



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

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## 1. Scope

1.1 This specification covers the requirements for four classes of machinable, high-density tungsten base metal produced by consolidation of metal powder mixtures of which the composition is mainly tungsten. This material specification may be used for bare parts or be used for parts that may be coated with other materials for protection against corrosion and abrasion.

1.2 *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.

1.3 *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 magnetic. 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 characteristics are defined as material having a maximum magnetic permeability of 1.05 (see Test Method B 193). Also for special applications involving large sections, methods for determining internal quality, such as mechanical tests on specimens from these larger sections or suitable nondestructive tests may be applied. If required, these additional tests shall be specified in the purchase order.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

## 2. Referenced Documents

### 2.1 ASTM Standards:

- A 600 Specification for Tool Steel Highspeed<sup>2</sup>
- B 193 Test Method for Resistivity of Electrical Conductor Materials<sup>3</sup>
- B 311 Test Method for Density Determination for Powder

- Metallurgy (P/M) Materials Containing Less than Two Percent Porosity<sup>4</sup>
- D 3951 Practice for Commercial Packaging<sup>5</sup>
- E 3 Test Methods for Preparation of Metallographic Specimens<sup>6</sup>
- E 8 Test Methods for Tension Testing of Metallic Materials<sup>6</sup>
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>6</sup>
- E 407 Practice for Microetching Metals and Alloys<sup>6</sup>
- 2.2 *Federal Standard:*  
Fed. Std. No. 151 Metals, Test Methods<sup>7</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):

Class	Tungsten, Nominal %
1	90
2	92.5
3	95
4	97

## 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 Machinability requirements, if any (see section 7.3),
- 4.1.4 Quantity,
- 4.1.5 Levels of preservation and packing (see 9.1),
- 4.1.6 Special markings, if required (see 9.2),
- 4.1.7 Method of hardness testing, if different from Rockwell “C” (see Table 1),
- 4.1.8 Freedom of parts from magnetic response, if required (see 1.3), and
- 4.1.9 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 and a metallic powder binder such as copper, nickel or iron, that, by

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 01.05.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 02.03.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 02.05.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 15.09.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 03.01.

<sup>7</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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

Class	Nominal Tungsten, weight %	Density, g/cc	Hardness <sup>A,B</sup> Rockwell <sup>C</sup> , max
1	90	16.85–17.25	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> For mechanically worked or aged material, the hardness can be as high as R C46.

**TABLE 2 Mechanical Properties, Minimum Values**

Class	Ultimate Tensile Strength		Yield Strength at 0.2 % Off-set		Elongation, <sup>A</sup> %
	ksi	MPa	ksi	MPa	
1	110 <sup>B</sup>	758	75	517	5 <sup>B</sup>
2	110 <sup>B</sup>	758	75	517	5 <sup>B</sup>
3	105 <sup>B</sup>	724	75	517	3 <sup>B</sup>
4	100	689	75	517	2

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

<sup>B</sup> Nonmagnetic composition to Classes 1, 2 and 3 shall be 94 ksi (648 MPa) minimum ultimate tensile strength. Minimum elongation shall be 2 % on Classes 1 and 2 and 1 % on Class 3.

sintering, will produce materials 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 *Composition, 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 Method E 8).

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 *Machinability*—When specified (see 4.1), the machinability of the basic parts or of a suitable test specimen shall be such that it shall pass the test specified in 8.4.6.

7.4 *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*—Unless otherwise specified, a minimum of two sintered test bars and one chemical analysis sample shall be made from each powder 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 *Chemical Composition*—If specified in the purchase order, a chemical analysis sample from each 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 E 18.

8.4.2 *Density*—The equal water displacement method performed in accordance with Test Method B 311 shall be used.

8.4.3 *Mechanical Properties*—Samples shall be tested in accordance with Test Methods E 8.

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 Methods E 3. The specimen may be etched (see Methods E 407), and shall be examined at a magnification of 200 times for conformance with 7.2.

8.4.6 *Machinability*—If specified by the procuring document, this test shall be made on a representative sample. Holes, 0.1695 in. in diameter and a minimum of 0.343 in. deep shall be drilled and tapped with a No. 10-32 high-speed steel tap to a minimum full thread of 0.312 in. deep. The tap shall be of high speed steel, conforming to Specification A 600, Type M1, heat treated to a hardness of 62-63 HRC. Machinability will be considered acceptable in each class if each of the number of holes indicated in Table 3 is satisfactorily threaded to a minimum 60 % without destruction to the tap.

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

**TABLE 3 Machinability Requirements**

Class	Number of Holes
1	8
2	6
3	4
4	2

## 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 D 3951 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 indi-

vidual 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

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