method for Knoop and Vickers Hardness of Materials~~ Test Method for Knoop and Vickers Hardness of Materials

E2626 Guide for Spectrometric Analysis of Reactive and Refractory Metals

2.2 ANSI Standard:

ANSI B46-1 Surface Texture³

2.3 ASNT Standard:

ASNT SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing⁴

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *rod, n*—material greater than 0.5 in. (13 mm) and less than 2.5 in. (60 mm) in. diameter.

3.1.2 *bar, n*—material greater than or equal to 2.5 in. (60 mm) and less than 6 in. (150 mm) in diameter.

3.1.3 *billet, n*—material greater than or equal to 6 in. (150 mm) in diameter.

3.1.4 *lot, n*—a lot shall consist of all material produced from the same ingot at one time, with the same cross section and with the same nominal metallurgical parameters.—a lot shall consist of 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 8th period for final continuous anneal, or to a single furnace load for final batch anneal.

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.

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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.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁴ Available from ~~The~~ American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlington Ln., Columbus, OH 43228-0518, <http://www.asnt.org>.

4. Ordering Information

- 4.1 Purchase orders for material under this specification should include:
- 4.1.1 ASTM designation and year of issue,
 - 4.1.2 Quantity in weight, number of pieces, and dimensions,
 - 4.1.3 Grain size limit for diameters greater than 7.75 in. (see 7.2 and Table 1),
 - 4.1.4 Surface texture, if required (see 10.3),
 - 4.1.5 Annealing condition, if different from 7.1,
 - 4.1.6 Permissible variations in diameter and length (see 9.1 and 9.2),
 - 4.1.7 Sampling and analytical methods, if required (see 11.3),
 - 4.1.8 Inspection requirements (see Section 15),
 - 4.1.9 Certification and report needs (see Section 17), and
 - 4.1.10 Additions to the specification and supplementary requirements, as required.

5. Materials and Manufacture

5.1 Materials covered by this specification shall be made from ingots which are produced by ~~vacuum or vacuum~~, plasma-arc melting, or electron beam furnace melting, or a combination of these methods. All melting is to be carried out in furnaces usually used for reactive metals.

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

6. Chemical Composition

6.1 The Nb-Ti alloy ingots, billets, and rods covered by this specification shall conform to the chemical composition limits shown in Table 2.

6.2 The manufacturer's ingot analysis shall be considered the chemical analysis for the products supplied to this specification, except for the interstitials carbon, oxygen, nitrogen, and hydrogen. When specified in the purchase order, the analysis for these interstitials shall be measured on product.

7. Physical Properties

7.1 Unless otherwise specified in the purchase order, the material will be supplied in the annealed state.

7.2 The grain size of finished billets or rods shall meet the limits in Table 1 (see 14.3).

7.3 The product shall be free of cracks, laminations, inclusions, voids, and other ruptures with size larger than 3 % of the product diameter or 0.096 in. (2.5 mm) equivalent diameter, whichever is smaller. This characteristic shall be measured by ultrasonic testing (see 14.5).

8. Mechanical Properties

8.1 Hardness testing will be performed on each lot of finished product and the average of three readings shall be less than 170 DPH (see 14.2).

9. Permissible Variations in Dimensions

9.1 Permissible variations in diameters for finished product shall be as specified in Table 3, unless otherwise agreed to between manufacturer and purchaser.

9.2 Permissible variations in length for finished product shall be as specified in the purchase order.

10. Workmanship, Finish and Appearance

10.1 *Surface Condition*—The finished material shall be free of visually detectable cracks, seams, slivers, blisters, laps, gouges, and other injurious imperfections.

10.2 *Liquid Penetrant Examination* —The surfaces of billet and bar shall be examined using liquid penetrant inspection methods (see 14.4). The following indications are unacceptable:

10.2.1 Cracks,

10.2.2 Linear indications,

TABLE 1 Grain Size Requirements

Rod, Bar, and Billet Diameter in. (mm)	Grain Size Number (weighted average)
0.5 to 2 incl (13 to 50 incl)	4.5 or finer
2 excl to 4.5 incl (50 excl to 115 incl)	2.5 or finer
4 excl to 6 incl (115 excl to 150 incl)	1.5 or finer
6 excl to 7.75 incl (150 excl to 200 incl)	1.0 or finer
Greater than 7.75 (200)	To be set in purchase order

TABLE 2 Chemical Requirements

Element	Ingot Maximum Limit (ppm)
Aluminum	100
Carbon	200
Chromium	100
Copper	100
Hydrogen	45
Iron	200
Nickel	100
Nitrogen	150
Oxygen	1000
Silicon	100
Tantalum	2500
Titanium	46 to 48 %

TABLE 3 Permissible Variations in Diameters

Diameter in. (mm)	Tolerance, plus or minus, in. (mm)
0.51 to 1.0 (13.1 to 25)	0.010 (0.25)
1.1 to 4.0 (25.1 to 100)	0.015 (0.4)
Over 4.0 (100)	0.020 (0.5)

10.2.3 Rounded indications with dimensions exceeding 0.03 in. (0.8 mm), and

10.2.4 For sidewall surfaces only, rounded indications that are separated by less than 0.03 in. (0.8 mm) edge to edge.

10.3 *Surface Finish*—Surface finish shall be as specified in the purchase order (see 14.6).

10.4 *Surface Preparation*—The finished surface shall be pickled and rinsed in water. Removal of liquid penetrant test materials after pickling shall be by rinsing or additional pickling.

10.5 *Cleanliness*—Materials shall be clean to the extent that no contamination is visible to the unaided eye, corrected for 20/20 vision, when viewed under an illumination of at least 100 foot candles (1100 lux) on the surface being tested.

11. Sampling

11.1 *Ingots*—Samples for ingot chemical analyses shall be taken on the ingot sidewall at least at three positions along the ingot including the middle and to within 5 in. (125 mm) of each end.

11.2 *Product*—Samples for chemical and mechanical testing shall be taken from the finished material after all metallurgical processing to determine conformity to this specification. The samples may be taken prior to final inspection and minor surface conditioning by abrasion and pickling, and shall be representative of the finished product.

11.3 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 questions relating to the sampling technique or the analysis thereof, the methods of sampling and analysis shall be as agreed upon between the purchaser and the manufacturer.

12. Number of Tests and Retests

12.1 *Initial Tests*—Each product sample shall be tested once for each product test requirement.

12.2 *Invalid Tests*—If any sample or test is found to be contaminated or improperly done, the result may be invalidated and a new test done to replace the original.

12.3 *Retests*—If a test result does not meet the specification or is questionable, retests may be performed on twice the number of samples originally tested. Both retest values must conform to the specification. All three values will be reported on the certification. The retest values shall be marked with an “R” or “R.” Alternatively, each piece in the lot may be tested and deviant pieces rejected or reworked.

12.4 *Rework*—Product not meeting this specification may be reworked to meet this specification.

13. Significance of Numerical Limits

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

14. Test Methods

~~14.1 Analytical methods for chemical composition shall be in accordance with industry or manufacturer’s standards.~~

14.1 Analytical methods for chemical composition shall be in accordance with industry or manufacturer’s standards. Guide E2626 may be used as a guide for chemical analysis techniques.