STANDARD TEST METHOD FOR EVALUATING TRIBOELECTRIC CHARGE GENERATION AND DECAY

TEST REPORT

Standard Test Method for Evaluating Triboelectric Charge Generation and Decay

ISSUED BY

National Aeronautics and Space Administration
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1.0 SCOPE

This method describes the triboelectric test device used at the Kennedy Space Center (KSC) for electrostatic evaluation of non-conducting materials, including sample preparation and preconditioning, test procedure, and calibration requirements. This method is intended for testing thin plastic films, foams, tapes, cloth fabrics, solid surfaces up to 0.5 inch thick, and surface coatings such as paint or anti-static coatings applied to thin solid samples.

2.0 SIGNIFICANCE AND USE

2.1 Attention has been given to the problem of static electricity because of its ability to damage or destroy certain semiconductor devices, unexpectedly initiate ordnance devices, ignite explosive atmospheres, and surprise workers doing critical jobs causing undesirable consequences and potential injuries. These hazards associated with electrostatic discharge (ESD) are a continuing safety and financial concern to the scientific, aerospace, and industrial communities. Thin materials such as plastic films, foams, and tapes are some of the materials most likely to develop damaging static charge buildup.

2.2 This test method may be used to evaluate the static electrical charge generated and the rate of discharge from materials under controlled environmental conditions.

2.3 This test method is different from others commonly used in industry. The uniqueness is that it addresses the combined effect of charge generation and dissipation. In contrast, surface resistivity measurement provides material information that is primarily related to the rate of charge dissipation. Decay rate measurement preceded by corona discharge also focuses on charge dissipation behavior. If necessary, these and other test methods can be employed in order to augment this test.

3.0 SUMMARY OF TEST METHOD

3.1 A test sample is placed in a metallic sample holder, which is connected to electrical ground during testing. Once the sample is preconditioned in the test environment for a minimum of 24 hours, it comes in contact with a PTFE rubbing wheel. Contact force is 3 pounds, rubbing speed is 200 rpm, and contact time is 10 seconds or less. Upon completion of rubbing, static voltage is monitored for 5 seconds.

3.2 Three (3) samples are tested. Test material passes the test when all 3 samples exhibit 5-second voltage between +350 and –350 volts (inclusive).

3.3 Test results are valid only for the color pigment associated with the material being evaluated. The standard test environment shall be 75±5°F

at 30% and 45% relative humidity. Special environmental conditions may be used as required by customer.

4.0 TEST DEVICE

4.1 The device consists of a sample holder, a PTFE rubbing wheel, a capacitive static voltage sensor, a sample transfer mechanism, a controller box, and a data acquisition system (Figure 1).

4.2 The sample holder consists of 2 aluminum plates of the same thickness. Each has a 5 1/2" diameter cutout in the middle. The plates hold an 8 inch diameter sample along the edge between them, exposing the central area for rubbing contact.

4.3 The rubbing wheel, 5 inches in diameter, consists of a PTFE rubbing medium, a foam cushion, and a phenolic backing plate. The standard medium is PTFE felt which is used on low friction samples such as plastic films. A solid PTFE with a convex surface radius of 12 inches is used on cloth fabrics, "wet" anti-static coatings, and other test materials that may damage or contaminate the felt. Other rubbing media such as soft wool, and other contact methods such as brush stroke can be employed to meet special testing needs. All wheels must be acclimated in the test condition for a minimum of 24 hours.

4.4 Some test materials may contain or be coated with a substance that will come off and be deposited on the rubbing wheel. If this occurs, the solid PTFE may be cleaned with alcohol; and the felt may be washed with soap and water, rinsed in alcohol, and dried.

4.5 The surface of unused PTFE felt has tightly knit fibers. When these become loose from repeated use, the felt must be discarded.

4.6 The wheel is attached to a 1/8 HP electric motor. Contact force between the rubbing wheel and the sample is maintained at 3 pounds by using a dead weight and a pulley system.

4.7 A capacitive sensor (Keithley 2501) provides a non-contact reading of the static voltage developed on the sample. This unit provides 10^{-4} voltage attenuation.

4.8 The pneumatic sample transfer mechanism moves the sample from the rubbing to the sensing position within 0.5 second.

4.9 The controller consists of electro-pneumatic valves and switches for automatic operation of the device. Contact time is also adjusted by the controller. Excessive rubbing may change the sample texture or cause

damage to the rubbing medium. Too brief a contact (e.g., less than 1 second) may generate insufficient charge.

4.10 Keithley 6514 electrometer amplifies the signal from the sensor.

4.11 Analog output from the electrometer is fed into an analog-to-digital data acquisition system. A micro switch is attached to the base of the motor slide. As the rubbing motor retracts from the sample, the micro switch is activated and a triggering signal is generated to initiate data acquisition.

5.0 PREPARATION OF TEST SAMPLES

5.1 Cut three 8-inch diameter samples from the test material. Precondition the samples as mounted in holders in the desired test environment for a minimum of 24 hours. Gloves are required during sample handling in order to prevent contamination.

5.2 When less than 3 samples are prepared due to insufficient test material, the discrepancy must be noted in the test report.

6.0 TEST PROCEDURE

6.1 Turn on ionizer for sufficient length of time to remove any residual static charge from the wheel and test sample.

6.2 Turn on electrometer and data acquisition system.

6.3 Turn on rubbing motor and verify 200 rpm.

6.4 Place sample holder on the sample carriage.

6.5 Activate Clamp on the controller.

6.6 Briefly press and then release Zero Check on the electrometer.

6.7 Arm the data acquisition system.

6.8 Activate Run on the controller.

6.9 Record peak, 1/2 s, 1 s, 2 s, 3 s, 4s, and 5 s voltage.

6.10 Repeat the test for all 3 samples except when failure occurs. Both sides of the sample need to be tested, unless they are identical.

7.0 CALIBRATION

7.1 The system must be calibrated when an electronic component is replaced or when mechanical changes are made. Regular calibration must be done every 6 months.

7.2 A test plate connected to a calibrated DC power supply is used for system calibration. The test plate is a 5 inch diameter metal disc supported on an insulating plastic sheet.

7.3 Apply a DC voltage to the test plate and check the electrometer display. Adjust the distance between the sensor and the test plate, if necessary. Verify that the rear analog output of the electrometer matches the front display. If there is a discrepancy, send the unit to KSC Calibration for correction. Trigger data acquisition system. Adjust gain and zero of the data acquisition system, if necessary. When the readout of the data acquisition system is within 97% of the applied voltage at $\pm$500 volts, and within 95% at $\pm$2000 volts, the system is considered calibrated.

7.4 A glass thermometer with graduation of 0.2 ^{o}C is adequate for temperature measurement. It must be periodically calibrated by KSC Calibration. Relative humidity (RH) sensors can be calibrated in the lab by using the reference solutions defined in ASTM E104. Yearly calibration is required.

7.5

7.6 As the PTFE felt becomes used, fibers become loose and tribocharging characteristics change. The felt needs to be replaced. Charge plate monitor such as Monroe 286A can be used to determine the time of replacement. Place a rubbing wheel on the plate with the felt down, and measure charge as the wheel is slid on the plate. Variation greater than 10% from new requires felt replacement.

8.0 TEST REPORT

A test report includes the following minimum information: job number, test method and revision number, sample description, test data (peak, 0.5s, 1s, 2s, 3, 5s voltage), temperature, relative humidity, calibration information, and name of test conductor.

9.0 CHANGES IN REV 6

9.1 An automated test device replaced a manually operated unit. Also, a digital electrometer (Keithley 6514) replaced an analog unit (Keithley 610C).

9.2 Contact time was changed from 10 seconds to 10 seconds or less. The previous 10 second requirement originated from the time that a test technician needed to operate the device manually.

9.3 The condition for discarding used PTFE felt was added.