Designation: F 180 – 94 (Reapproved 1999)

Standard Test Method for Density of Fine Wire and Ribbon Wire for Electronic Devices [1]

This standard is issued under the fixed designation F 180; 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 test method covers the determination of, to an accuracy of 1.0 %, the density of fine wires ranging from 0.25 to 0.02 mm (0.010 to 0.001 in.) in diameter, or ribbons of similar thicknesses, for electronic devices.

1.2 The values stated in SI 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 the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific hazard statements are given in Section 4.

2. Terminology

2.1 Definition:

2.1.1 *density*—the weight per unit volume, expressed in grams per cubic centimetre, in accordance with the following equation:

$$\Delta = W/V$$

where:

Δ = density of the specimen
W = weight of the specimen, g, and
V = volume of the specimen, cm^3.

3. Apparatus

3.1 *Balance*—A suitable chemical balance capable of being read to 0.1 mg.

3.2 *Micrometer*, capable of being read to 0.002 mm (0.0001 in.)

3.3 *Standard Volume Cylinder*—A cylinder of standard volume made from corrosion-resistant material such as nickel, cylindrical in shape to within 0.0025 mm (0.0001 in.) and of uniform diameter and length. The length of the cylinder shall be approximately the same as the diameter and about 12.7 to 25.4 mm (½ to 1 in.). The surface of the cylinder shall be smooth and free from defects, pits, or cracks. The corners of the cylinder shall not be rounded.

3.4 *Thermometer*, capable of being read to 0.2°C within the range from 10 to 35°C.

3.5 *Vacuum Pump and Desiccator*—A vacuum pump capable of producing a vacuum of 0.1 mm Hg and a vacuum desiccator.

3.6 *Hook* suspended by a fine wire about 0.08 mm (0.003 in.) in diameter, both made of corrosion-resistant material, for supporting the test specimen while weighing it in the liquid.

3.7 *Cradle* suspended by a fine wire about 0.08 mm (0.003 in.) in diameter, both made of corrosion-resistant material, for supporting the standard volume cylinder while weighing it in the test liquid.

4. Test Liquid

4.1 The test liquid in which the test specimen and standard volume cylinder are to be immersed while being weighed shall be pure, stable, and shall have a low viscosity, low surface tension, low vapor pressure and a density of not less than 2 g/cm^3. Tetrabromoethane and tribromomethane have been found satisfactory for this purpose.

4.2 **Precaution** [2]—These liquids are moderately toxic and should only be used by those familiar with the hazards involved.

4.2.1 Tests should be carried out under a fume hood. The fluids used should be considered potentially dangerous.

4.2.2 *Hazard*—When treated, highly toxic fumes are given off. Prolonged inhalation can cause unconsciousness.

4.2.3 *Treatment*—Fresh air; artificial respiration if unconscious; oxygen if required.

5. Test Specimen

5.1 The preferred length of wire or ribbon required for the test specimen shall be such that the volume is approximately 0.5 cm^3. The use of a specimen of less than 0.2 cm^3 is not recommended.

6. Preparation of Specimen

6.1 The wire or ribbon shall be wiped and loosely wound into a small coil and bound with wire of the same composition in such a manner that no loose ends project from the body of the coil in order to produce a compact coil sufficiently loosely

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[2] See Sax, N. I., *Handbook of Dangerous Materials*, 1951.

wound to permit penetration of the test liquid upon immersion. The test specimen shall be thoroughly cleaned of lubricants by washing or boiling in suitable solvents and thoroughly drying in an oven.

7. Procedure

7.1 Weigh the test specimen in air to the nearest 0.1 mg. Pour sufficient test liquid into a beaker to completely cover either the test specimen or the standard volume cylinder (see 7.4) when suspended by their respective supports in the liquid for weighing (Note 2). Immerse the specimen in the liquid, and place the beaker containing the specimen entirely submerged in the vacuum desiccator. The vacuum produced by the pump shall be sufficient to bring the liquid to a slow boil at room temperature and the boiling shall be continued for 10 to 15 min. During this boiling period, jar or tap the desiccator in order to detach bubbles of air or vapor clinging to the specimen.

NOTE 1—The size of the beaker and the quantity of liquid are a matter of convenience. One pound of the liquid is a sufficient quantity to use.

7.2 Break the vacuum and upon removal of the beaker from the desiccator, insert and fasten the thermometer so as not to interfere with the weighing of the specimen in the liquid. Take care that the specimen, liquid, and thermometer all have the same temperature, before weighing. This may be accomplished by allowing the liquid to stand a few minutes before weighing and stirring occasionally, but not vigorously.

7.3 Support the beaker, containing the specimen and thermometer, independently of, and above, the weighing pan of the balance. Determine the weight of the unloaded hook to the nearest 0.1 mg while the hook is suspended totally immersed in the liquid. Then place the specimen on the hook, taking care that the specimen is not exposed at any time to the atmosphere above the liquid, and weigh to the nearest 0.1 mg (Note 3). Record the temperature to the nearest 0.1°C.

NOTE 2—In weighing the specimen in the liquid, it will be found desirable to confine the magnitude of the swing of the pointer to a few millimetres, because of the strong damping effect of the liquid upon the motion of the specimen.

7.4 Measure the standard volume cylinder to the nearest 0.002 mm (0.0001 in.) and weigh in air to the nearest 0.1 mg. Place the standard volume cylinder in the cradle, immerse it in the test liquid, and weigh to the nearest 0.1 mg. Then weigh the unloaded cradle to the nearest 0.1 mg while it is suspended in the liquid completely immersed. Record the temperature of the liquid to the nearest 0.1°C.

8. Calculation

8.1 *Density of Test Liquid*—The density of the test liquid shall be calculated as follows:

$$d = (w_a + c_l - w_l)/v$$

where:

d = density of test liquid, g/cm^3,
w_a = weight of standard volume cylinder in air, g,
c_l = weight of cradle in liquid, g,
w_l = weight of standard volume cylinder and its supporting cradle in liquid, g, and
v = volume of standard cylinder, cm^3.

The density of most liquids varies considerably with the temperature. If the weight of the specimen and the weight of the cylinder have been determined at different temperatures, it will be necessary to apply a temperature correction to obtain the density of the liquid for the temperature at which the specimen is tested.

NOTE 3—The temperature coefficient of density for tetrabromoethane is − 0.0023/°C and for tribromomethane − 0.0022/°C.

8.2 *Density of Specimen*—The density of the specimen shall be calculated as follows:

$$\Delta = (W_a \times d)/(W_a + h - W_l)$$

where:

Δ = density of specimen, g/cm^3,
W_a = weight of specimen in air, g,
d = density of test liquid g/cm^3,
h = weight of hook in liquid, g, and
W_l = weight of specimen and its supporting hook in liquid, g.

9. Report

9.1 Report the following information:

9.1.1 Analysis of specimen,

9.1.2 Size of specimen,

9.1.3 Weight of specimen,

9.1.4 Density of specimen to three significant figures,

9.1.5 Temperature at which density determination is made,

9.1.6 Test liquid, and

9.1.7 Previous mechanical and thermal treatment of specimen.

10. Precision and Bias

10.1 *Precision*—The precision of this test method has not been formally evaluated using an interlaboratory testing program. However, it is possible to evaluate the standard deviation of the density, $\sigma(\Delta)$, for a given experimental setup, using the following equation that is based on propagation of errors:

$$\sigma(\Delta) = \sqrt{\{(\delta\Delta/\delta W_a)^2 \sigma^2(W_a) + (\delta\Delta/\delta d)^2 \sigma^2(d) + (\delta\Delta/\delta h)^2 \sigma^2(h) + (\delta\Delta/\delta W_l)^2 \sigma^2(W_l)\}}.$$

where each of the partial derivative terms are obtained from appropriate differentiation of the definition of specimen density, Δ , shown in 8.2.

10.2 *Bias*—Proper measurement technique for all the variables shown in the equation that defines $\sigma(\Delta)$ in 9.1 should eliminate bias from this test method.

11. Keywords

11.1 density measurements; electronic devices; fine wire; ribbon; wire bonding