DYNAMIC RESISTANCE TEST METHOD FOR THERMOFORMED CONDUCTIVE MATERIALS

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INTRODUCTION

Thermoformed plastic material is usually rendered electrostatically conductive or dissipative by adding powdered carbon, stainless steel or carbon fibers, or other metallic additives. Depending on the material, the amount of loading and the thermoforming process the measured resistance may become a function of the test voltage used. This non-linearity is primarily caused by the amount of dielectric material between conductive particles. In a typical DC resistance measurement as the test voltage increases the measured resistance decreases to some base value. Typical test voltages range from less than 1 Volt to 500 Volts. However, conductive material used in static-safe applications provides a low resistance path to control the rate of discharge for an ESD event.

Because of the non-linear resistance characteristics of these materials ETS has developed a test method to determine the effective resistance of the material when exposed to a Human Body Model (100pf/1,500 Ohms) discharge. This resistance is referred to as the “Dynamic Resistance” verses the DC resistance measured with a standard resistance meter or other apparatus. In addition, the rate that the material dissipates a static discharge is too fast for existing static decay test methods. Analyzing the decay curve of the discharge waveform provides this information directly by multiplying the fall time, time constant by 2.2 for decay to the 10% level and 4.8 for decay to the 1% level.

TEST METHOD

The “Dynamic Resistance” test method consists of applying a HBM discharge pulse as defined in ESD STM5.1 to a clamp electrode with conductive rubber pads on both sides attached to one end of the test plaque or component. A second electrode is clamped to the other end. A Tektronix CT-1 current transducer is placed in series with this second clamp electrode and ground. The CT-1 is connected to a high-speed oscilloscope having at least a 200 MHz bandwidth and a 1 Gs/sec sampling rate. A single discharge is applied. The waveform is similar to the calibration waveform described in STM5.1.

It is recommended that the test be performed at 10, 100, 2000, 4000 and 8000 Volts to determine the nonlinearity of the material. However, other voltages may also be used.

The total ESD resistance is calculated by dividing the test voltage by the peak current measured on the scope. For the CT-1 the conversion factor is 5V/1 amp (5mv/ma). For the HBM there is the 1500 Ohm discharge resistor in series with the material resistance. To determine the effective ESD resistance of the material, subtract 1500 from the above calculation. The test may also be performed using 0 Ohms instead of the 1,500 Ohms.

The dissipation time is calculated by multiplying the displayed fall time to the 37% point (1 time constant) by 2.2 or 4.8 to obtain the decay times to the 10% and 1% points respectively. The respective decay times can also be determined by reading the waveform directly.

TEST PROCEDURE

The following is the suggested test procedure for measuring the overall resistance characteristics and static dissipation time of conductive and low dissipative thermoformed material.

1. Measure the DC resistance of the test plaque or test object using a standard resistance meter having test voltages of 10 and 100 volts and the ETS Model 832 clamp electrodes. Perform the 10 Volt measurement first. If no reading is obtainable or is unstable note that on the data sheet. Record the resistance measured at both 10 and 100 Volts.
2. Without moving the clamp electrodes connect the electrodes to the ESD simulator as described above.
3. Set the ESD simulator to 10 Volts. Initiate a discharge. Record the peak voltage measured and then convert it to current. Record the fall time.
4. Calculate the total measured resistance by dividing the test voltage by the measured current. Calculate the desired the decay time.
5. Subtract the 1500 Ohm HBM resistor value. The resulting resistance is the effective discharge resistance (Dynamic Resistance) for a given voltage.
6. In most cases the Dynamic Resistance will differ from the measured DC resistance.
7. Repeat the above procedure for the other test voltages.

TEST RESULTS

1. Record the measured resistance taken at 10V.
2. Record the measured resistance taken at 100V.
3. Print and present the discharge waveform taken at each voltage level.
4. Calculate the effective discharge resistance as follows:

   $$R_{eff} = V/I – 1500$$

5. Calculate the decay time as follows:

   $$t_{10\%} = 2.2\tau$$

   $$t_{t\%} = 4.8\tau$$