WIDE RANGE RESISTANCE METER
Model 8873

Operating Instructions

6/08

electro-tech systems, inc.
3101 Mt. Carmel Avenue, Glenside, PA 19038 • Tel: (215) 887-2196 • Fax: (215) 887-0131

www.electrotechsystems.com

1.0 INTRODUCTION

Many applications, especially in the application of static control products, require the measurement of the resistance characteristics of packaging, materials, work surfaces, and flooring plus any object where the build-up and dissipation of static charge is of concern. Some materials are nonlinear and have a measured resistance that is a function of test voltage. Various specifications including those written by the Electrostatic Discharge Association (STM 4.1, 11.11, 11.12, 11.13, etc.), ASTM (D257, 4496, F150 etc.), EIA, SAE (J1645, etc.), NFPA (77, 99 etc) military (MIL PRF 81705 etc.) plus most international documents specify or use test voltages of 10 and 100 Volts.

Certain specifications such as ASTM F-150, NFPA 99 and certain DOD Standards also require test voltages of 500 volts. Normally, higher test voltages tend to result in lower resistance readings. Hence, an acceptable reading utilizing 10 or 100 volts will generally meet any resistance requirements specified at higher voltages where resistance below a specified value is required. On the other hand, when 500 V is required to ensure the resistance does not drop below a specified value for safety purposes then a 500 V instrument **MUST** be used.

The ETS Model 8873, shown in Figure 1.0-1 is an accurate, battery-powered, microcomputer-based instrument that meets the requirements for measuring resistance from 10^2-10^{12} Ohms using selectable regulated test voltages of 10 or 100V. It is available as a stand-alone meter for use with external probes or with the optional plug-in, 2.5” dia. solid electrode/concentric ring electrode assembly. Also available is the Model 8873 Test Kit that includes the Model 8873 Meter, electrode assembly, 4” dia. conductive and acrylic test beds, cables and spare batteries plus a Model 850, 5 lb Surface Resistance Probe housed in a dust/waterproof carrying case. An optional external universal voltage power module is available for continuous operation of the Model 8873 without draining the batteries. Also available is an ETS Model

5646 Humidity/Temperature Indicator for measuring the environmental conditions where the testing is being performed

Model 8873 with optional electrode assembly

Kit shown with optional Power Module and Hum/Temp Indicator.

Figure 1.0-1: Model 8873 Configurations

2.0 DESCRIPTION

The Model 8873 Wide Range Resistance Meter is an accurate, easy to use instrument. The standard Meter features manual on/off plus auto standby (internally selectable) and a momentary **PUSH TO TEST** button for making a measurement. The voltage at which the measurement is taken is selected using a push-push **TEST VOLTAGE** select button. The 2-line alphanumeric LCD readout displays the measured resistance plus a flashing * on the top line and the test voltage (V_e=10 or 100V) on the bottom line. The flashing * indicates a measurement is being made. It stops flashing when the measurement is complete. If V_e=100V is used, it is also turned off at this time. Resistance is displayed in engineering units (ex: 6.35e+8= $6.35x10^8$ Ohms) plus **UNDERSCALE and OVERSCALE** indication. The lowest measurable resistance is 100 Ω at 10V and 10 kΩ at 100V. The highest measurable resistance is approximately 100 GΩ at 10V and 1 TΩ at 100V. The electrification time required to take a measurement at the highest resistance is normally less than 15 seconds when the integrated electrode assembly is used. Measurement accuracy is as follows:

±5% (10^2 to 10^{10} Ω @10V
±5% (10^4 to 10^{11} Ω @100V)
±15% (>10^{10} @10V, >10^{11} @100V)

When external test probes are used the electrification time will increase as a function of the test lead, probe and sample capacitance. External probes are connected to the Model 8873 via standard banana jacks located on the side of the instrument. Refer to available ETS Series 800 Resistance/Resistivity Probes literature sheets for probes to meet virtually any surface, volume (solids, liquids and powders) and point-to-point resistance measurement requirement. Other probes having standard banana plug leads may also be used. When using external probes the integrated electrode assembly must either be removed or the Meter must be placed on an insulated surface (resistance >10^{12} Ω).

The auto shutoff feature places the unit in “**sleep”** mode if no activity is detected after approximately 15 minutes. To perform a test, simply depress the **PUSH TO TEST** button and the unit will “wake up”. When not being used the instrument should be completely turned off using the **POWER** switch. For applications where this feature is not required an internal switch disables the time-out and power on/off will be totally controlled by the **POWER** switch To access this switch remove the outer shell (see changing batteries) It is located left of the POWER switch. When battery voltage is low the display automatically displays **Low Battery**.

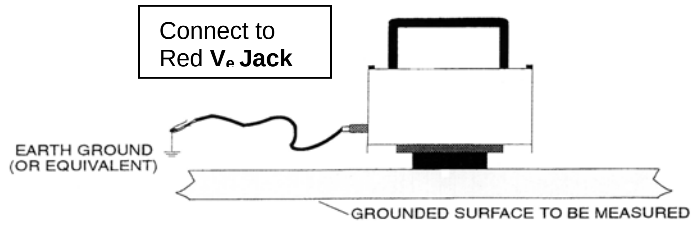
3.0 OPERATION

To make a measurement using the integrated electrode select the appropriate electrode configuration, depress the push-push **POWER** button. The LCD will indicate **PUSH TO TEST** and the test voltage selected. Place the Model 8873 on the surface to be measured and press the **PUSH TO TEST** button momentarily. The * will flash and measurements will be indicated until a stable reading is obtained, usually within 5 seconds. The * will stop flashing and the final measurement will be displayed for 60 seconds or until another test is initiated. The solid 2.5” (6.35 cm) electrode is used to measure point-point resistance and resistance to ground (RTG). The concentric rings are used to measure surface resistance per ESDS STM 11.11. When applicable, the resistance measurement can be converted to surface resistivity per ASTM D 257 by multiplying the measured resistance by 10 (ρ_s=10R_m Ohms/sq).

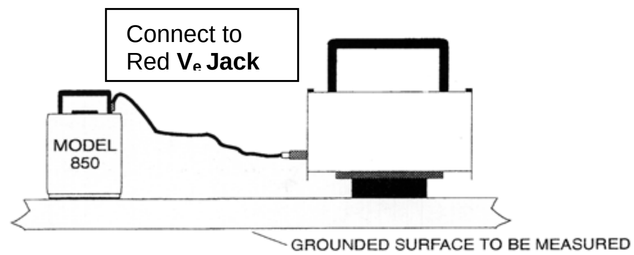
Volume resistance can be measured between the 2.5” dia. electrode and the conductive test bed (included in the Model 8873 Kit). **Note:** The center electrode of the concentric ring cannot be used for this measurement because the outer V_e electrode is always connected. If the test sample is less than 2.5” in diameter and does not make contact with the outer ring then the center electrode can be used to make a volume resistance measurement per STM 11.12. To measure per STM 11.12 an external probe must be used.

To make a volume resistance measurement connect the conductive test bed to the V_e output (Red) located on the side of the instrument. Place the planar material to be tested on the conductive plate and then place the instrument on top of the material. Momentarily press the **PUSH TO TEST** button and wait until a stable reading is obtained. To convert a volume resistance measurement to volume resistivity, multiply the reading by 31.7 (the area of the 2.5” electrode in cm^2) and divide by the thickness of the sample in cm (ρ_v=31.7/t Ohms-cm). If the center electrode is used (STM 11.12) then use 7.1 instead of 31.7.

The electrode assembly is connected to the measuring unit by 3 banana jacks. Thumbscrews (one for each electrode configuration) are located on the side of the assembly to lock it in place. To measure point-to-point resistance or RTG insert the electrode assembly into the banana jacks with the 2.5” electrode facing out. Plug an ETS Model 850, 845 or equivalent probe into the V_e (Red) jack. To measure pt-pt resistance place both the Meter and the external probe onto the surface to be measured. To measure RTG connect the supplied red wire from the V_e jack to the desired ground point using either the banana plug or the alligator clip adapter supplied. Refer to Figure 3.0-1 for RTG and pt-pt connections.



Resistance To Ground Test Set-Up



Point-To-Point Resistance Measurement

Figure 3.0-1: RTG and pt-pt connections

Place the instrument firmly on the test surface and perform the test as described above. Since the 5-pound weight of the Model 8873 provides the specified contact pressure, no additional pressure should have to be applied.

When using external probes, remove the electrode assembly, if provided, and plug the probes into the external Red $\mathbf{V_e}$ and Black **SENSE** banana jacks. Follow the instructions for measuring with the respective external probes. Figure 3.0-2 shows the connection of an ETS Model 844 2-Point Probe.

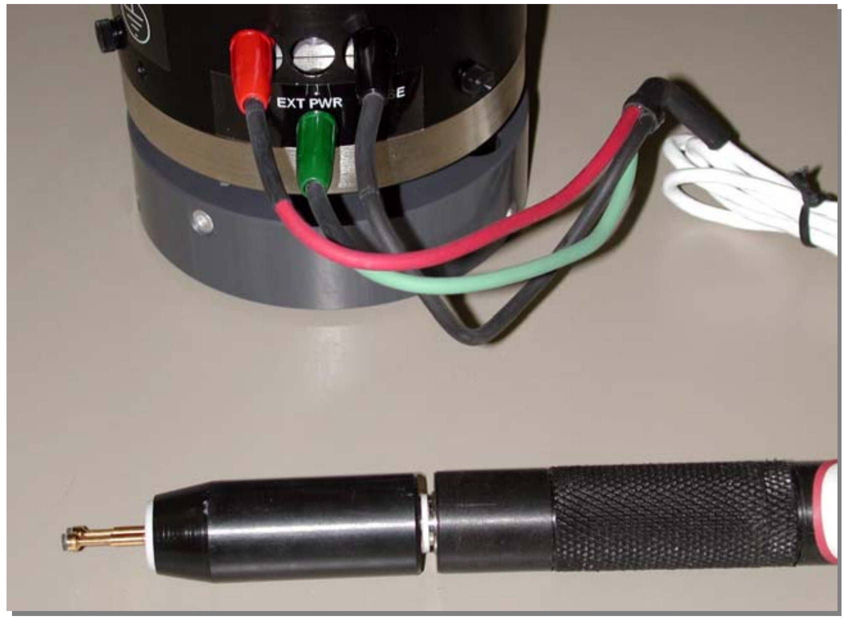


Figure 3.0-2: External Probe Connections

4.0 MEASUREMENT CONSIDERATIONS

4.1 Resistance

For most film and foam materials the standard 5- pound weight of the Model 8873 Wide Range Resistance Meter is sufficient for the electrodes to make total contact with the material surface. However, for rigid materials such as work surfaces, plastics, cardboard, etc, additional force, which will have to be determined by the user, may have to be applied to the Meter to ensure total electrode contact. Microscopically, these surfaces are generally not smooth and are uneven as illustrated in Figure 4.0-1.

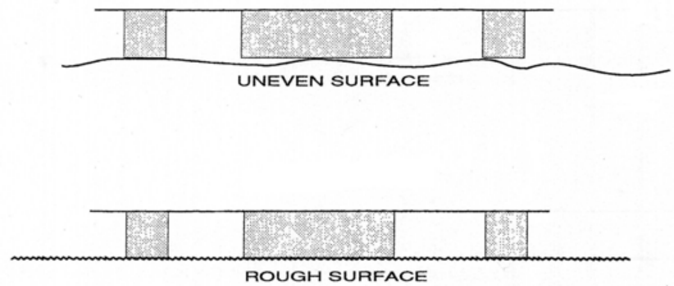


Figure 4.0-1: Microscopic Electrode/Rigid Surface Contact

In most cases the application of additional pressure will cause the measured resistance reading to decrease. This is a result of both lower contact resistance and total electrode/surface contact area (greater number of parallel resistance paths). Optimum contact pressure is obtained when the resistance measurement is stable.

Another area that must be considered when attempting to measure surface resistance is the composition of the material being evaluated. ANSI/ASTM D-257, a widely used test standard, is specified for homogeneous, insulating material.

However, many materials are either not homogeneous, relatively conductive and in the case of some composite material, nonlinear. For these materials a surface resistance measurement in accordance with ESD STM11.11 must be used.

For example, the surface resistance of bulk loaded materials have relatively low volume resistance and cannot easily be measured because the volume and surface resistance become part of the measurement. The current path between the electrodes is not only across the top surface but also through the material.

Similarly, the surface resistance of materials that are coated with, or laminated to, a conductive surface must also be measured using STM11.11. The surface resistance may actually be very high, but the volume resistance may be significantly lower. Therefore, the measured resistance may be that of the surface resistance path between the electrodes in parallel with the series combination of the two volume conductive paths and the conductive layer as shown in Figure 4.0-2.

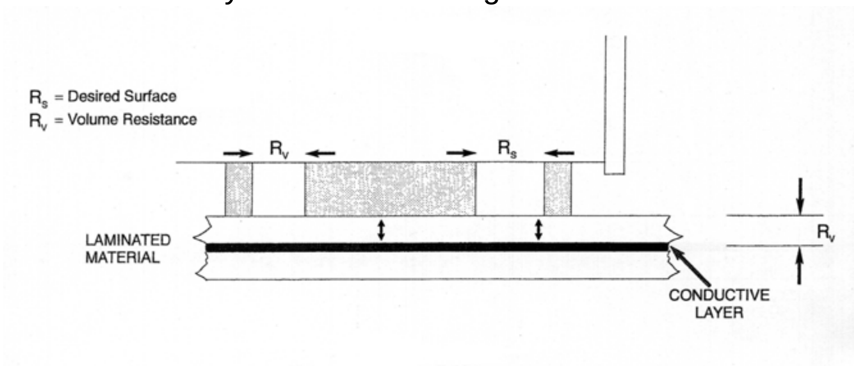


Figure 4.0-2: Multiple resistance paths of laminated material

Composite materials are very difficult to measure. They usually consist of a plastic resin filler with very high resistance properties loaded with a small percentage of a conductive material such as carbon powder, fibers or utilize nanotube technology. When molded these parts exhibit either conductive or static dissipative properties as defined in the ESD ADV1.0: Glossary of Terms. These materials have bulk resistance properties verses the surface only resistance properties found in other ESD materials. When a voltage is applied either across or through the material the dielectric of the filler breaks down and current flows from particle to particle. As the loading of the conductive medium decreases there is greater distance between particles that require a higher voltage to break down the increased dielectric. At some point, once a higher voltage is applied to establish continuity the resistance path created may become altered permanently. It should be noted that loaded thermoplastic materials is only effective in reducing the upper resistance limit to approximately 10^8 Ohms.

Another characteristic of loaded thermoplastic materials that affects the resistance measurement is the microscopic insulative layer that develops on the surface of the molded part. The dielectric of this layer must be broken down before a resistance measurement can be made. Once this occurs the actual resistance of the part may be lower than the measuring range of the instrumentation used.

Essentially, these materials are non-linear and voltage dependent. Different test voltages will give different results. Even the series resistor incorporated in virtually all resistance meters vary from meter to meter and can cause measurement variations. When measuring these materials the initial measurement should be always be made first at V_e = 10V then at 100V.

Another very important consideration in measuring surface resistance is the time of electrification. This is the time for the effective capacitance of the material to charge up. At this time, the current flow through the material reaches steady state and its flow is then a function of only the resistance of the material.

Effective material capacitance is generally quite low. For low resistance materials, the RC time constant, τ, is very short. On the other hand, for very high resistance materials the time constant can become quite long. When using the Model 8873 the overall capacitance of the system is relatively low so an electrification time of only 5-15 seconds is required to measure the maximum resistance. For material in the static dissipative range the electrification time is usually less than 5 seconds.

Resistances that are measured before the full time of electrification has occurred will appear to be lower than the actual resistance of the surface. This difference can be several orders of magnitude. ASTM D 257 recommends a time of electrification of 60 seconds, but in many measurements a shorter time may be used or a longer time may be required. Typically for small sample specimens with resistances less than 10^{12} ohms, the of 5 to 15 second electrification time is sufficient. On the other hand, large surfaces such as table tops, floors etc. the capacitance is relatively large and 60 seconds may not be long enough. Here, the user may either wait for complete electrification to obtain a true resistance measurement or specify the measurement at the 60 second electrification time point for a relative resistance measurement. A rule of thumb, “When in doubt, allow more rather than less time!”

4.2 RESISTANCE CHARACTERIZATION

Over the years many different resistivity or resistance values have been assigned to designate the various classifications of ESD material. Surface resistivity per ASTM D257 was the most common specification used to classify materials. However, this specification is for insulating materials and when the bulk characteristics of the material come into play significant errors are introduced. This became apparent during packaging material specification development approximately 15 years ago. It was found that by specifying all test parameters measurement variations between laboratories testing the same material was reduced from 3 orders of magnitude to better than one-half order of magnitude. Since all measurement parameters were now specified it was no longer necessary to specify the measured resistance readings in Ohms/square since the electrode configuration factor was no longer required. Therefore, all ESD resistance values are now specified in Ohms. This is covered in ESDS STM 11.11, 11.12 and 11.13 for surface, volume resistance and 2-point measurements respectively.

Currently ESD materials are classified as follows:

	Conductive	Dissipative	Insulative
Surface	$<10^4$	10^4 to $<10^{11}$	$\geq 10^{11}$ Ω
Volume		same	same

Materials with bulk resistance characteristics can also be classified by specifying its volume resistivity. This is simply done by multiplying the measured resistance by the area of the measuring electrode or material surface, whichever is smaller, and divided by the thickness. All values are in cm giving a volume resistivity in Ohms-cm. To convert to Ohms-meter, multiply by 100.

Increasing or decreasing the thickness of the material will also change the actual resistance of the part with a specified volume resistivity. This is a common technique used in ESD products to achieve a particular resistance. It is the actual resistance of the part, not its resistivity that determines how a part dissipates a static charge.

While the above resistance classifications were developed for ESD packaging materials many specifications used for other applications that specify material resistance/resistivity refer to these resistance limits.

It should be noted that the resistance/resistivity property of material does not predict whether the material will be low charging (antistatic) or not.

4.3 Measurement Documentation

When certifying material it is best to do it under controlled environmental conditions. Since lower humidity can affect the material resistance properties all certification tests should be prepared and performed at 12% RH and 23°C as specified in

ESD STM 11.11 & 11.12. ***Since current plastics industry standards specify standard conditions at 50% RH, 23°C certification should also be performed at these conditions also to allow comparison of existing data.***

For testing components and assemblies a controlled environment may not be practical. Under these conditions the humidity and temperature should be recorded at the time of testing. (Refer to the optional ETS Model 5646 Humidity/Temperature Indicator.)

The following procedure should be followed when measuring and documenting resistance measurements:

1. Sample preparation

2. Test instrumentation including setup and system verification tests.

   For loaded thermoformed material the test instrumentation, electrodes and system verification are critical in obtaining multi-lab correlation and must be specified.

3. A defined electrification period (measuring time).

   When measuring very high resistance the RC time constant of the sample and the instrumentation may require a significant amount of time for the test voltage to completely develop across the sample. The electrification time may be different for different instruments. Hence, measuring a known resistor at the upper limit will enable the user to determine the time it takes to measure the correct value.

   Some materials may exhibit a change in resistance during measurement. Taking measurements at a fixed time minimizes this problem.

4. Test procedure

   The test procedure is extremely important. How the sample is prepared, test electrodes, how the instrumentation is connected, test voltages used and how the measurement is taken all affect the ultimate accuracy of the data.

5. Documentation and reporting of data.

   Complete documentation of the measurements is essential. The level of data processing is a function of the end user requirements.

5.0 EXTERNAL POWER MODULE

An optional universal power module that operates from 90-260VAC, 50/60Hz power (Mains) is available. It plugs into the 5mm jack located between the auxiliary probe jacks. When plugged in, the internal batteries are disconnected. When using this module, the unit **must be connected to ground.**

Plug one end of the green ground cable into the hole in the base marked with the ground symbol as shown in Figure 5.0-1 and connect the other end to house ground.

Figure 5.0-1: Optional Power Module connections

6.0 MAINTENANCE

The Model 8873 has no user serviceable parts except changing the batteries. It must be returned to ETS for service. Contact ETS Calibration Department at 215-887-2196 to obtain a Return Material Authorization (RMA) for all warranty, service and calibration.

The user can check the calibration of the Meter by measuring the resistance of precision resistors over the measurement range of the instrument.

To change batteries remove the 3 black thumbscrews securing the outer shell to the base. Lift off the shell and slide the batteries out of the recess. Replace batteries as a pair. Use only 9-Volt alkaline or other high capacity batteries for best performance.

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7.0 WARRANTY

Electro-Tech Systems, Inc. warrants its equipment, accessories and parts of its manufacture to be and remain free from defects in material and workmanship for a period of one (1) year from date of invoice and will, at the discretion of Seller, either replace or repair without charge, F.O.B. Glenside, similar equipment or a similar part to replace any equipment or part of its manufacture which, within the above stated time, is proved to have been defective at the time it was sold. All equipment claimed defective must be returned properly identified to the Seller (or presented to one of its agents for inspection). This warranty only applies to equipment operated in accordance with Seller's operating instructions.

Seller's warranty with respect to those parts of the equipment which are purchased from other manufacturers shall be subject only to that manufacturer's warranty.

The Seller's liability hereunder is expressly limited to repairing or replacing any parts of the equipment manufactured by the manufacturer and found to have been defective. The Seller shall not be liable for damage resulting or claimed to result from any cause whatsoever.

This warranty becomes null and void should the equipment, or any part thereof, be abused or modified by the customer of if used in any application other than that for which it was intended. This warranty to replace or repair is the only warranty, either expressed or implied or provided by law, and is in lieu of all other warranties and the Seller denies any other promise, guarantee, or warranty with respect to the equipment or accessories and, in particular, as to its or their suitability for the purposes of the buyer or its or their performance, either quantitatively or qualitatively or as to the products which it may produce and the buyer is expected to expressly waive rights to any warranty other than that stated herein.

ETS must be notified before any equipment is returned for repair. ETS will issue an RMA (Return Material Authorization) number for return of equipment.

Equipment should be shipped prepaid and insured in the original packaging. If the original packaging is not available, the equipment must be packed in a sufficiently large box (or boxes if applicable) of double wall construction with substantial packing around all sides. The RMA number, description of the problem along with the contact name and telephone number must be included in formal paperwork and enclosed with the instrument. Round trip freight and related charges are the owner’s responsibility.