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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Specification for Tungsten Wire for Electron Devices and Lamps [1]

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This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification covers three types of drawn wire suitable for fabrication into parts for electron tubes, lamps, and other devices; and one type of rod for metal-to-glass sealing (grid wire is excepted):

1.1.1 *Type 1A*—Commercially pure nonsag wire (Note 2 and Note 3).

1.1.2 *Type 1B*—Commercially pure rod suitable for metal-to-glass sealing.

1.1.3 *Type 2A*—Thoriated filament wire containing 1 % thoria.

1.1.4 *Type 2B*—Thoriated filament wire containing 2 % thoria.

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

1.3 Types 1A and 1B are designated as UNS R07005. Type 2A is designated as UNS R07911. Type 2B is designated as UNS R07912.

1.4 The following precautionary caveat pertains only to the Chemical Analysis, Section 12 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.*

NOTE 1—A dimensional measurement method for testing nonsag tungsten wire above 0.030 in. (0.76 mm) in diameter is provided in Test Method F 269.

NOTE 2—Acceptance of nonsag wire characteristics for particular applications of size shall be by agreement between producer and consumer based on either a flashed microstructure as shown by photomicrographs, or on dimensional measurement limits determined in accordance with Test Method F 269.

2. Referenced Documents

2.1 ASTM Standards:

F 16 Test Methods for Measuring Diameter or Thickness of Wire and Ribbon for Electronic Devices and Lamps[2]

F 204 Test Method for Surface Flaws in Tungsten Seal Rod and Wire[2]

F 205 Test Method for Measuring Diameter of Fine Wire by Weighing[2]

F 219 Test Methods of Testing Fine Round and Flat Wire for Electron Devices and Lamps[2]

F 269 Test Method for Sag of Tungsten Wire[2]

2.2 Military Standards:

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes[3]

MIL-STD-129 Marking for Shipment and Storage[3]

3. Terminology

3.1 *Definition of Terms Specific to This Standard:*

3.1.1 *wire*—The term wire as used in this specification applies to all drawn material that is spooled or coiled, and to short cut lengths 0.020 in. (0.51 mm) or less in diameter.

3.1.2 *nonsag or doped tungsten wire*—This term designates a wire which, when recrystallized, shows elongated interlocking grains.

3.1.3 *rod*—The term rod as used in this specification applies to centerless ground material 0.020 in. (0.51 mm) or larger in diameter, in short cut lengths or random cut lengths.

4. Ordering Information

4.1 Orders for wire and rod furnished to this specification shall include the following information:

4.1.1 Length in metres, or quantity of short cut lengths,

4.1.2 Type and UNS No. (Section 1),

4.1.3 Straightness (Section 10),

4.1.4 Finish (Section 8),

4.1.5 Weight or size (Section 7) and tolerance, and

4.1.6 Specification number.

NOTE 3—A typical ordering description for straight chemically cleaned wire is as follows: xxxx metres, tungsten wire, Type 1A UNS R07005, straightened, Finish 2; 280.8 mg/200 mm (±3 %), to ASTM F288 – XX.

[1] This specification is under the jurisdiction of ASTM Committee F-1 on Electronics and is the direct responsibility of Subcommittee F01.03 on Metallic Materials.

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[2] *Annual Book of ASTM Standards*, Vol 10.04.

[3] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

5. Chemical Composition

5.1 The wire and rod shall conform to the chemical requirements specified in Table 1. The sample for analysis shall be representative of the lot submitted. Lot size, sample size, and sampling method shall be as agreed upon by the supplier and purchaser.

6. Physical Properties

6.1 *Tensile Strength*—The tensile strength of a 10-in. (250-mm) gage length of wire in grams per milligram per 200 mm shall be within the limits specified in Table 2 when tested in accordance with 13.1.

6.2 *General Ductility Requirements*—The ductility of Types 1A, 2A, and 2B wire shall be sufficient to meet the following requirements:

6.2.1 *Wire up to 75 mg/200 mm, Inclusive*—Six 1-m lengths shall be tested in accordance with 13.2. The wire shall not break more than two times in the six tests. Where required, a lower limit may be negotiated between purchaser and seller.

6.2.2 *Wire over 75 mg/200 mm*—Thirty successive close-wound turns completely around mandrels shall be free of splitting or cracking when tested in accordance with 13.2.2 and examined at a magnification of 30×.

6.2.3 *Special Ductility Requirements*—Wire for certain applications may require a special ductility as agreed upon between the purchaser and the seller.

6.3 *Surface Defects*—Type 1B rod shall not show faults when tested in accordance with 13.5.

7. Dimensions, Weights, and Permissible Variations

7.1 Dimensional tolerances for Type 1A (nonsag) wire for use as incandescent filaments shall conform to the requirements specified in Table 3.

NOTE 4—Tolerances are industry standards; closer tolerances may be obtained in certain instances, usually at a premium.

7.2 Out-of-roundness of wire or rod over 0.020 in. (0.51 mm) in diameter shall be within 5 % of the maximum diameter, when measured by a method agreed upon by supplier and purchaser. A referee method for this test is contained in Procedure B of Test Methods F 16.

7.3 *Weight/Diameter Conversion Formulas*:

7.3.1 The weight of Type 1A wire and Type 1B rod (density 19.17), is as follows:

$$\text{wt in mg/200 mm} = (\text{diameter in mils})^2 \times 1.943, \text{ or}$$
$$(\text{diameter in mm})^2 \times 3011 \quad (1)$$

7.3.2 The weight of Type 2A wire (density 18.80), is as follows:

$$\text{wt in mg/200mm} = (\text{diameter in mils})^2 \times 1.905, \text{ or}$$
$$(\text{diameter in mm})^2 \times 2953$$

TABLE 1 Chemical Requirements [A]

Type, UNS number	Thoria, weight %	Tungsten, weight %
1A and 1B (R07005)	....	99.95 min
2A (R07911)	0.8 min, 1.2 max	balance
2B (R07912)	1.7 min, 2.2 max	balance

[A] For all Types:
Other elements (each)—100 ppm max.
Total other elements—500 ppm max.

7.3.3 The weight of Type 2B wire (density 18.50), is as follows:

$$\text{wt in mg/200mm} = (\text{diameter in mils})^2 \times 1.875, \text{ or}$$
$$(\text{diameter in mm})^2 \times 2906$$

8. Workmanship, Finish, and Appearance

8.1 Furnish the wire in the following finishes:

8.1.1 *Finish 1*—Black, as-drawn,

8.1.2 *Finish 2*—Chemically cleaned,

8.1.3 *Finish 3*—Chemically cleaned and stress-relieved.

8.1.4 *Finish 4*—Reducing atmosphere cleaned and annealed,

8.1.5 *Finish 5*—Etched, and

8.1.6 *Finish 6*—Electropolished.

8.2 The rod shall be furnished in the following finish:

8.2.1 *Finish 7*—Centerless ground.

9. General Requirements

9.1 The material shall be smooth, free of twists, bends, kinks, curls, and as free of dents, swaging marks, scratches, die marks, laps, seams, splits, slivers, inclusions, bumps, pits, grooves, cracks, and other physical defects when examined at a magnification of 30× as best commercial practice will permit.

9.2 Unless black finish is specified, all types of wire shall have a clean finish, free of graphite, grease, oil, and lubricants. All finishes shall be as free of dirt, oxide, stains, scale, and other surface defects, as best commercial practice permits. Wire for hooks, supports, springs, anchors, and mesh shall have a bright smooth surface free of cracks, holes, or craters when examined at a magnification of 10×.

9.3 Rod of Type 1B shall have a bright smooth surface and be capable of making acceptable metal-to-glass seals when tested in accordance with Test Method F 204.

10. Straightness

10.1 When ordered as straightened, straightness of wire 3.00 mg/200 mm and larger shall be specified as the radius of curvature or camber of a given length of wire as agreed upon between the purchaser and supplier. For wire under 3.00 mg/200 mm, alternative methods for straightness requirements may be used as agreed upon between the purchaser and the supplier.

11. Coiling and Spooling

11.1 Spools and bands shall be clean and free of open seams or projections which might catch or tangle the wire during winding or unwinding.

11.2 Wire shall be furnished in one continuous length and wound smoothly with no loose turns. There shall be no piling up of turns such as to prevent free unwinding or cause kinks or bends when the wire is removed from the spool. The outer end shall be attached firmly to the spool or band by suitable means.

11.3 Spool and band dimensions are shown in Table 4.

11.4 Except for Finishes 5 and 6, no spools or bands in any one shipment shall contain less than 300 m of wire for sizes up to 35 mg/200 mm; not less than 200 m of wire between 35 and 50 mg/200 mm, and not less than 100 m between 50 and 100

TABLE 2 Tensile Properties of Nonsag Tungsten Wire (Type 1A) [A]

Weight of Wire, mg/200 mm	Diameter of Wire, in. (mm, Approximate)	Tensile Strength, g/mg/200 mm					
		High Tensile Wire (Finishes 1 and 2)		Medium Tensile Wire (Finish 3)		Low Tensile Wire (Finish 4)	
		Min	Max	Min	Max	Min	Max
Up to 1.95	Up to 0.001 (0.03), incl	80	110	70	90	55	95
Over 1.95 to 7.91, incl	Over 0.001 to 0.002 (0.03–0.05, incl)	75	105	70	90	55	90
Over 7.91 to 17.60, incl	Over 0.002 to 0.003 (0.05–0.08, incl)	70	100	60	90	55	90
Over 17.60 to 48.25, incl	Over 0.003 to 0.005 (0.08–0.13), incl	65	95	60	85	50	85
Over 48.25 to 198.00, incl	Over 0.005 to 0.0010 (0.13–0.25), incl	60	90	60	85	50	85
Over 198.00 to 760.00, incl	Over 0.010 to 0.020 (0.25–0.51), incl	50	80	55	80		

[A] Tensile properties for Types 2A and 2B wire are governed by the ductility requirements specified in 6.2.

TABLE 3 Permissible Variations in Weight and Size for All Types of Wire and Rod

Weight of Wire, mg/200 mm	Dimensional Tolerances	Size Uniformity Within a Spool
Up to 0.36	±0.02 mg/200 mm	0.02 mg/200 mm
Over 0.36 to 0.67, incl	±0.03 mg/200 mm	0.02 mg/200 mm
Over 0.67 to 2.0, incl	±3 weight %	0.02 mg/200 mm
Over 2.0 to 760.0, incl	±3 weight %	1 weight %
Over 760.0	±1.5 % of diameter	...

TABLE 4 Size of Spool, Band, or Coil

Flange or Head Diameter, in. (mm)	Mandrel or Hub Diameter, in. (mm)	Inside or Hole Diameter, in. (mm) [A]	Traverse, in. (mm)
0.715 to 0.785	0.580 to 0.605	0.437 to 0.450	0.420 to 0.435
(18 to 20)	(15 to 15)	(11 to 11)	(11 to 11)
0.745 to 0.755	0.620 to 0.630	0.250 to 0.260	0.620 to 0.630
(19 to 19)	(16 to 16)	(6 to 7)	(16 to 16)
1.88 to 2.38	1.13 to 1.63	0.340 to 0.375	0.75 to 1.0
(48 to 60)	(29 to 41)	(8.6 to 9.5)	(19 to 25)
3.50 to 4.63	3.0 to 4.13	0.375	0.625
(89 to 118)	(76 to 105)	(9.5)	(16)
4.0 to 4.75	3.88 to 4.0	3.50 to 3.88	0.75 to 1.0
(102 to 121)	(98 to 102)	(89 to 98)	(19 to 25)

[A] Except on conical chamfered center mount spools.

mg/200 mm. For wire sizes above 100 mg/200 mm each spool or band shall contain no less than 50 g, minimum weight, of wire.

12. Chemical Analysis

12.1 *Purity*—Determine purity gravimetrically or by a combination of spectrochemical and gravimetric analyses.

12.2 *Thoria Content*—Transfer approximately 0.5 to 1.0 g of the wire (weighed to the fourth decimal place) to a clean porcelain boat. Place the boat in the combustion tube and bring the temperature up to 600 to 700°C. While the furnace is being brought to that temperature, pass a slow stream of air through the tube. When a temperature of approximately 600°C has been reached inside the tube, introduce a flow of hydrochloric acid (HCl) gas (Note 5) along with the air. Maintain a temperature of 600 to 700°C and continue the flow of HCl gas and air until all the tungsten has been volatilized and only the white powder of thoria remains (Note 6). The thoria may be transferred to a balance pan for weighing, or weighed in the boat. If it is weighed in the boat, the weight of the boat should be determined both before and after the heating period, to correct for any loss of weight by the boat during its stay in the furnace. Calculate the thoria content as follows:

$$\text{Thoria, \%} = (\text{mg of thoria/mgof sample}) \times 100$$

NOTE 5—Hydrochloric acid (HCl) gas can be produced by dripping, from a separatory funnel, concentrated sulfuric acid on sodium chloride in a flask. (The optimum ratio of HCl gas to air and the optimum total gas flow through the tube have not been determined. A rate of approximately three bubbles of HCl gas per second has been found satisfactory.)

NOTE 6—In the ordinary carbon furnace two samples can be run simultaneously. The approximate time for volatilization is 5 h.

13. Test Methods

13.1 *Tensile Strength*—Determine the tensile strength of the wire in accordance with Test Methods F 219. Use a flat black background when testing fine wire below 0.005 in. (0.13 mm) in diameter.

13.2 *Ductility*—Determine the ductility of the wire as follows:

13.2.1 *Wire up to 75 mg/200 mm, Inclusive*—Draw the wire over a 90° steel bar edge having a radius approximately equal to the diameter of the wire to be tested. Hold the wire against the edge of the bar with the thumb and draw the wire at an angle of 45° to the bar edge at a rate of approximately 1 m/s until the tension on the wire is sufficient to cause a tight helical coil to be formed after the tension is released.

13.2.2 *Wire over 75 mg/200 mm*—Wind 30 successive close-wound turns completely around mandrels of sizes as specified in Table 5 at the recommended forming temperatures.

13.3 *Visual Inspection*—Check conformance of the wire to the requirements specified in 9.2 by visual inspection, except

TABLE 5 Ductility Test Conditions for All Types of Wire

Wire Diameter, in. (mm)	Mandrel Diameter, in. (mm)		Forming Temperature. °C	
	Thoriated	All Others	Thoriated	All Others
0.0065 to 0.010 (0.17 to 0.25), incl	0.040 (1.02)	0.025 (0.64)	650	400
Above 0.010 to 0.015 (0.25 to 0.38), incl	0.062 (1.57)	0.030 (0.76)	700	500
Above 0.015 to 0.020 (0.38 to 0.51), incl	0.125 (3.18)	0.045 (1.14)	800	600
Above 0.020 (0.51):				
For each 0.005 in. (0.13 mm), add	0.062 (1.57)	0.015 (0.38)	800	700

that wire for hooks, supports, springs, anchors, and mesh shall be checked with a magnification of 10×.

NOTE 7—Orders placed by agencies of the U.S. government require special acceptance criteria applied to visual inspection (13.3) and dimensional measurement (13.4). In these instances, samples shall be selected for examination in accordance with MIL-STD-105 at Inspection Level I. The acceptance quality level (AQL) shall be 1.5 % defective. A unit shall be one reel, coil, band, or spool of wire.

13.4 *Dimensional Measurements*—Determine the size and uniformity of wire up to 760 mg/200 mm in accordance with Test Method F 205 (Note 7).

13.5 *Surface Flaws, Type 1B*—Examination of random lengths and cut lengths of seal rod for surface flaws shall be conducted in accordance with Test Method F 204. A fault shall consist of a tungsten-glass seal in which a fissure, either delineated by a line of bubbles, or in itself clearly discernible, is observed as prescribed in this method.

14. Rejection

14.1 Any spool of wire, length of rod, or individual cut pieces not conforming to the specified requirements may be rejected. If 15 % or more of the spools of wire, lengths of rod, or cut pieces in any shipment do not conform to the specified requirements, the entire shipment may be rejected.

14.2 The purchaser shall return rejected material in a suitable container for shipping, the original if possible, so that it may arrive at the manufacturer's plant in the same condition as it left.

15. Packaging and Package Marking

15.1 *Commercial*:

15.1.1 Each shipment shall be packaged in such a manner that it will be protected from injury in transit or in handling. No dusty or linty material shall be used, nor any paperwrapping material containing ingredients that would in any way be injurious to the tungsten.

15.1.2 Each spool or band shall be marked with the following information:

15.1.2.1 Name of manufacturer,

15.1.2.2 Weight per 200 mm or the size (in inches and millimetres), or both,

15.1.2.3 Type of wire and manufacturer's process designation,

15.1.2.4 Manufacturer's lot number of material and finishing date,

15.1.2.5 Quantity in metres, and

15.1.2.6 Tensile strength of straightened wire.

15.1.3 Each shipping container shall contain a packing slip plainly marked with the following information:

15.1.3.1 Purchaser's order number,

15.1.3.2 Purchaser's specification,

15.1.3.3 Gross and net weight, and

15.1.3.4 Name of manufacturer.

15.2 *Special*—Orders placed by agencies of the U.S. government may specify special marking requirements, and marking for shipment shall be in accordance with MIL-STD-129.

16. Keywords

16.1 electron devices; thoriated tungsten wire; tungsten wire; UNS R07005; UNS R07911; UNS R07912