



# Standard Specification for Tungsten Base, High-Density Metal<sup>1</sup>

This standard is issued under the fixed designation B777; 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 the requirements for four classes of machinable, high-density tungsten base metal produced by consolidating metal powder mixtures, the composition of which is mainly tungsten. This material specification may be used for bare parts or for parts that may be coated with other materials for protection against corrosion and abrasion.

1.2 This specification describes physical, mechanical, and microstructural testing of a material lot based on the use of test coupons, not actual parts. Sintered properties typically vary both with part size and sampling location within a given part. Results obtained from coupon testing may therefore differ from the properties of a specific location in a larger part.

1.3 *Intended Use*—Parts made from this material are intended for uses such as weights or counter-balances in static or dynamic balancing, high-speed rotating inertia members, radiation shielding, hypervelocity impact, and vibration-damping applications. In selecting the appropriate alloy for a given application, it is important to note that as the tungsten content of the alloy is increased, stiffness, radiation attenuation, and density increase with an accompanying decrease in attainable ductility.

1.4 *Special Applications*—For particular applications, properties or requirements other than those specified in Sections 5, 6, and 7 of this specification may be important. These alloys may contain elements which make them weakly ferromagnetic. Where freedom from magnetic response is required, this should be specified in the purchase order. Class 4 is not available in a non-magnetic grade. For purposes of this specification, non-magnetic material is defined as material having a maximum magnetic permeability of 1.05 (see Test Method A342). Also for special applications involving large sections, methods for determining internal quality, such as mechanical testing of specimens excised from these larger sections or suitable nondestructive tests may be applied. If such part property data are required, an additional part-specific test program shall be specified in the purchase order.

<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 B10.04 on Molybdenum and Tungsten.

Current edition approved Dec. 1, 2015. Published December 2015. Originally approved in 1987. Last previous edition approved in 2013 as B777 – 07 (2013). DOI: 10.1520/B0777-15.

1.5 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.

## 2. Referenced Documents

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

A342 Test Methods for Permeability of Weakly Magnetic Materials

B311 Test Method for Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity

D3951 Practice for Commercial Packaging

E3 Guide for Preparation of Metallographic Specimens

E8/E8M Test Methods for Tension Testing of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

E407 Practice for Microetching Metals and Alloys

2.2 *Federal Standard*:

Fed. Std. No. 151 Metals, Test Methods<sup>3</sup>

## 3. Classification

3.1 The tungsten base metal shall be of the following classes (see Table 1 and Table 2), as specified (see 4.1).

## 4. Ordering Information

4.1 Orders for tungsten base, high-density metal should specify the following:

4.1.1 Title, designation, and year of issue of this specification,

4.1.2 Class, (see 3.1),

4.1.3 Quantity,

4.1.4 Levels of preservation and packing (see 9.1),

4.1.5 Special markings, if required (see 9.2),

4.1.6 Method of hardness testing, if different from Rockwell “C” (see Table 1),

<sup>2</sup> 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.

<sup>3</sup> Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

**TABLE 1 Composition, Density and Hardness Properties**

Class	Nominal Tungsten, weight %	Density, g/cc	Hardness <sup>A,B</sup> Rockwell "C," max
1	90	16.85–17.30	32
2	92.5	17.15–17.85	33
3	95	17.75–18.35	34
4	97	18.25–18.85	35

<sup>A</sup> When specified by the purchaser, other hardness testing methods may be employed.

<sup>B</sup> Hardness values are for unworked (as-sintered or annealed) material. For mechanically worked or strain aged material, the hardness can be as high as R<sub>c</sub>49.

4.1.7 Freedom of parts from magnetic response, if required (see 1.4), and

4.1.8 Dimensions and tolerances.

## 5. Materials and Manufacture

5.1 *Materials*—The raw materials shall be a mixture of loose metal powders consisting mainly of tungsten with some combination of binder elements such as copper, nickel, iron, or other which, by sintering, will produce sintered shapes meeting the requirements of this specification.

## 6. Chemical Composition

6.1 The specified class shall have the nominal tungsten content in Table 1.

## 7. Physical and Mechanical Properties

7.1 *Physical and Mechanical Properties*—The sintered material shall have properties conforming to Table 1 and Table 2 as determined on standard sintered test bars (see Test Methods E8/E8M).

7.2 *Microstructure*—The microstructure of each sample shall be a uniform distribution of tungsten particles in a binder metal matrix when viewed at a magnification of 200 times. The location may be specified (see 8.4.5).

7.3 *Identification*—Each lot and associated test bars shall be clearly marked with a lot serial number (see 8.3.1).

## 8. Quality Assurance Provisions

8.1 *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own facilities for the performance of the inspection or any other facility that is acceptable to the purchaser.

8.2 *Responsibility for Compliance*—All parts must meet all the requirements agreed upon by purchaser and manufacturer from Sections 4, 6 and 7. The inspections set forth in this specification shall become a part of the manufacturer's overall inspection system or quality program.

8.3 *Quality Conformance Inspection:*

8.3.1 *Inspection Lot*—An inspection lot shall consist of a uniform blend from one batch of powder, and submitted for inspection at one time. If a shipment is made from more than one lot, the purchaser may choose to consider that shipment as a single inspection lot or may choose to separate the shipment into several inspection lots for acceptance purposes.

8.3.2 *Sampling for Sintered Property Determination*—Unless otherwise specified, a minimum of two sintered test bars shall be made from each powder (inspection) lot.

8.3.3 *Hardness Tests*—Each test bar shall be tested for conformance with the hardness requirements of Table 1 (see 8.4.1).

8.3.4 *Density*—Each test bar shall be tested for conformance with the density requirements of Table 1 (see 8.4.2).

8.3.5 *Tension Tests*—Each test bar shall be tested for conformance with Table 2 (see 8.4.3).

8.3.6 *Sampling for Chemical Composition*—A sample from each blended powder lot shall be tested for the tungsten content in conformance with Table 1 (see 8.4.4).

8.3.7 *Examination of Microstructure*—This test shall be accomplished on one of the test bars (see 8.4.5).

### 8.4 Methods for Test and Examinations:

8.4.1 *Hardness*—Samples shall be tested in accordance with Test Methods E18.

8.4.2 *Density*—The equal water displacement method performed in accordance with Test Method B311 shall be used.

8.4.3 *Mechanical Properties*—Samples shall be tested in accordance with Test Methods E8/E8M.

8.4.4 *Chemical Analysis*—Analysis of the lot or lots in question shall be made by Method 111 or 112 of Fed. Std. No. 151 for conformance with 8.3.6. In case of dispute, chemical analysis by Method 111 shall be the basis for acceptance.

8.4.5 *Microstructure*—A test bar shall be sectioned and a specimen shall be prepared for examination in accordance with Guide E3. The specimen may be etched (see Practice E407), and shall be examined at a magnification of 200 times for conformance with 7.2.

8.5 *Rejection*—Unless otherwise stated in the purchase order, failure to conform to any of the requirements of this specification shall be cause for rejection of the lot.

## 9. Packaging and Package Marking

9.1 *Preservation, Packaging, and Packing*—The material shall be prepared for delivery in accordance with the producer's commercial practice or Practice D3951 as specified in such a manner as to ensure acceptance for safe delivery by common or other carriers to the point of delivery.

9.2 *Marking*—If specified in the purchase order, each individual item and test bar shall be clearly identified with a lot serial number. Where parts are too small to be individually identified, they may be grouped for this purpose.

## 10. Keywords

10.1 high-density metal; tungsten

**TABLE 2 Tensile Properties, Minimum Values**

Class	Standard Alloys			Nonmagnetic Alloys		
	Ultimate Strength ksi (MPa)	0.2 % Offset Yield ksi (MPa)	EL <sup>A</sup> (%)	Ultimate Strength ksi (MPa)	0.2 % Offset Yield ksi (MPa)	EL <sup>A</sup> (%)
1	110 (758)	75 (517)	5	94 (648)	75 (517)	2
2	110 (758)	75 (517)	5	94 (648)	75 (517)	2
3	105 (724)	75 (517)	3	94 (648)	75 (517)	1
4	100 (689)	75 (517)	2	na	na	na

<sup>A</sup> Determine with an extensometer accurate to 0.5 % elongation or less.

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