Designation: ~~B1009 – 18~~ B1009 – 20

Standard Specification for Titanium Alloy Bars for Near Surface Mounts in Civil Structures[1]

This standard is issued under the fixed designation B1009; 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 titanium alloy bars with surface deformations and 90-degree anchorage hooks for use as near surface mounts for flexural and shear strengthening of concrete beams. The product can be furnished with or without anchorage hooks as specified by the purchaser. If supplied without hooks, the hooks shall be bent on-site prior to installation, as this method requires two 90-degree anchorage hooks.

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 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A944 Test Method for Comparing Bond Strength of Steel Reinforcing Bars to Concrete Using Beam-End Specimens

B348 Specification for Titanium and Titanium Alloy Bars and Billets

D7913/D7913M Test Method for Bond Strength of Fiber-Reinforced Polymer Matrix Composite Bars to Concrete by Pullout Testing

E8/E8M Test Methods for Tension Testing of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E539 Test Method for Analysis of Titanium Alloys by Wavelength Dispersive X-Ray Fluorescence Spectrometry

E1409 Test Method for Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion

E1447 Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

E1941 Test Method for Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis

E2371 Test Method for Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission Spectrometry (Performance-Based Test Methodology)

E2626 Guide for Spectrometric Analysis of Reactive and Refractory Metals (Withdrawn 2017)[3]

E2994 Test Method for Analysis of Titanium and Titanium Alloys by Spark Atomic Emission Spectrometry and Glow Discharge Atomic Emission Spectrometry (Performance-Based Method)

2.2 *CRSI Standard:*[4]

CRSI Manual of Standard Practice

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[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 B10.01 on Titanium.

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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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Concrete Reinforcing Steel Institute (CRSI), 933 N. Plum Grove Rd., Schaumburg, IL 60173, www.crsi.org.

2.3 *ACI Standard:*[5]
ACI 318 Building Code Requirements for Structural Concrete

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *bar, n*—a hot rolled, forged, extruded or cold worked semi-finished solid section product whose cross-sectional area is equal to or less than 16 in.^{2} (10 323 mm^2).

3.1.2 *bonding material, n*—material used to bond the titanium near surface mount to the concrete substrate; these materials can include epoxy, polyester, vinyl ester resins, and cementitious grouts.

3.1.3 *deformed bar, n*—titanium bar with rough surface to promote bond strength with bonding material and concrete; a bar that is intended for use as reinforcement in concrete construction.

3.1.4 *out to out dimension, n*—if a bar contains two 90-degree anchorage hooks, it is the dimension from the outside of the one hook to the outside of the other hook.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information as applicable:
4.1.1 Quantity (length),
4.1.2 Bar designation number (size) of deformed bars,
4.1.3 Number of anchorage hooks (0, 1, or 2) to be supplied by manufacturer along with length and bend diameter of hook per CRSI Manual of Standard Practice,
4.1.4 ASTM designation and year of issue,
4.1.5 Mechanical Properties or Class (Table 1),
4.1.6 Marking (Section 15.1),
4.1.7 Packaging (Section 15.2),
4.1.8 Required reports (Section 14), and
4.1.9 Disposition of rejected material (Section 13).

4.2 The purchaser shall have the option to specify additional requirements including but not limited to, the following:
4.2.1 Require bars in each bundle to be supplied from a single heat,
4.2.2 Requirements for inspection,
4.2.3 Other special requirements.

5. Chemical Composition

5.1 The titanium alloy metal covered by this specification shall conform to the requirements as to the chemical composition prescribed in Table 2 (reference Specification B348 Grade 5).

5.1.1 The elements listed in Table 3 are intentional alloy additions or elements which are inherent to the manufacture of titanium sponge, ingot or mill product.

5.1.1.1 Elements other than those listed in Table 2 are deemed to be capable of occurring in the grades listed in Table 2 by and only by way of unregulated or unanalyzed scrap additions to the ingot melt. Therefore, product analysis for elements not listed in Table 2 shall not be required unless specified and shall be considered to be in excess of the intent of this specification.

5.1.2 Elements intentionally added to the melt must be identified, analyzed and reported in the chemical analysis.

5.2 When agreed upon by the producer and purchaser and requested by the purchaser in his written purchase order, chemical analysis shall be completed for specific residual elements not listed in this specification.

5.3 *Product Analysis:*

TABLE 1 Tensile Requirements

Class	Tensile Strength, min		Yield Strength (0.2 % Offset), min or range		Elongation in ~~4D~~ D^A or 2 in. (~~50~~ mm), min %
	ksi	MPa	ksi	MPa	
120	130	895	120	828	10
130	140	965	130	895	10

^{A} D is equivalent to the nominal diameter of the bar as described in Table 4.

[5] Available from American Concrete Institute (ACI), 38800 Country Club Dr., Farmington Hills, MI 48331-3439, www.concrete.org.

TABLE 2 Chemical Requirements

Composition, Weight Percent[A,B,C,D,E]									
Grade	Carbon, max	Oxygen, max	Nitrogen, max	Hydrogen, max	Iron, max	Aluminum	Vanadium	Other Elements, max each	Other Elements, max total
5	0.08	0.20	0.05	0.015	0.40	5.5-6.75	3.5-4.5	0.1	0.4

[A] At minimum, the analysis of samples from the top and bottom of the ingot shall be completed and reported for all elements listed for the respective grade in this table.
[B] Final product hydrogen shall be reported. Ingot hydrogen need not be reported. Lower hydrogen may be obtained by negotiation with the manufacturer.
[C] Single values are maximum. The percentage of titanium is determined by difference.
[D] Other elements need not be reported unless the concentration level is greater than 0.1 % each, or 0.4 % total. Other elements may not be added intentionally. Other elements may be present in titanium or titanium alloys in small quantities and are inherent to the manufacturing process. In titanium these elements typically include aluminum, vanadium, tin, chromium, molybdenum, niobium, zirconium, hafnium, bismuth, ruthenium, palladium, yttrium, copper, silicon, cobalt, tantalum, nickel, boron, manganese, and tungsten
[E] The purchaser may, in the written purchase order, request analysis for specific elements not listed in this specification.

TABLE 3 Permissible Variations in Product Analysis

Element	Product Analysis Limits, max or Range, %	Permissible Variation in Product Analysis
Aluminum	2.5-6.75	±0.40
Carbon	0.10	+0.02
Hydrogen	0.02	+0.002
Iron	0.80	+0.15
Nitrogen	0.05	+0.02
Oxygen	0.30	+0.03
Vanadium	0.6-4.5	±0.15
Residuals,[A] each	0.15	+0.02

[A] A residual is an element present in a metal or alloy in small quantities and is inherent to the manufacturing process but not added intentionally. In titanium these elements include aluminum, vanadium, tin, iron, chromium, molybdenum, niobium, zirconium, hafnium, bismuth, ruthenium, palladium, yttrium, copper, silicon, cobalt, tantalum, nickel, boron, manganese, and tungsten.

5.3.1 Product analysis tolerances do not broaden the specified heat analysis requirements but cover variations between laboratories in the measurement of chemical content. The manufacturer shall not ship material which is outside the limits specified in Table 2. Product analysis limits shall be as specified in Table 3.

5.3.2 The product analysis is either for the purpose of verifying the composition of a heat or manufacturing lot or for determining variations in the composition within the heat.

5.3.3 Acceptance or rejection of a heat or manufacturing lot of a material must be made by the purchaser on the basis of this product analysis. Product analyses outside the tolerance limits allowed in Table 3 are cause for rejection of the product. A referee analysis may be used if agreed upon by supplier and purchaser.

5.3.4 For referee purposes, use Test Methods E539, E1409, E1447, E1941, E2371, E2626, and E2994 or other analytical methods agreed upon between the purchaser and the supplier.

5.4 Samples for chemical analyses shall be representative of the material being tested. The utmost care must be used in sampling titanium for chemical analysis because of its great affinity for elements such as oxygen, nitrogen, and hydrogen. Therefore, in cutting samples for analysis, the operation should be carried out insofar as possible in a dust-free atmosphere. Chips should be collected from clean metal and tools should be clean and sharp. Samples for analysis should be stored in suitable containers.

5.5 At least two samples for chemical analysis shall be tested to determine chemical composition. Samples shall be taken from the ingot or from the opposite extremes of the product to be analyzed.

6. Mechanical Properties

6.1 Material supplied under this specification shall conform to the mechanical property requirements given in Table 1, as applicable. Higher strength bars can be ordered if agreed upon between purchaser and supplier.

6.2 Tension testing specimens shall be the full cross-section of the as-supplied bar with surface deformations and tested in accordance with Test Method E8/E8M. Unit stress determinations for yield and tensile strength shall be based on the average cross sectional-area defined in 8.2. Tensile properties shall be determined using a strain rate of 0.003 to 0.007 in./in./min through the specified yield strength, and then increasing the rate so as to produce failure in approximately one additional minute.

7. Bond Strength

7.1 To enhance bond along the length of the titanium alloy bar, surface deformations are required. The surface deformations may be rolled or machined or produced by another suitable method to deform the surface. The surface deformations shall be sufficient to preclude failure along the titanium alloy bar-bonding material interface. The deformations must be capable of producing 1.0 ksi