Designation: F364 – 96 (Reapproved 2014)

Standard Specification for Molybdenum Flattened Wire for Electron Tubes [1]

This standard is issued under the fixed designation F364; 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 two types of molybdenum flattened wire up to 0.050 in. (1.27 mm) thick and up to 0.375 in. (9.52 mm) wide, specifically for use in electron tubes. The two grades have UNS numbers R03604 and R03603.

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 The following safety hazards caveat pertains only to the test method described in this specification (see 10.2). *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:*[2]

E18 Test Methods for Rockwell Hardness of Metallic Materials

E315 Test Methods for Chemical Analysis of Molybdenum (Withdrawn 2010)[3]

E384 Test Method for Knoop and Vickers Hardness of Materials

3. Classification

3.1 Two types of molybdenum flattened wire are covered by this specification:

3.1.1 *Type I, UNS R03604*—This type shall have the composition limits prescribed in Table 1.

3.1.2 *Type II, UNS R03603*—This type shall be a high-recrystallization-temperature material having the composition limits prescribed in Table 1 and shall be capable of retaining its ductility after firing at a temperature of 2375 ± 25°F (1300 ± 14°C) for at least 20 min.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information:

4.1.1 Quantity of each size,

4.1.2 Dimensions or size (see 8.1),

4.1.3 Edgewise curvature (camber) if required (see 8.2),

4.1.4 Type (see 3.1),

4.1.5 Temper (see 7.1), and

4.1.6 How furnished (coils, spools, etc.).

5. Materials and Manufacture

5.1 The molybdenum wires covered by this specification shall be made by any appropriate process.

NOTE 1—It has been found that molybdenum wire made by the powder metallurgy process will meet the requirements of this specification.

6. Chemical Composition

6.1 Type I and Type II molybdenum wire shall conform to the chemical compositions prescribed in Table 1.

6.2 The materials shall be analyzed in accordance with Test Methods E315 or other appropriate ASTM methods when available. Other methods, as mutually agreed upon between seller and purchaser, may be employed.

7. Physical Properties

7.1 *Temper*—Material under this specification shall be supplied in one of the following classifications of temper:

7.1.1 *Hard*—As-rolled, not stress-relieved, suitable for spring applications, or

7.1.2 *Stress-Relieved*— Suitable for bending or winding.

7.2 The hardness test (see 10.1) is to be used as the criterion for identifying hard and stress-relieved materials in accordance with Table 2.

7.2.1 When determining microhardness using light loads, the thickness and load relationships shown in Table 3 are recommended for best correlation and reproducibility.

---

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

Current edition approved June 1, 2014. Published July 2014. Originally approved in 1973. Last previous edition approved in 2009 as F364 – 96 (2009). DOI: 10.1520/F0364-96R14.

[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.

TABLE 1 Chemical Composition

Element	Composition, max, ppm	
	Type I UNS R03604	Type II UNS R03603
Carbon	50	15
Oxygen	80	175
Nitrogen	20	10
Hydrogen	10	10
Aluminum	150	150
Calcium	50	50
Silicon	100	350
Iron	100	100
Tungsten	200	200
Potassium	150	150
Tin	25	25
Other elements, each	50	50
	min % by difference	
Molybdenum	99.90	99.90

TABLE 2 Hardness Ranges

Temper	Diamond Pyramid Hardness (HDP) or Vickers Hardness (HV)	Rockwell Superficial Hardness 30T-Scale [A]
Hard	300 and over	85 and over
Stress-relieved	up to 300, excl	up to 85, excl

[A] Rockwell 30T for material 3⁄16 in. (4.8 mm) wide and over only.

TABLE 3 Thickness and Load for Determination of Diamond Pyramid Hardness or Vickers Hardness

Thickness, in. (mm)	Load, gf
Less than 0.003 (0.08)	100
0.003 to 0.0050 (0.08 to 0.127), incl	200
Over 0.050 to 0.100 (0.127 to 2.54), incl	500
Over 0.100 (2.54)	1000

7.3 *Bend and Delamination (Type I and Type II Wire in Stress-Relieved Temper)*—In the as-received condition (no firing), this wire shall show no evidence of cracking, splitting, delamination, or splintering when subjected to the bend and delamination test (see 10.2).

7.4 *Bend and Delamination (Type II Wire in Hard and Stress-Relieved Tempers)*—After firing Type II material at a temperature of 2375 ± 25°F (1300 ± 14°C) for at least 20 min, it shall show no evidence of cracking, splitting, delamination, or splintering when subjected to the bend and delamination test (see 10.2).

NOTE 2—Type II material will show little or no evidence of recrystallization after firing as prescribed in 7.4. This may be determined by microstructural comparison of a fired and an unfired specimen, displaying a longitudinal section, from the same spool or coil of material.

8. Dimensions and Permissible Variations

8.1 The dimensional tolerances shall be in accordance with Table 4.

8.2 Edgewise curvature (camber), if specified, shall be measured in inches (or millimetres) per unit length and shall be as agreed upon between purchaser and seller.

9. Workmanship, Finish, and Appearance

9.1 The finish of these flattened wires may be either a matte or shiny surface, and shall be smooth, free of dirt, oxides, pits, scratches, seams, stains, scale, delamination, splits, slivers, or any other defects not considered good commercial finish.

TABLE 4 Dimensional Tolerances

Specified Thickness, in. (mm)	Tolerance plus and minus, in. (mm)
Up to 0.0050 (0.127), incl	0.0002 (0.005)
Over 0.0050 to 0.0100 (0.127 to 0.254), incl	0.0003 (0.008)
Over 0.0100 to 0.0200 (0.254 to 0.508), incl	0.0004 (0.010)
Over 0.0200 to 0.0300 (0.508 to 0.762), incl	0.0005 (0.013)
Over 0.0300 to 0.0500 (0.762 to 1.270), incl	0.0010 (0.025)
Specified Width, in. (mm)	**Tolerance plus and minus, in. (mm)**
Up to 0.025 (0.64), incl	0.001 (0.02)
Over 0.025 to 0.075 (0.64 to 1.90), incl	0.002 (0.05)
Over 0.075 to 0.125 (1.90 to 3.18), incl	0.003 (0.08)
Over 0.125 (3.18)	0.005 (0.13)

10. Test Methods

10.1 *Hardness*—Hardness shall be determined in accordance with Test Method E384. Recommended loads are shown in Table 3. For material 3⁄16 in. (4.8 mm) wide and over, Rockwell superficial hardness may be measured in accordance with Test Methods E18 as an alternative test.

10.2 *Bend and Delamination:*

10.2.1 Perform the test with the wire at a temperature in the range 65°F (18°C) to 86°F (30°C), inclusive.

10.2.2 Wind the wire in close turns on a cylindrical mandrel whose diameter is approximately twice the thickness of the wire. Unwind the wire in approximately the same plane as it was originally wound, perpendicular to the axis of the mandrel. Pull the wire to substantial straightness.

10.2.3 Examine the wire visually (Note 3) for evidence of cracking, splitting, delamination, and splintering.

NOTE 3—Visual examination, unaided except for normal visual correction shall be used.

11. Rejection

11.1 Any spool or coil not conforming to the specified requirements may be rejected. If 15 % or more of the spools or coils in any shipment do not conform to the specified requirements, the shipment does not conform to this specification and will be rejected, and the supplier shall be notified within 30 days after receipt of material.

11.2 On agreement by seller and purchaser, 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.

12. Certification

12.1 When agreed upon in writing between the purchaser and the seller, a certification shall be made the basis of acceptance of the material. This shall consist of a copy of the manufacturer's test report or a statement by the seller, accompanied by a copy of the test results, that the material has been

sampled, tested, and inspected in accordance with the provisions of the specification. Each certification so furnished shall be signed by an authorized agent of the seller or manufacturer.

13. Product Marking

13.1 Each coil or spool shall be legibly marked with the:
13.1.1 Type of material, and temper,
13.1.2 Name of manufacturer,
13.1.3 Heat, lot, or manufacturer's identification number,
13.1.4 Specification number,
13.1.5 Gross, tare, and net weight or number of feet or metres on spool,
13.1.6 Thickness and width of flat wire,
13.1.7 Shipping date, and
13.1.8 Inspector's number or designation.

14. Packaging and Package Marking

14.1 Packaging shall be adequate to protect coils and spools from contamination or damage during shipment.

15. Keywords

15.1 electron tubes; molybdenum; molybdenum flattened wire; UNS R03604; UNS R03603