Designation: F 135 – 76 (Reapproved 1991)

Standard Test Method for Embedment Stress Caused by Casting Compounds on Glass-Encased Electronic Components[1]

This standard is issued under the fixed designation F 135; 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 measurements of stress created by the chemical and thermal shrinkage of casting compounds. The usefulness has been demonstrated at all pressures up to 6000 psi (40 MPa) but the maximum limit of usefulness has not been determined. Measurements can be made from −40°F (−40°C) to 220°F (105°C). This test simulates the pressure exerted on glass-encased electronic components when embedded in casting compounds. This test method is also usable for determining the effect of a flexible conformal coating used to protect parts from the shrinkage of casting compounds.

1.2 *This standard does not purport to address all of the safety problems, 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.*

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

2. Summary of Test Method

2.1 A mercury thermometer and thermocouple are both embedded in the specimen of the encapsulating material. When a conformal coating is being tested, the bulb of the thermometer is coated with the conformal material. The principle of the test is that pressure exerted upon the bulb of the mercury thermometer forces the mercury up the capillary, resulting in an apparent temperature increase which is proportional to the applied stress. The stress can be calculated from the differences between this apparent temperature and the true temperature, which is provided by the thermocouple measurement. When a conformal coating is being tested it is necessary to measure stress on coated and uncoated specimens.

3. Apparatus

3.1 *Potentiometer* (1), calibrated to ± 1°F at 0 and 70°F (±0.5°C at −18 and 21°C), with thermocouple leads.

3.2 *Thermocouples* (3).

3.3 *Thermometers* (3), mercury, −40 to 220°F (−40 to 105°C) range.[2] No ASTM standard thermometer covering this range is available.

3.4 *Beakers* (3), Griffin, low-form, 150-mL (150-cm^3).

3.5 *Tape*, unimpregnated, glass fiber, pressure-sensitive adhesive.

3.6 *Elevated-Temperature Bath* (1), controllable to ±5°F (3°C), 73 to 220°F (23 to 105°C) range, or *Oven* (1), controllable to ±5°F (3°C), 73 to 220°F (23 to 105°C) range, equipped with window.

3.7 *Low-Temperature Bath* (1), controllable to ±5°F (3°C), 40 to 73°F (−40 to 23°C) range, or *Cold Box* (1), controllable to ±5°F (3°C), −40 to 73°F (−40 to 23°C) range, equipped with window.

3.8 *Vacuum Chamber* (1), suitable to maintain pressures of 4 mm Hg (0.5 kPa).

4. Material

4.1 Casting material to be evaluated.

4.2 Conformal coating material to be evaluated.

4.3 Suitable glass cleaning solvent such as trichloroethylene or isopropyl alcohol.

5. Test Specimens

5.1 Prepare three test specimens as follows (Fig. 1):

5.1.1 Hold each thermometer perpendicularly in its beaker so that the bottom of the bulb is 1 ± 1/16 in. (25.4 ± 1.6 mm) from the bottom of the beaker. Mark the thermometer shaft at the level represented by the surface of a liquid filling the beaker to the point of overflow. Wrap the shaft with reinforcing tape so that the tape covers the shaft for 1/4 in. above and below the mark.

5.1.2 *Conformal Coating Application (optional):*

5.1.2.1 Clean dirt and grease from the thermometer bulbs and glass test slide with a suitable solvent. A recommended procedure is to rinse in a bath of clean, fresh solvent, allow to drip dry, rinse in a second bath of clean, fresh solvent, and air dry taking care not to recontaminate the cleaned surfaces before application of the conformal coating.

5.1.2.2 Coat the bulb of the thermometer with the conformal coating to be evaluated. Exercise care to assure a coating of uniform thickness on each thermometer and within each test set of thermometers. When dip coating is used, a recommended method for determining coating thickness is as follows: Coat the cleaned thermometer bulbs by dipping in the coating material using a controlled rate of immersion and removal. Coat three cleaned glass microscope specimen slides by dipping in the coating material using the same rate of immersion and removal and same depth of immersion as used on the thermometer bulbs. Cure the coating material on all samples. Measure the thickness of the coating on the glass slides at approximately the center of the

[1] This test method is under the jurisdiction of ASTM Committee F-1 on Electronics and is the direct responsibility of Subcommittee F01.05 on Molding Compounds for Semiconductor Encapsulation.

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[2] A Central Scientific No. 19283-5 thermometer has been found to be satisfactory.

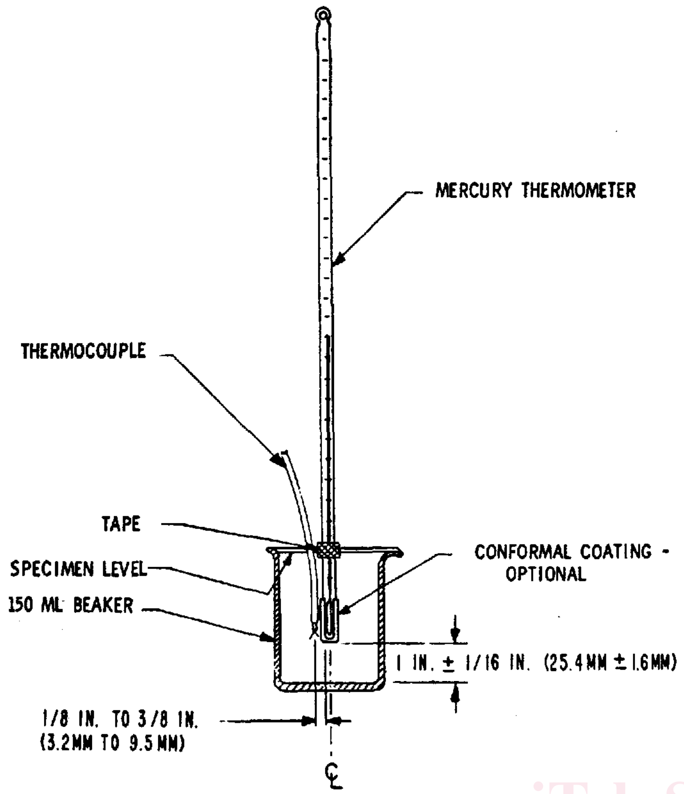

FIG. 1 Test Specimen Details

coated surface with a suitable measuring device capable of accuracy to ±0.001 in. (0.025 mm). Record, as the coating thickness, the average thickness of a single layer of the coating on these three specimens.

5.1.3 Coat the interior of each beaker with a mold-release agent suitable for the encapsulant being used.

5.1.4 Position the thermometers and thermocouples in the beakers, as shown in Fig. 1, using fixtures such as standard laboratory stands and clamps.

5.1.5 Using the manufacturer's directions, prepare the casting compound and evacuate to remove entrapped air. Carefully pour the material into each beaker to the point of over-flowing, avoiding the formation of bubbles.

5.1.6 Cure the casting compound as recommended by the manufacturer. Record the exotherm peak as sensed by the thermocouple and as measured using the potentiometer.

NOTE 1—Neither the exotherm peak nor the cure temperature may exceed the limits of the thermometer.

5.1.7 Cool each specimen to 73 ± 5°F (23 ± 3°C) and carefully remove each beaker.

6. Procedure

6.1 Record the thermometer and thermocouple readings for each specimen when it has reached equilibrium at 73 ± 5°F (23 ± 3°C) as indicated by the potentiometer. Designate the thermometer reading at any given temperature as T_p and the thermocouple reading (true specimen temperature) as T_s.

6.2 Position the specimen in the controlled elevated temperature bath or oven. If the bath is used, the upper surface of the casting material should be about ½ in. (13 mm) below the surface of the bath liquid.

6.3 *Rigid Casting Materials* (Note 3):

6.3.1 Adjust the temperature control to obtain a potentiometer temperature reading about midway between +73°F (+23°C) and the peak exotherm temperature.

6.3.2 When equilibrium has been reached, record T_p and T_s.

6.3.3 Position the specimen in the controlled temperature bath or cold box. If the bath is used, the upper surface of the casting material should be about ½ in. (13 mm) below the surface of the bath liquid.

6.3.4 Adjust the specimen temperature to −30°F (−35°C) and record T_p and T_s when the sample has reached equilibrium.

NOTE 2—Rigid casting compounds have been shown to exhibit a linear relationship between embedment pressure and temperature over the limits of this test. For these materials three points will give a good representation of the pressure-temperature relationship. A typical pressure-temperature curve is shown in Fig. 2(*a*).

6.4 *Semirigid and Flexible Materials* (Note 4):

6.4.1 Make measurements at as many different temperatures as are necessary to define the shape of the curve on either side of the transition point.

NOTE 3—Semirigid and flexible casting compounds exhibit a change in modulus (transition point) at some temperature below the peak exotherm, resulting in a sharp change in the slope of the pressure-temperature curve. For these compounds, more than three points may be necessary to define completely the pressure-temperature curve. For some flexible compounds this change in modulus (transition point) may occur at a temperature below the lower limits of the test (−40°F or −40°C). Typical pressure temperature curves are shown in Figs. 2(*b*) and 2(*c*).

6.4.2 For each temperature chosen, adjust the control of the appropriate controller and position each specimen as described for rigid materials, allow equilibrium to be reached, and record T_p and T_s.

7. Calculations

7.1 Calculate the embedment pressure as follows:

$$P = C(T_p - T_s) \quad (1)$$

where:

P = embedment pressure at T_s, psi (or MPa),
T_p = average thermometer reading, °F (or °C),
T_s = average thermocouple reading, °F (or °C),
C = proportionality constant (Section 8).

NOTE 4—The value of the proportionality constant has been empirically determined to be 90 psi/°F (112 MPa/°C) for a sample of Central Scientific Company No. 19283-5 thermometers.

8. Method for Determining Thermometer Proportionality Constant

8.1 This method covers the determination of proportionality constants for thermometers to be used in measuring the embedment stress.

8.2 *Summary of Test*—A thermometer to be calibrated is subjected to hydraulic pressure in increasing steps to the maximum capacity of the thermometer. The hydraulic pressure exerted upon the bulb of the thermometer forces the indicating liquid up the capillary, resulting in an apparent temperature increase that is proportional to the applied stress. The proportionality constant can be calculated from