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Standard Specification for Molybdenum Wire and Rod for Electronic Applications [1]

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1. Scope

1.1 This specification covers two grades of molybdenum wire less than 0.050 in. (1.27 mm) in diameter and one grade of molybdenum rod 1.00 in. (25.4 mm) or less in diameter as follows:

1.1.1 *Grade 1*—Commercially pure molybdenum wire suitable for leads, hooks, supports, heaters, and metal-to-glass seals.

1.1.2 *Grade 2*—Commercially pure molybdenum wire suitable for mandrel either black or cleaned.

1.1.3 *Grade 3*—Commercially pure molybdenum rod suitable for leads, hooks, supports, and metal-to-glass seals.

1.2 The term wire applies to all spooled or coiled material and 0.050 in. (1.3 mm) or less in diameter and to short cut lengths 0.020 in. (0.51 mm) or less in diameter.

1.3 The term rod applies to all material over 0.020 in. (0.51 mm) in diameter, supplied in straight lengths.

1.4 The values stated in inch-pound units are to be regarded as the standard. The metric equivalents of inch-pound units may be approximate, except for the size of the wire expressed in milligrams per 200 mm.

1.5 *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:*

D 374 Test Methods for Thickness of Solid Electrical Insulation [2]

E 8 Test Methods of Tension Testing of Metallic Materials [3]

E 315 Test Methods for Chemical Analysis of Molybdenum [4]

F 16 Test Methods for Measuring Diameter or Thickness of Wire and Ribbon for Electronic Devices and Lamps [5]

F 205 Test Method for Measuring Diameter of Fine Wire by Weighing [5]

F 219 Test Methods of Testing Fine Round and Flat Wire for Electron Devices and Lamps [5]

2.2 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies) [6]

2.3 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage (Military Agencies) [6]

3. Chemical Composition

3.1 All grades of wire and rod shall be 99.90 % minimum pure molybdenum. The maximum allowable oxygen content shall be 0.007 weight% , while the maximum carbon content shall be 0.03 weight %.

4. Mechanical Properties

4.1 *Tensile Properties*:

4.1.1 The tension test specimens and procedures shall conform to Methods F 219 for wire diameter up to and including 0.010 in. (0.25 mm), and Test Methods E 8 for all other wire and rod diameters.

4.1.2 The tensile requirements of wire in sizes up to and including 0.020 in. (0.51 mm) in diameter shall conform to the requirements of Table 1 and shall be calculated by dividing the breaking load in grams-force by the size of the wire expressed in milligrams per 200 mm.

4.1.3 The tensile requirements of wire in sizes over 0.020 in. (0.51 mm) up to 0.050 in. (1.3 mm) in diameter shall conform to the requirements of Table 2.

4.1.4 The tensile requirements of rod shall be as agreed upon between the purchaser and the supplier.

4.2 *Ductility Properties*:

4.2.1 Wire up to 0.003 in. (0.08 mm) in diameter shall not break when subjected to the test prescribed in 11.4.1.

4.2.2 Wire over 0.003 in. (0.08 mm) up to 0.020 in. (0.51 mm) in diameter shall not break or show cracks under observation through a binocular microscope at 30× when subjected to the test prescribed in 11.4.2.

4.2.3 Wire over 0.020 in. (0.51 mm) in diameter shall not

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[2] *Annual Book of ASTM Standards*, Vol 10.01.

[3] *Annual Book of ASTM Standards*, Vol 03.01.

[4] *Annual Book of ASTM Standards*, Vol 03.05.

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

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

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TABLE 1 Tensile Requirements

Wire Size, mg/200 mm	Maximum Diameter, [A] in. (mm)	Minimum Tensile Breaking Load, gf/(mg/200 mm)	Elongation in 10 in. (250 mm), %	
			Grade 1	Grade 2
Up to 4.11, incl	0.0020 (0.051)	50	>6	≤6
Over 4.11 to 6.42, incl	0.0025 (0.064)	46	>6	≤6
Over 6.42 to 10.53, incl	0.0032 (0.081)	44	>6	≤6
Over 10.53 to 411.2, incl	0.020 (0.51)	40	>6	≤6

[A] Wire diameter, in. = $9.86 \times 10^{-4} \sqrt{\text{weight in mg/200 mm}}$.

TABLE 2 Tensile Requirement

Wire Diameter, in. (mm)	Minimum Tensile Strength, psi (MPa)	Elongation in 10 in. (250 mm), %	
		Class 1, min	Class 2, max
Over 0.020 (0.51) to 0.050 (1.27)	64 000 (441)	6	6

TABLE 3 Centerless-Ground Rod Diameter Tolerances

Specified Diameter, in. (mm)	Permissible Variation in Diameter, plus or minus, in. (mm)
Over 0.020 (0.51) to 0.060 (1.53), incl	0.001 (0.025)
Over 0.060 (1.54) to 0.500 (12.70), incl	0.002 (0.050)
Over 0.500 (12.71) to 1.00 in. (25.4), incl	0.003 (0.075)

break or show cracks under unaided visual observation when subjected to the test prescribed in 11.4.3.

4.2.4 Rod shall have ductility properties as agreed upon between the purchaser and the supplier.

5. Surface Finish

5.1 Molybdenum wire shall be furnished in the following finishes:

5.1.1 As drawn, black, or

5.1.2 As drawn, cleaned.

5.2 Molybdenum rod shall be furnished in the following finishes:

5.2.1 Black,

5.2.2 Cleaned, or

5.2.3 Centerless ground.

5.3 Surfaces shall be smooth and free of contamination and pernicious surface defects.

6. Dimensional Tolerances

6.1 For wire in diameters up to and including 0.020 in. (0.51 mm) in diameter the tolerance shall be ±5 % of weight per 200 mm. The size of wire shall be uniform for Grades 1 and 3 within 2 weight % as measured at both ends of the wire; and for Grade 2 within 1 weight % within the total length of the wire. The standard size tolerance for wire in a diameter range of 0.020 to 0.030 in. (0.51 to 0.76 mm) is± 3 % by diameter; but such wire can be ordered by any of several weight tolerances (mg/200 mm) as agreed upon between the purchaser and the supplier.

6.2 For black or cleaned rod in diameters over 0.020 in. (0.51 mm) and wire over 0.030 in. (0.76 mm) the tolerance shall be ±3 % of the specified diameter.

6.3 Out-of-roundness of wire over 0.005 in. (0.13 mm) in diameter and all rod except centerless ground shall be within 4 % of the specified diameter, maximum.

6.4 When centerless ground rod is specified, the diameter shall meet the tolerances shown in Table 3.

7. General Requirements

7.1 The material shall be uniform in composition, cross section, and in structural condition.

7.2 Unless otherwise specified, all material shall be provided in the stress-relief annealed condition (not recrystallized).

8. Straightness

8.1 When ordered as straightened, straightness of wire shall be specified as the radius of curvature or camber of a given length of wire as agreed upon between the purchaser and the supplier.

8.2 Rod and short cut lengths shall be straight to within ⅛ in. camber in 1 ft (or 3 mm camber in 300 mm) of length.

NOTE 1—The straightness criterion in terms of maximum permissible camber in an arbitrary length, L', is calculated as the product of the known maximum permissible camber in a specified length, L, and the square of the ratio of L' to L. As an example, consider L' to be 3 ft. In inch-pound units, the maximum camber per 3-ft length = (⅛ in.) $(\frac{3}{1})^2$ = 1⅛ in. In SI units, the maximum camber per 760-mm length = (3 mm) $(\frac{914}{300})^2$ = 28 mm. The relation given constitutes an approximation valid for the purpose as long as L' is not too large; the exact solution can be obtained by considering a circle with the camber in length L' as one segment of a diametral chord perpendicularly bisecting a chord of length L'.

9. Coiling and Spooling

9.1 The spools or bands shall be clean and free of seams or projections that might catch or tangle the wire during unwinding. The wire shall be in one continuous length and wound smoothly in layers, with no piling upon turns, so that it unwinds freely without forming kinks. Inner and outer ends shall be firmly attached to the spool or band by suitable means. The spool shall be shipped in a container that will prevent contamination of the wire. Ninety percent of the spools in a shipment of one size shall contain not less than 150 m for sizes up to and including 0.006 in. (0.15 mm) in diameter, and not less than 100 m for sizes in the range over 0.006 to 0.012 in. (over 0.15 to 0.30 mm) in diameter. No spools or bands shall be filled higher than 1/16 in. (1.6 mm) from the top of the flange. The size of spool, band, or coil shall be as agreed upon between the purchaser and the supplier.

10. Sampling

10.1 The sample selected for testing shall be representative of the material and form and shall not be contaminated by the sampling procedure.

10.2 Specific sampling procedures shall be agreed upon between the purchaser and the supplier.

11. Test Methods

11.1 *General Appearance and Finish*—Check by visual inspection at 10× magnification.

11.2 *Molybdenum Content*—Determine gravimetrically or by a combination of analysis for impurities by spectrochemical and chemical methods. Impurity levels shall be as agreed upon between the purchaser and the supplier. In case of disagreement, Test Methods E 315 shall be used as the referee method.

11.3 *Tensile Strength*—Determine tensile properties in accordance with Test Methods F 219 for wire diameters up to 0.010 in. (0.25 mm), and Test Methods E 8 for all other wire and rod diameters.

11.4 *Ductility*—Use the ductility test appropriate to the wire diameter (see 4.2 for requirements): up to 0.003 in. (0.08 mm), knife-edge test (11.4.1); from 0.003 to 0.020 in. (0.08 to 0.51 mm), inclusive, mandrel test (11.4.2); and for wire larger than 0.020 in. (0.51 mm) but smaller than 0.050 in. (1.3 mm), bend test (11.4.2).

11.4.1 *Knife-Edge Ductility Test*—Using at least 10 ft (or 3 m) of wire, with the spool or band in one hand and a knife in the other, grasp the wire between the thumb and the edge of the knife blade. Incline the knife blade at about 45° to the wire with the back of the blade positioned away from the spool or band. Apply pressure with the thumb on the wire and knife blade and draw the latter along the free length of the wire at a rate of about 3 ft/s (or 1 m/s). Apply pressure sufficient to form the wire into a continuous tight helix less than 3⁄16 in. (4 mm) in outside diameter when the tension is released.

11.4.2 *Mandrel Ductility Test*—Clamp one end of a mandrel of diameter 1½ times the diameter of the wire to be tested in a bench vise. Grasp one end of a 10-in. (250-mm) wire specimen in each hand and bend it in a plane perpendicular to the mandrel so as to wind tightly one wrap around the mandrel. Unwind in approximately the same plane, and then pull it to substantial straightness.

11.4.3 *Bend Ductility Test*—Clamp one end of a mandrel of diameter 2½ times the diameter of the wire to be tested in a bench vise. Coil wire around the mandrel, making sure that the space between turns is not greater than the diameter of the wire. Form a minimum of 20 turns around the mandrel.

11.5 *Dimensions of Wire*—Determine wire dimensions as follows:

11.5.1 Determine dimensions other than out-of-roundness in accordance with Test Method F 205 for wire up to and including 0.020 in. (0.51 mm) in diameter and Test Methods F 16 for wire over 0.020 in. (0.51 mm) to 0.050 in. (1.3 mm), inclusive, in diameter.

11.5.2 Determine out-of-roundness in accordance with Test Methods F 219.

NOTE 2—Methods F 219 incorporates references to Test Methods D 374.

12. Inspection

12.1 Unless otherwise specified in the purchase contract, the supplier is responsible for the performance of all inspection requirements specified herein.

12.2 If the purchaser desires that his representative inspect or witness the inspection and testing of the product prior to shipment, such agreement shall be made between the purchaser and the supplier as part of the purchase contract.

13. Rejection and Rehearing

13.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the supplier promptly and in writing. In case of dissatisfaction with the results of the test, the supplier may make claim for a rehearing.

13.2 Any spool of wire or individual cut piece that does not conform to the specified requirements may be rejected. If 15 % or more of the spools of wire or cut pieces in any shipment do not conform to the specified requirements, the entire shipment may be rejected.

13.3 When agreement on rejection is established, the purchaser shall return rejected material in a suitable container for shipping, using the original container if possible, so that the wire or rod may arrive at the supplier's plant in the same condition as it left.

14. Product Marking

14.1 Each spool, band, coil, container of straight lengths, or rod shall be identified with the name of the supplier and the lot number, size and quantity of material, date of shipment or date of manufacture, grade, and finish. In addition, each container of spools, bands, coils, or straight lengths shall contain the purchaser's order number.

14.2 Special marking and packaging requirements shall be as agreed upon between the purchaser and the supplier.

14.2.1 For civilian Federal agencies, markings for shipment shall be in accordance with Fed. Std. No. 123, and for military agencies, in accordance with MIL-STD-129.

15. Keywords

15.1 electronic applications; molybdenum; molybdenum wire and rod; stress-relief annealed condition

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