Designation: F 219 – 96 (Reapproved 2002)

Standard Test Methods of Testing Fine Round and Flat Wire for Electron Devices and Lamps[1]

This standard is issued under the fixed designation F 219; 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 These test methods cover the testing of fine wire, flat or round, approximately 0.010 in. (0.25 mm) and smaller in diameter or thickness, used in electronic devices and lamps.

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 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

B 63 Test Method for Resistivity of Metallically Conducting Resistance and Contact Materials[2]

D 374 Test Methods for Thickness of Solid Electrical Insulation[3]

F 16 Test Methods for Measuring Diameter or Thickness of Wire and Ribbon for Electronic Devices and Lamps[4]

F 205 Test Method for Measuring Diameter of Fine Wire by Weighing[4]

F 289 Specification for Molybdenum Wire and Rod for Electronic Applications[4]

3. Test Specimens

3.1 The number of spools per shipment to be checked shall be agreed upon by the producer and consumer. Three test specimens from each spool to be tested shall be taken for the purpose of each of the tests covered by these methods, except Section 4, where one specimen per shipment shall be submitted. These specimens shall be selected sufficiently far from either end of the spool of wire to be free from kinks, bends, and distortion. With the exceptions mentioned in 3.2, the specimens shall be taken from points in the length of the wire separated by at least 1 ft (305 mm).

3.2 For the edgewise curvature test, straightness test, and tension tests the specimens shall be taken from points in the length of the wire separated by at least 3 ft (0.9 m).

4. Chemical Analysis

4.1 In case of disagreement between producer and consumer chemical analysis of the material shall be made in accordance with the methods of the American Society for Testing and Materials for the respective materials when such methods of analysis are available. When ASTM test methods are not available, the analytical procedures shall be agreed upon by the producer and the consumer.

5. Dimensions

5.1 *Procedure A for Round Wire*—Determine the weight-size of round wire in accordance with Test Method F 205.

5.2 *Procedure B for Round Wire*—As an alternative method, the diameter of wire over 0.005 in. (0.13 mm) may be determined in accordance with Test Methods D 374.

5.3 *Procedure for Flat Wire*:

5.3.1 Determine the dimensions of flat wire in accordance with 5.1 in conjunction with width as measured in accordance with 5.2, or if agreed upon by the manufacturer and the purchaser, any dimension exceeding 0.005 in. may be determined in accordance with 5.2 alone.

5.3.2 In determining the width of flat wire, form a flatwise loop loosely with the ends held between the fingers. The minor axis of the loop shall be ½ to ¾ of the diameter of the micrometer jaws. Measure the width of the ribbon with the curve loop perpendicular to the micrometer jaws. Take care not to distort the ribbon or bend it out of the correct plane during measurement.

5.4 In case of disagreement between producer and consumer, Test Methods F 16 shall be used as the referee method.

5.5 *Report*—The report shall include the average weight of wire or ribbon in mg/200 mm to three significant figures. The average measurements for diameter, width, or thickness shall be reported to the nearest 0.0001 in. (0.002 mm).

6. Out-of-Roundness

6.1 *Procedure*—Measure out-of-roundness on round wire over 0.005 in. (0.13 mm) in diameter in accordance with Sections 3 and 4 of Test Methods D 374. For wire 0.005 in. or less in diameter the same method shall apply except a bench type micrometer reading to 0.0001 in. (0.002 mm) shall be

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[1] These test methods are under the jurisdiction of ASTM Committee F01 on Electronics and are the direct responsibility of Subcommittee F01.03 on Metallic Materials.

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[2] *Annual Book of ASTM Standards*, Vol 03.04.

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

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

used. Make the measurements by exploring a plane of cross section of the test specimen to determine both minimum and maximum values of diameter at the cross section. Take care to have the specimen straight so that its normal curvature will not influence readings.

6.2 *Calculation*—Calculate out-of-roundness as follows:

$$\text{Out-of-roundness, percent} = [(A - B)/A] \times 100$$

where:

A = maximum diameter of the cross section, in. (or mm), and

B = minimum diameter of the cross section, in. (or mm).

6.3 *Report*—The report shall include the average of the three determinations of out-of-roundness reported to the nearest 1 percent.

7. Edgewise Curvature of Ribbon

7.1 *Procedure*—Lay a specimen 200 mm in length on a flat glass plate. Lay a second glass plate over the ribbon to ensure its lying flat with no edgewise bending. Place in lined graph, which consists of parallel lines spaced 1.0 mm apart and is numbered 50 mm above and below the zero line, under the glass plates. Manipulate the plates over the graph so that the ends of the ribbon coincide with the zero line. Measure the extreme depth of chord.

7.2 *Report*—The report shall include the maximum depth of chord reported to the nearest 0.5 mm.

8. Straightness of Straightened Round Wire

8.1 *Procedure*—Hold a specimen 200 mm in length parallel to and 2 to 3 in. (51 to 76 mm) above a glass plate and allow it to fall freely onto the glass plate. Take extreme care not to stretch or distort the wire with too much tension. Manipulate the glass plate over the graph described in 7.1 so that the ends of the wire coincide with the zero line. Measure the maximum deviation from the zero line. Also measure the distance from end to end.

8.2 *Report*—The report shall include the maximum deviation from the zero line and the apparent length of the wire to the nearest millimetre. The readings shall be expressed as: *X* mm deviation/*X* mm (For example, if the maximum deviation were 25 mm and the apparent length were 165 mm, the expression would be 25 mm deviation/165 mm).

9. Tension Test

9.1 *Apparatus*—Any standard testing machine that applies the load at a constant rate of traverse or a machine calibrated in terms of a constant rate of traverse shall be satisfactory. The capacity of the testing machine shall be such that all specimens fail at greater than 40 percent of the capacity of the machine. The clamps used shall be such that there will be no slipping of, or damage to, the test specimen.

9.2 *Procedure*—Determine the tensile strength, yield strength, and elongation at room temperature. The gage length of the specimen shall be 10 in. (254 mm). The initial load applied to the specimen before making the test shall be sufficient to keep the wire straight. The rate of traverse shall be 1 in./min (25.4 mm/min). The yield strength shall be defined as the stress at which the specimen exhibits an elongation of 1 %. If the specimen breaks within 0.5 in. (12.7 mm) of the clamps, repeat the test.

9.3 The report shall include the averages of at least three determinations each of the tensile strength and yield strength[5] expressed in gf/(mg/200 mm) or in kgf/cm^2, and the percentage of elongation in 10 in. (254 mm).

NOTE 1—Conversion factors are as follows:

$$\text{gf/(mg/200 mm)} = \text{psi} \times 0.003515/\Delta$$

$$\text{psi} = F/W \times 284.5 \times \Delta$$

$$\text{kgf/cm}^2 = \text{psi} \times 0.0703$$

$$\text{psi} = \text{kgf/cm}^2 \times 14.22$$

where:

F = breaking load, gf,

Δ = density of material, g/cm^3, and

W = weight of material, mg/200 mm (see 5.1).

10. Electrical Resistivity

10.1 *Procedure*—Determine the electrical resistance of wire and ribbon at room temperature in accordance with Test Method B 63. The electrical resistivity shall then be calculated in accordance with 10.2. This test shall be applicable to smaller sizes by omitting 5.1.3 of Test Method B 63.

10.2 *Calculation*—The electrical resistivity at 25 C may be expressed either in terms of Ω cmil/ft, μΩ·cm, or as Ω·mg/200 mm·ft, calculated (Note 2) as follows:

$$\rho = (1.640 \times \Omega\text{/ft} \times \text{mg/200 mm})/(\text{g/cm}^3)$$

$$\rho_c = (9.868 \times \Omega\text{/ft} \times \text{mg/200 mm})/(\text{g/cm}^3)$$

$$\rho_w = \Omega\text{/ft} \times \text{mg/200 mm}$$

where:

ρ = resistivity, μΩ·cm at 25 C,

ρ_c = resistivity, Ω cmil/ft at 25 C, and

ρ_2 = resistivity, Ω·mg/200 mm·ft at 25 C.

NOTE 2—The following illustrates the derivation of the equations for calculating weight resistivities:

Using known values of:

R = resistance, Ω/ ft, at 25 C,

W = weight, mg/200 mm, and

Δ = density, g/cm^3.density, g/cm^3.

Let

A = cross section of wire, cm^2, and

L = length of wire, cm.

Then

$$W/1000 = \Delta LA = \Delta 20A$$

or

$$A = W/20{,}000\Delta$$

Let

ρ = resistivity, μΩ·cm,

ρ_c = resistivity in Ω cmil/ft, and

[5] For an explanation of units used, see Specification F 289.

ρ_w = resistivity in Ω-mg/200 mm·ft.

Then

$$\rho = RA/L$$

$$\rho = (1.640 \times \Omega/\text{ft} \times \text{mg}/200\ \text{mm})/(\text{g/cm}^3)$$

$$\rho_c = (9.868 \times \Omega/\text{ft} \times \text{mg}/200\ \text{mm})/(\text{g/cm}^3)$$

or

$$\rho = 0.1662\ \rho_c = 1.640\ \rho_w/\Delta$$

$$\rho_c = 6.015\ \rho = 9.868\ \rho_w/\Delta$$

$$\rho_w = 0.6096\ \rho = 0.10134\ \rho_c\Delta$$

10.3 *Report*—The report shall include the following:

10.3.1 Identification of test specimen,

10.3.2 Kind of material,

10.3.3 Temperature of surrounding medium,

10.3.4 Length of specimen used,

10.3.5 Method of obtaining cross-sectional area:

10.3.5.1 If by micrometer, a record of all micrometer readings, including average values and calculated cross-sectional area.

10.3.5.2 If by weighing, a record of length, mass and density determinations and calculated cross-sectional area.

10.3.6 Method of measuring resistance,

10.3.7 Value of resistance,

10.3.8 Calculated value of electrical resistivity, and

10.3.9 Previous mechanical and thermal treatments. (since the resistivity of a material usually depends upon them, these shall be stated whenever the information is available.)

11. Keywords

11.1 electrical resistance; electron devices; lamps; round and flat wire; tensile testing