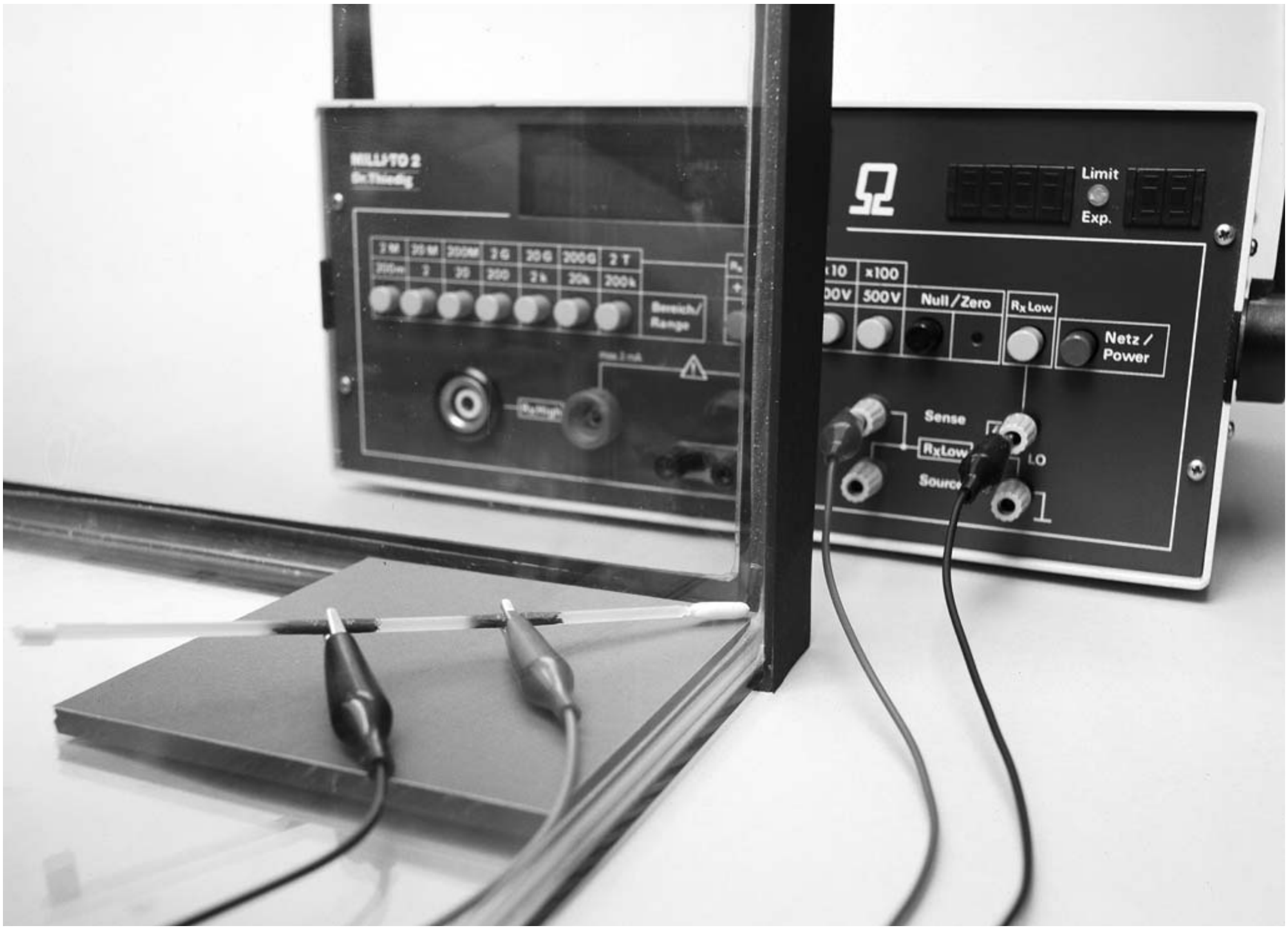
Test Method Number 16

Determination of the Resistance per Unit Length (ohm/cm) of Swab Handles



ITW Texwipe®

Version 1.0

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Background and Theory

PURPOSE

To determine the resistance per unit length of swab handles at 12±3% relative humidity (RH) and 23±3°C for at least six samples

Swabs can transport charge and generate static charge due to contact with other surfaces. Such charges can subsequently lead to electrostatic discharge (ESD) that can damage products or equipment. Although swab handle resistance (see below) is not the only factor determining the charge accumulated by the swab or placed on other surfaces by the swab, it is a major factor. Lower resistance leads to less charge accumulation. Very low resistance can lead to excessive rates of charge transfer (current).

For a simple resistor, resistance is often measured by applying a voltage difference (V) to the leads, measuring the current (I) and inferring the resistance as $R = V/I$, once a steady state has been reached or after a fixed time. Resistance will depend on the geometry of the resistor. For a cylinder, it is $R = (\text{rho.v})\ L/A$, where (rho.v) is the volume resistivity, L is the length and A is the cross-sectional area (assuming a negligible contribution from surface current).

Resistance measurements for some high-resistance materials are complicated by several factors:

1. Resistance may change during the measurement due to changes in the sample. This can be made less of a problem by fixing the time, the voltage and the electrode geometry, as done here.

2. Resistance may depend on the voltage gradient, the change in voltage per change in distance. This can be made less of a problem by fixing the voltage and the electrode geometry, as done here.

3. Resistance will depend on the temperature. This can be made less of a problem by fixing the temperature, which is also done here.

4. Resistance will depend on the humidity. This can be made less of a problem by fixing the relative humidity and conditioning the samples within the set temperature and humidity ranges for an extended period. We fix the humidity at 12±3%RH by using a saturated aqueous solution of LiCl over which air is forced to flow by a small fan. The swab samples are given 48 hours or more to reach equilibrium, as done in the ESD Association S11.11 standard for measuring surface resistivity for planar materials. A closed vessel with attached gloves allows manipulation of the equipment and samples with minimal opening of the chamber to the laboratory environment.

5. Resistance at the contacts (Rc) between the electrodes and the specimen can be appreciable. Recall that for a cylinder, $R = (\text{rho.v})\ L/A$. Modeling the contact region as cylindrical, $Rc = (\text{rho.v})\ Lc/Ac$, if volume resistivity predominates. For two cylindrical regions coated with a conductor (the technique used here), Lc is roughly the radius, $Lc = D/2$, and Ac is roughly the circumferential area, $Ac = 2\ (\pi\ D\ L)$, so the ratio of this resistance to that of the region being measured is roughly $(Lc/L)(A/Ac) = (D/2L)\ (\pi\ D^2/4)/(2\ \pi\ D\ L) = D^2/16L^2$, which will be negligibly small for $D<<L$. This method uses electrodes made of conductive conformal coating material (e.g., “Ni Print” from GC Electronics) with the coating length much longer than the swab diameter.

6. The geometry of the resistor can affect the proportion of current carried by the surface and by the volume, so there is some ambiguity about whether surface or volume resistivity is being measured, as the measurement is influenced by both.

EQUIPMENT/ MATERIAL

a. Temperature and humidity control chamber (approx. 60cm x 30cm x 30cm, glass) with:

1. Fan (e.g., small 9V cooling fan used for electronics, having c. 27cfm flow)
2. Saturated solution of LiCl in water (9–15%RH) or other humidity controller
3. RH and temperature measurement device (e.g., Electro-Tech Systems Model 535)
4. Insulating base (e.g., 10cm x 10cm x 0.6cm acrylic, surface resistivity greater than 10^14ohm/square, or equivalent)
5. Gloves integral to the chamber
6. Temperature, humidity meters (20°C – 50°C ± 0.3°C, 5%RH – 95%RH ± 0.5%RH)

b. Associated equipment and materials for the measurement:

7. Conductive paint, such as GC Electronics Nickel Print
8. Wires to connect to ohmmeter and alligator clips to connect to swabs
9. High-impedance-input ohmmeter (e.g., Electro-Tech Systems Model Milli-TO-2), resistance calibration check standards, and appropriate probe for the standard
10. Stopwatch

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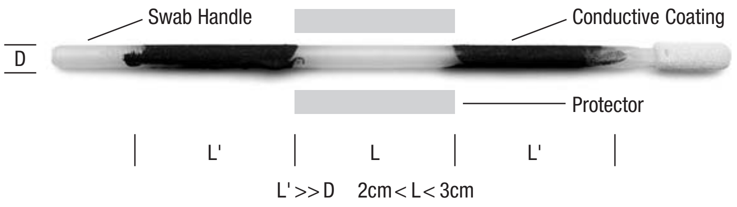
Procedure

a. Select at least six swab samples. (Use gloves whenever handling the samples.)

b. Protect the middle L = 2 to 3cm length of the swab handle, such as with oversized tubing, but not with anything that might leave a conductive residue (e.g., certain tapes) and coat at least 1 cm (length >> diameter) of the remaining two lengths with a conductive coating such as GC Electronics Co. Nickel Print (or equivalent). Let dry. See Figure 1.

Figure 1: Preparation



c. Remove the protecting material. Measure and record the length (L) of the uncoated region (within ±0.1cm).

d. Condition the swabs at 9–15%RH and 20–26°C for at least 48 hours, recording initial and final temperatures and humidities.

e. Before the tests begin, measure and record the relative humidity and temperature in the chamber.

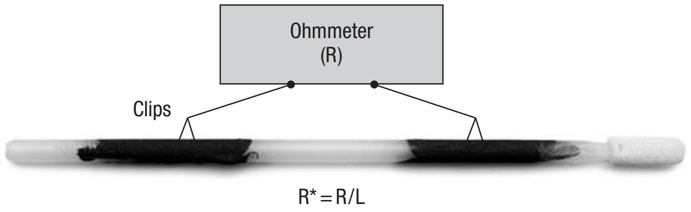
Do what follows, f. to h., in the chamber:

f. Check resistance ranges. At 100V, measure resistances of calibrating resistors that have values toward the upper and lower ends of the range of resistances of interest. If the measured means are more than 10% from the known values, have the instrument re-calibrated or use a correction factor.

g. Testing the specimens.

1. Keep the swab samples (at least 6) in the conditioned environment
2. Put one swab sample on the insulative base.
3. Connect the electrodes to the coated portions of the swab handle. See Figure 2.
4. Apply 100V to the handle and record the reading after 60s. (Then, turn off the voltage.)
5. Repeat 2 through 4, for the other samples, one reading per sample.

Figure 2: Measurement



(Note that for resistances of 100Gohm or more, it is important to minimize operator movement during the last 15 seconds of the measurement, as changes in capacitance can cause currents to flow in the wires from the sample to the ohmmeter.)

h. At the end of the tests, remeasure and record the temperature and humidity of the chamber.

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Sample Calculations

a. The resistance, R, is measured in ohms. Resistance per unit length is $R^* = R/L$, ohm/cm, which is resistance divided by the spacing between the electrodes, L, in cm.

b. The maximum, minimum, mean, and sample standard deviation are as conventionally defined. The sample standard deviation for the N readings is s, where $s^2 = \text{sum}\ \{(\text{reading} - \text{mean})^2/(N-1)\}$.

Example:

If the readings from each of the samples were $R^* = 2, 2, 4, 2, 4, 4$ Mohm/cm, then

number of samples = N = 6

maximum = 4 Mohm/cm

minimum = 2 Mohm/cm

mean = (2 + 2 + 4 + 2 + 4 + 4)/6 = 3 Mohm/cm

s = square root of $\{[(2-3)^2+(2-3)^2+(4-3)^2+(2-3)^2+(4-3)^2+(4-3)^2]/[6-1]\}=$ 1.095 Mohm/cm

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Reporting

a. Identify the test specimens unambiguously.

b. Report the minimum, maximum, mean, and standard deviation of the measured resistances in units of ohm/cm, for the group of samples tested. Use #.## x 10^# ohm/cm as the format.

c. Report the conditioning period duration (pre-test) and the temperatures and relative humidities at the start and end of the conditioning period and of the tests.

d. Report the test voltage (100V) and the duration of its application (60s).

e. Indicate who performed the tests and who wrote the report and when it was written.

f. A suggested form is given at right.

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Swab Handle Resistance Measurement Report

ITW Texwipe

Date of report: ____________________

Author of report: ____________________

Measurements performed by: ____________________

Date measurements completed: ____________________

Sample identification: ____________________

Number of samples: ____________________

Dimensions: ____________________

Applied voltage was 100V, for 60 seconds.

Resistance results

Maximum (ohm/cm): ____________________

Minimum (ohm/cm): ____________________

Mean (ohm/cm): ____________________

Sample std. dev. (ohm/cm): ____________________

No. of hours conditioned at 23 ± 3°C and 12 ± 3%RH: ________

Initial conditioning T and RH: ____________________

Final conditioning T and RH: ____________________

Initial testing T and RH: ____________________

Final testing T and RH: ____________________

Measurement equipment:
High-impedance-input ohmmeter (Electro-Tech Systems Model Milli-TO-2)