SAE J1645 TEST KIT
Model 2004

Operating Manual

9/08

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1.0 INTRODUCTION

The Model 204 Charged Plate Analyzer is a fully functional charged plate monitor that combines the ETS Model 212 Static Meter with a ±1200V low current power supply, timing circuit and a removable charged plate detector. The Model 2004 J1645 Test Kit contains the necessary accessories that provide a convenient and economical approach to performing electrostatic measurements requiring a charged plate monitor. The Model 204 meets the requirements of ESD STM3.1-2000, *Ionization* and ESD SP3.3-2000 *Periodic Verification of Air Ionizers,* SAE 1645 plus most other specifications requiring a charged plate monitor.

The standard Model 204 has a 60 second timer, however, when used to test the dissipation time of automotive fuel system components as specified in SAE J1645 the optional 6 second timer version is provided.

Typical charged plate tests that can be performed with the Model 2004 Kit are measuring ionizer balance and neutralization time, static propensity of floors and footwear, triboelectric charge evaluation of material, static dissipation plus evaluation of the effectiveness of personnel grounding systems. In addition, removing the detachable charged plate detector from the Model 204 converts it to an electrostatic fieldmeter.

1.1 SAEJ1645 Test Kit

The standard Kit consists of the following instruments and accessories:

1. Model 204 Charged Plate Analyzer
2. Model 880 Autoranging Resistance Indicator
3. Model 256 Utility Wiring Verifier with electrical ground banana jack (North American Std only. Omitted in kits destined for locations using 220-240 VAC.)
4. Tripod
5. 10’ coiled ground cord with clip
6. Model 5646A Humidity/Temperature/Dew Point Indicator
7. Model 832 Clamp Electrodes
8. Grounding Relay Module
9. 30” (76cm) Red & Black cables with plug-in alligator clips

Kit is housed in a ABS carry case with foam insert measuring 13.5”Wx10”Dx4.5”H (343x245x114mm)

2.0 EQUIPMENT DESCRIPTION

This section provides a detailed description of each of the instruments and adaptors included in the Model 2004 SAE J1645 Test Kit.

The Kit shown in Figure 2-1 is specifically designed to measure the resistance and dissipation characteristics of automotive fuel systems as specified in SAE

J1645, but can be used wherever any of these parameters need to be measured.

The included tripod is used to hold the Model 204 in either a vertical or horizontal position to facilitate) measurements.

Figure 2-1: Model 2004 SAE J1645 Test Kit

2.1 Model 204 Charged Plate Analyzer

The Model 204 Charged Plate Analyzer, shown in Figure 2-2, is a compact “pocket size” charged plate analyzer that measures 8”Lx2.4”W x0.9”H (203x146x229mm) and weighs only 9oz. (255gm). It incorporates many of the features found in CPA’s much larger in size and cost. The unit is a combination of an electrostatic fieldmeter, ±1200 Volt charging source and a digital timer. The electrostatic detector is a non-contacting, chopper type field sensor to ensure accurate and consistent continuous measurements both in and outside ionized fields. The Model 204 displays both electrostatic voltage and decay time on a single 3½-digit LCD meter with ½” character height. The meter is “zeroed” easily with the turn of a small knob and does not need re-zeroing between measurements.

The Model 204 has a detachable charged plate detector. When the detector is installed the unit is a charged plate monitor with a range of ±2000V and a resolution of 1V.

With the detector removed the unit performs as an electrostatic fieldmeter having a range of ±20kV at 1” (25.4mm) with a resolution of 10V. Measurement accuracy is ±10% in this mode. It includes a convenient ¼” (6mm) ground snap, compatible with most standard wrist strap cords, to facilitate grounding and to increase accuracy.

The charging function automatically activates the timing mode. As the applied 1200 Volt charge on the detector plate decays, either by

ionization or by dissipation through a resistance. The timer starts when the measured voltage drops to 1000 Volts and stops when it decays to 100 Volts. Decay times to 6 sec. in 0.03 sec. increments can be measured.

The 3½-digit LCD meter displays the voltage, polarity, or dissipation time when the decay function of the Analyzer is used.

The Model 204 operates from a single 9V alkaline battery with a typical operating life of approximately 20 hours. Low battery is indicated by all decimal points illuminated on the DPM.

Figure 2-2: Model 204 Charged Plate Analyzer

2.1.1 Charged Plate Detector

The Charged Plate Detector converts the Model 204 to a charged plate monitor having the specified 20pf (ESD S3.1) capacitance with both the 2.5”x1” (161x25mm) detector plate and the optional 6”x6” (152x152mm) standard size plate. When installed, the detector plate contacts the charging source and the sensitivity of the measurement system is increased by a factor of 10. After + or - V is applied, the system automatically converts to a timer when the voltage on the plate drops to 1000V, within the range of 0-6

seconds with 0.03 seconds resolution. It then measures the time for the charge on the plate to bleed down to 100V at which time the DPM switches over from a voltage display to a time display. If the charging source is not activated then the instrument just measures the detected voltage generated by ionizer imbalance, static propensity, or any charged object placed onto the charged plate. The optional 6”x6” (152x152mm) square detector plate plugs into the Model 205C detector plate to provide full size charged plate monitor capability. The maximum current output of the charging source is limited to 1 μAmp.

2.2 Model 256 Utility Wiring Verifier

This device plugs into a standard (North American) 110 VAC outlet and checks both the wiring of the outlet and provides a convenient standard banana jack output to access electrical ground. This device is not included in kits destined for locations using 220-240 VAC.

2.3 Model 5646A Humidity/Temperature/Dew Point Indicator

The Model 5646A enables the user to establish the humidity and temperature at the time of test as required by most specifications. The Indicator measures relative humidity over the range of 5-95% RH with an accuracy of ±3% RH and temperature over the range of 32 to 122°F (-20 to +70°C) with an accuracy of ±0.9°F (0.5°C). °F or °C can be selected and the dew point automatically calculated and displayed at the press of a button. The Model 5646A operates from 3 standard 1.5V AAA batteries. Refer to Figure 2-3 for the Model 5646A Operating Instructions.

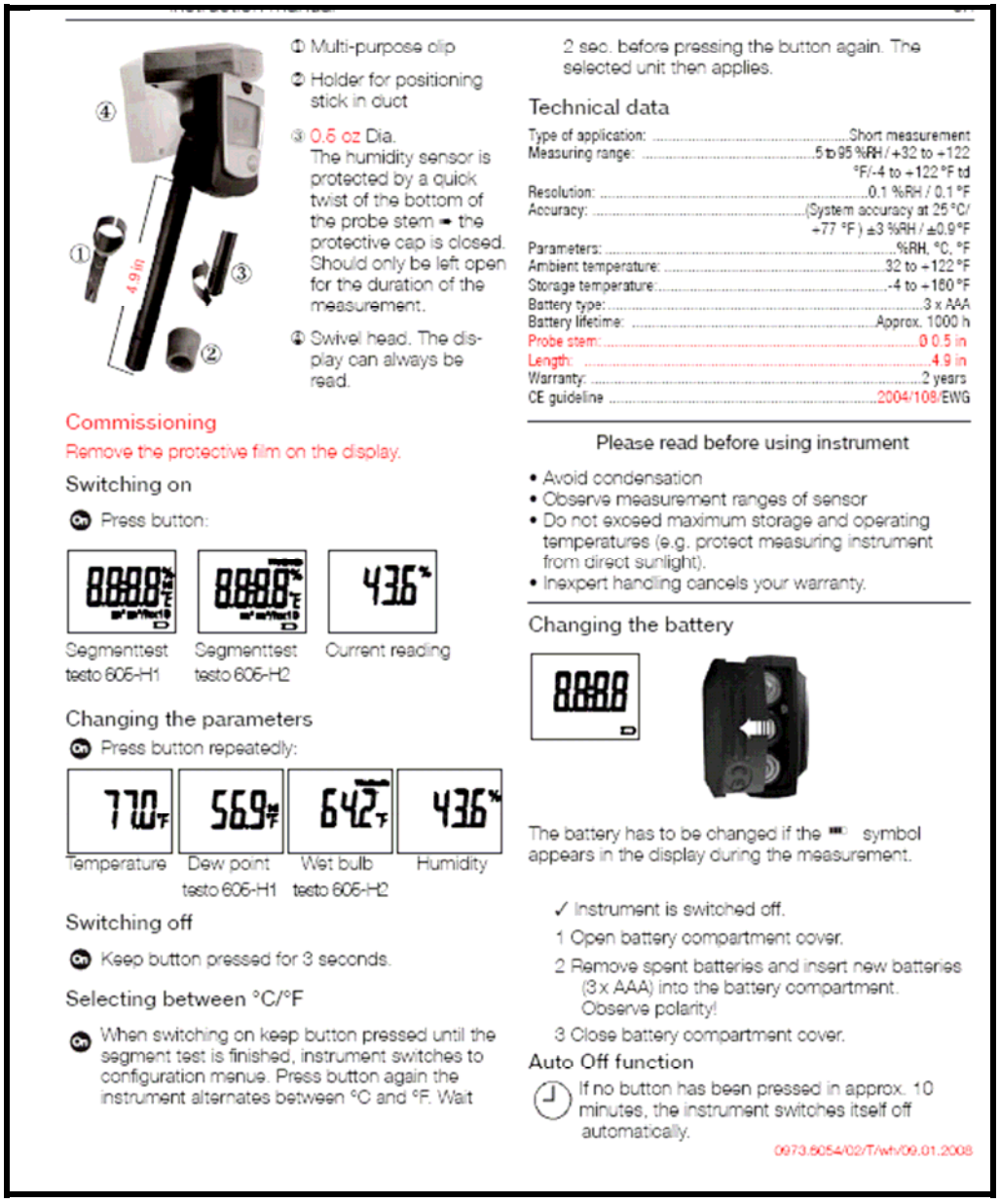

Figure 2-3: Model 5646A Operating Instructions

2.4 Model 880 Autoranging Resistance Indicator

Refer to the Model 880 Operating Instructions included as Appendix A to this manual.

2.5 Model 232 Clamp Electrodes

Refer to the Model 232 Operating Instructions included as Appendix B to this manual.

2.6 Grounding Relay Module

Refer to the Model 232 Operating Instructions included as Appendix B to this manual.

3.0 OPERATION

To use the Model 204 as a charged plate monitor, install the Charged Plate Detector onto the front of the unit. To measure the charge build-up on personnel or moving objects, plug a clip lead, probe or wrist strap into the detector plate. Ground the detector plate by depressing the ZERO/RESET button for approximately 1 second. Release the button. Any voltage generated will be transferred to the plate and measured directly by the static meter in Volts.

To install the optional 6”x6” (152x152mm) plate, plug it into the 2 banana jacks on the detector plate. Make sure the plate is seated fully so that the ends of the banana plugs fit into the holes in the lower plate.

To measure induced electrostatic fields such as ionizer imbalance, first zero the meter as above then hold it in front of the ionizer or other field being measured and monitor the meter reading.

To utilize the Model 204 as an electrostatic fieldmeter, remove the Charged Plate Detector by pulling down on the tab to unsnap it from the ground snap and then slide it forward. Turn on the POWER, depress the green ZERO/RESET push button for approximately 1 second to zero the meter. If a reading other than 000±2 is indicated, zero the meter using the ZERO control. If an offset is required adjust the ZERO control at this time. **CAUTION: When zeroing the meter make sure it is pointing away from any electrostatic fields. Covering the front of the meter with the hand will shield the input from any fields present.**

Bring the Meter towards the surface being measured. At a distance of 1” (25mm), read the magnitude and polarity. Multiply the reading on the DPM by 10 to obtain the actual voltage being measured. (The meter is permanently set to read 2000V full scale for the CPM mode.) All measurements are normally referenced to the potential of the user who may or may not be at ground. To obtain a solid ground reference, connect the Analyzer to ground using the coiled cord provided.

To return the Model 204 to the charged plate analyzer function, install the Charged Plate detector by sliding it over the front of the unit and snapping it onto the ¼” (6mm) snap located on the bottom of the instrument.

4.0 TEST PROCEDURES

The Model 2004 Test Kit is capable of performing many tests normally performed with laboratory grade equipment. The following describes recommended procedures for performing the most common CPM tests. Specific J1645 test procedures are detailed in Appendix B.

4.1 Static Dissipation of Fuel system Components per SAE J1645

This test is described in detail along with pictures of the specific system hook-up in Appendix B. It is similar to the measurement of dissipation time of material and objects described in Section 4.5 below.

4.2 Ionizer Balance

This test is performed with either the Charged Plate detector attached or with the addition of the optional 6”x6” (152x152mm) detector plate. Turn on the ionizer. Hold the Analyzer approximately 12“ (305mm) in front of the ionizer. Momentarily ground the detector plate by touching it with a finger or a grounded lead. Make sure the DPM reads zero. Observe the meter reading for approximately 15 seconds. The meter should typically read less than ±30 Volts or whatever maximum balance limit is specified.

4.3 Static Propensity

This test is the measurement of static charge build-up on personnel walking across a floor or performing a defined step test. It is used to evaluate flooring and footwear. However, this test procedure also applies to any activity that results in a static charge being generated.

The test set up consists of the Model 204 with the Detector attached. Connect either a wrist strap or a cable with probe. The test subject puts on the wrist strap or grasps the probe. The tripod can be used to hold the instrument.

Before starting the test, both the test subject and meter should be momentarily grounded. The voltage displayed on the meter will be the voltage generated by the test subject during the activity.

4.4 Triboelectric Charge Analysis

This test uses the Charged Plate Detector plus the 6”x6” (152x152mm) detector plate. The assembly is mounted onto the tripod with the plate in the horizontal position. Momentarily ground the detector plate. Take the material being tested and rub it with an appropriate second material. Place the test material on the detector plate. The voltage measured is a relative indication of the antistatic characteristics of the material.

The test procedure can also be used to measure the build-up of static charge on material, objects, liquids and powders in motion by connecting the appropriate probes or test leads from the object or isolated detector (for powders and liquids in a contained environment) to the detector plate.

4.5 Static Dissipation of Material and Objects

The built-in timer is activated only when the CHARGE button is depressed and then it only measures dissipation time from 1000 to 100V up to 6 seconds. For measurements that do not require the application of

voltage (Triboelectrically charged material, for example), having voltage levels less than 1000V or having dissipation times greater than 6 seconds the timer cannot be used. An external timing device such as an oscilloscope or chart recorder connected to the RECORDER output or a stopwatch will be required.

If the decay time is less than 6 seconds and the sample can be conductively charged by the charging source then the internal timer can be used.

If longer decay times are required (>6 sec.) then the standard 60 second version with 0.3 second resolution should be used.

To measure the decay time of the sample, after being grounded is desired first place the charged sample on the detector plate, **then connect a ground lead to the sample, NOT TO THE PLATE.**

To measure the decay time of a sample that is either conductive or dissipative, place it on the detector plate. Charge it by depressing the CHARGE button and holding it for several seconds to ensure the sample is charged to the full voltage. Connect a ground lead to the sample. The Analyzer will measure the time for the detector plate and sample to dissipate its charge.

Another dissipation test is to charge the detector plate and then place a grounded sample on the plate and measure the time for the plate to dissipate its charge through the sample.

4.6 Charge Neutralization Time

This test measures the time for an ionizer to neutralize a charge on an object. It is also referred to as "Discharge Time". This test can be performed with either the standard detector or with the optional 6”x6” (152x152mm) plate.

Turn on the ionizer and allow it to run long enough to stabilize. Hold the Analyzer 12” (305mm) or other specified distance away from the front of the ionizer. Momentarily ground the detector plate then depress either the + or – CHARGE button. The red LED indicator will light and the plate will charge up to approximately 1150 Volts. Release the CHARGE button. The ionizer will immediately start to neutralize the charge on the plate. When the charge drops to 1000V the built-in timer starts and the unit will start measuring the time for the charge on the plate to bleed down to 100V. When the voltage on the plate reaches 100V the meter switches over from reading voltage to reading time as indicated by the yellow “TIME-SEC” LED. Depressing the ZERO/RESET pushbutton grounds the detector plate and resets the timer.

4.7 Static Dissipation of Personnel

This test measures the time it takes a charged person to bleed off the charge when a static control procedure is implemented such as stepping

onto a conductive floor or sitting down in a conductive chair. The test subject is connected to the detector plate using a wrist strap or a probe assembly plugged into the front of the detector plate.

Momentarily ground the detector plate and test subject. Depress the CHARGE button to charge both plate and test subject. The meter should indicate a reading of approximately 1150V. The test subject must be standing on an insulated surface during charging. The test subject should then immediately step onto the surface being evaluated. The Analyzer will measure the time for the voltage on the test subject to bleed down to 100V.

5.0 Calibration

The Model 204 is a complex instrument. It is recommended that it be calibrated at the factory.

However, the customer can check the voltage reading calibration by applying a known voltage, such as 500 or 1000V directly to the detector plate and compare it with the meter reading. If out of tolerance, the Charged Plate Detector Assembly can be moved slightly in to increase or out to decrease the meter reading.

6.0 MAINTENANCE

The Model 204 Charged Plate Analyzer and the respective kits contain both electronic instruments (Charged Plate Analyzer and Humidity/Temperature/Dew Point Indicator) plus mechanical fixtures (Charged Plate Detector, 6”x6” [152x152mm] Detector Plate (optional) and tripod). As with all instrumentation, care should be exercised in handling and using the equipment. If not exposed to hostile environments, the mechanical fixtures should not require any maintenance. To clean the fixture, wipe with only isopropyl alcohol using a soft lint-free cloth and let air-dry.

DO NOT USE ANY OTHER TYPE CLEANER AS THIS WILL PRODUCE A LEAKAGE PATH TO THE ISOLATED CHARGED PLATE.

When used with reasonable care, the instruments should provide many years of trouble-free service. If either electronic unit fails to operate properly, first check the battery. The sensors, both static and humidity/temperature, should never be touched by a charged object or by personnel. Also, the sensors could be permanently damaged if the instruments are dropped.

Note:

The sensor used in the Model 204 is very sensitive to shock. Dropping the unit could result in permanent damage to the sensor and will require replacement.

To clean the conductive ABS plastic case, a damp cloth should be used. Do not use any solvents as these may react with the plastic and damage the case.

The Model 5646A Humidity/Temperature/Dew Point Indicator does not contain any user serviceable parts and must be returned to the factory for service or replacement.

7.0 SPECIFICATIONS

FIELDMETER/POWER SUPPLY

Sensor: Vibrating Reed
Range: ±20 kV @ 1" (25.4mm)
Display: 3 ½-Digit LCD
Resolution: 1V (10V as a Fieldmeter)
Accuracy: ±10% (Fieldmeter)
Linearity: ±10%
HVPS: ±1200V (approx)
Timer: 0-60 sec. (0-6 sec. optional)
Accuracy: 5% of Reading
Resolution: 0.3 sec. (0.03 sec.)
Rec. Out:
2.5 mm Jack
Signal: 10 mV/kV (200mV FS)
Power: 9V Battery
Life: 20 Hrs. typical.
Bat Low: All decimal pts. Illuminated

CHARGED PLATE DETECTOR

Capacitance: 20±3pf
Detector Plate: 1"x3" (2.5x7.6cm)
Plug-in option:.6"x6" (152x152mm)
Accuracy: ±20%
Ground:
Cord: 10' (3m)
Connection: ¼" (6mm) Male Snap

MECHANICAL

Dimensions: 8"Lx2.4"Wx0.9"H (203x146x229mm)
Weight: 9 oz. (255gm)
Case: Conductive

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8.0 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 that 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.

Appendix A

AUTORANGING RESISTANCE INDICATOR

MODEL 880

OPERATING INSTRUCTIONS

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1.0 GENERAL

The Model 880 Autoranging resistance Indicator, shown in Figure 1-1, is a **CE** certified, precision, easy to use instrument that incorporates features found only in more expensive units. Twelve (12) LEDs indicate the Conductive (Green), Static Dissipative (Yellow) and Insulative (Red) ranges in one (1) decade steps from $<10^3$ to $>10^{12}$ Ohms.

Figure 1-1: Model 880 Autoranging resistance Meter

Accuracy is ±10% of the mean value, with changeover points of ½ decade on a logarithmic scale.

Measurements in the Conductive range ($<5x10^5$ Ohms) are made at 10 Volts. All remaining measurements are made at 100 Volts.

The measurement electrodes, shown in Figure 1-2, consist of chrome-plated parallel bars 2.5" (62.5mm) long, spaced 1.56" (40mm) apart. The conversion to surface resistivity is 1.6, however, the measurement resolution of one decade enables the user to convert the indicated resistance in Ohms directly into surface resistivity in Ohms/sq.

Figure 1-2: Electrode configuration

Two auxiliary input banana jacks enable the user to plug in virtually any type of resistance measurement electrode having cables with standard 0.161” (4mm) banana plugs that converts the Model 880 to an independent wide range resistance indicator. When the auxiliary probe banana plug is inserted the built-in parallel bar electrodes are automatically disconnected. The supplied ground cable enables resistance-to-ground (RTG) measurements to be made by disconnecting one of the parallel bar electrodes and using the other parallel bar as the surface electrode for quick checks.

When testing to SAE J1645 the ETS Model 832 Clamp Electrodes are used and are included in the Model 2004 Kit. Refer to Appendix B for additional instructions for using the clamps.

Using the optional ETS Model 850, 5lb (2.27kg), 2.5” (63.5mm) diameter Surface Resistance Probe(s) standard RTG and point-to-point resistance measurements can be made. Volume resistance, seating resistance per ESDA STM12.1 or other resistance measurements using the appropriate electrode configuration can also be made with the Model 880.

The Model 880 Autoranging Resistance Indicator comes complete with RTG cable, 9 Volt battery and vinyl carry case.

2.1 OPERATION

2.1.1 Surface Resistance

The Model 880 is designed to measure samples having a flat surface at least 2.5”x1.75” (64x45mm). The sample being tested should be placed on an insulated surface (>10^{13} Ohms) to avoid parallel measurement paths, especially if the material has any bulk resistance.

Prior to making measurements first check the Indicator by holding it away from any surface and pressing the TEST button. The >10^{12} Red LED should light. Place the Model 880 on the surface to be measured, then depress and hold the TEST button for approximately 3-5 seconds. The illuminated LED indicates the surface resistance of the material in Ohms or Ohms/sq., if desired.

2.2 Resistance-to-Ground (RTG)

To measure the RTG of a table top, mat or flooring plug the RTG cable supplied into one of the auxiliary banana jacks. This will disconnect the corresponding bar electrode. Clip the cable to the common point ground and place the Indicator on the surface to be measured. The other bar electrode performs the function of a surface probe. Depress and hold the TEST button for approximately 3-5 seconds. The illuminated LED indicates the RTG in Ohms.

2.3 Other Resistance Measurements

Plug the appropriate electrodes into the auxiliary jacks. The bar electrodes will now be disconnected. Place the probe(s) on the surface being measured. Follow the above test procedure. The illuminated LED indicates the measurement resistance in Ohms.

For volume resistance, either a standard volume resistance probe and test bed can be used or just simply connect the RTG cable to a test bed and then place the sample on the test bed and the Model 880 on the sample. The resulting measurement is the volume resistance in Ohms. To obtain volume resistively, place the optional 2.5” (6.45cm) diameter conductive rubber electrode on top of the sample and the Model 880 on top of the electrode. The volume resistivity will be

$$\rho_v = A/t\ R_m$$
$$= 31.7/t\ R_m \quad \text{Ohms-cm}$$

Where A is the area of the electrode in cm^2 and t is the thickness of the sample in cm.

3.0 MAINTENANCE

The Model 880 operates from a standard 9 Volt battery. The momentary nature of the measurements allows for a very long battery life. When the LEDs appear dim and/or the measurements are unstable, change the battery.

Remove the four (4) Phillips head screws and carefully remove the bottom cover. Replace the battery and reinstall the cover.

To clean the instrument, wipe with a clean, damp cloth. Do not use any solvents as these make react with the plastic case and may damage it.

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Appendix B

CLAMP ELECTRODES

MODEL 832

Plus

SAE J1645 Measurements

Operating Instructions

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1.0 GENERAL DESCRIPTION

The Model 832 Clamp Electrode Assembly is designed to test tubes, valves and other planar and non-planar objects such as IC Shipping Tubes and Automotive Fuel Line components and assemblies in accordance with current and proposed industry specifications requiring resistance and/or static dissipation measurements. The probes feature a unique dual-pad design capable of measuring point-to-point, point-to-ground, volume resistance/resistivity and static dissipation. The Model 832 meets the electrode configuration specified for measuring the resistance of fuel line components and assemblies in accordance with SAE J1645 (versions dated 9/03 or later).

The electrodes are designed to be used with resistance meters having test voltages of 10 and 100 volts such as the ETS Models 880 and 871 (shown below) or the Models 8873 and 863-6487. When connected to the detector plate of a charged plate monitor such as the ETS Model 204 Charge Plated Analyzer, the electrodes enable the user to measure dissipation time from 1kV to 100 volts, in accordance with SAE J1645.

Model 880

Model 871

2.0 ELECTRODE DESCRIPTION

The Model 832 electrode assembly consists of one .25” square (6mm) and one .25”x.125” (6x3mm) conductive elastomer pads with volume resistivity of 0.08 ohm-cm and Shore-A hardness of 65 durometer. The pads are mounted to stainless steel electrodes that in turn are mounted to an insulated clamp exerting approximately 10 pounds (4.5kg) of force.

The smaller electrode is designed to be inserted up to 1” (25mm) into a .25” (6mm) diameter tube such as those used in standard fuel system fittings and tubing or a .125”x.125” (3x3mm) slot.

When measuring surface resistance the .25” (6mm) square pad is typically used. When measuring volume resistance both pads are used. Volume resistively in Ω-cm, if required, is calculated using the area of the smaller pad, (0.18 sq. cm).

Standard .162” (4mm) banana jacks are located at the end of each handle. The BLACK jack is connected to the .25” sq. (6mm) electrode and the RED jack is connected to the .25x.125” (6x3mm) electrode. Red and Black cables 30” (762mm) long, terminated with banana plugs are supplied with each pair of Electrodes. Standard cables with banana plugs supplied with most resistance meters are also satisfactory for the resistance measurements. NOTE: For static dissipation measurements, the supplied cables should be used because the higher insulation resistance of these cables will reduce secondary leakage paths.

3.0 USING THE ELECTRODES

3.1 Material Characteristics

Loaded, thermoformed plastics consist of plastic resin filler with very high resistance properties loaded with a small percentage of a conductive material such as stainless steel fibers, carbon powder or fibers. When molded, these parts exhibit either conductive or static dissipative properties as defined in the ESD Association 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 in turn requires a higher voltage to break down the increased dielectric. At some point, once a higher voltage is applied to establish continuity the resistance of the path created may become altered permanently. Loaded thermoplastic materials are effective in reducing the upper resistance limit to approximately 10^8 Ohms.

Another characteristic associated with loaded thermoplastic materials that affects resistance measurements 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.

In essence, these materials are non-linear and voltage dependent. Hence, different test voltages will give different results. Even the series resistor incorporated in virtually all resistance meters are different from meter to meter which will cause variations in the measurements. Loaded thermoelectric material is generally not adversely affected by humidity, as

long as it is reasonable such as less than 75% R.H. Currently, ESD materials are classified as follows:

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

* The above ranges are resistance in ohms (Ω) not resistivity in Ohms/sq (Ω/sq).

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.

$$\rho_v = A/t\ R_m\ \ \Omega\text{-cm}$$

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 for 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 volume resistance or resistivity is most appropriate to classify a bulk conductive material it is the measured resistance across or through the affected surface to ground that is used to determine the ability of material to dissipate a static charge.

While the resistance classifications were developed for ESD packaging materials, most specifications referencing resistance/resistivity for materials used in hazardous locations usually specify resistance limits that fall within the Conductive range.

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

3.2 Measuring Resistance

Prior to use, the calibration of the test apparatus should be checked. Plug the cables from the resistance meter into the BLACK banana jacks of the Model 832. Clamp the electrodes across a 1 kohm and a 10 megohm, 1% resistors. Measure the resistance using both 10 and 100 volts. The resistors are not included with the clamp electrodes.

Whenever the electrostatic characteristics of materials are measured the temperature and relative humidity at the time of measurement should be recorded. Many materials are humidity dependent. Measurements taken

at different RH levels may result in a significant variation in the measurements.

The following recommended test procedure was developed for testing automotive fuel system components and assemblies. The same procedure can also be applied to just about any desired point-point, point-ground and volume resistance measurement.

1. Place the component or assembly being measured on a surface having a surface resistance at least two orders of magnitude higher than the upper resistance limit (>1x10^9 Ohms).

2. Verify the test set up by clamping the electrodes to a 1 kohm and a 10 Megohm, 1% resistor and measure at both 10 and 100 Volts.

3 For surface measurements, both clamps are required. Clamp both Clamp Electrodes on to the surface with the .25" sq. (6mm) contacts spaced apart at a desired distance on the surface to be measured. If the area is too small then use the smaller contact. For tubing place the .25"x.125" (6x3mm) contact inside the tube.

   In all cases, make sure the contact electrode sits flat and makes maximum surface contact with the part.

   If the part has a metal ground strap take measurements at both the point on the plastic part where the ground strap is attached and at the point on the strap where the strap is connected to the ground point.

   If using the .25" (6mm) contacts then connect the resistance meter to the BLACK jack on each Electrode. If using the .125" (6x3mm) contacts connect the resistance meter to the RED jacks.

4. If the resistance meter being used allows manual selection of the test voltage, select 10 Volts.

   Apply the voltage for 5 seconds or until a consistent reading is obtained, then take and record the reading. If the reading is unstable, record the reading as "unstable".

   Select 100 Volts. Apply as above and record the reading.

   The lower the measured resistance, the smaller the differential between the 10 and 100 Volt readings should be.

   In most cases a product is considered acceptable if either the 10 Volt or the 100 Volt resistance reading is within the specified limits.

   Note: A measured resistance may be unstable at 10 Volts, but stable and within the specified limit at 100 Volts. On the other hand, the resistance may be below the measurement capability of the instrument at 100 Volts. It is also possible the resistance is below the measurement capability of the instrument at 10 Volts. In

either case, record that the measured resistance is less than the measurement capability of the instrument (ex: $<10^3$ Ohms). The part would be considered acceptable. *If actual low resistance measurements are required then use appropriate instrumentation and test voltage to obtain the reading.*

5. To measure volume resistance, connect the resistance meter to both the BLACK and RED jacks of a single Clamp Electrode and clamp it to the part to be measured. Follow the measurement procedure above. To calculate volume resistively, multiply the measured resistance by the area of the small contact divided by the thickness of the material in cm (refer to Section 3.1).

3.3 Static Dissipation

This test measures the ability of a material or assembly to dissipate a charge using the measured resistance path.

1. Prepare the samples to be tested in the same manner as for measuring resistance.
2. Verify the test set up by measuring the dissipation time for a 10 megohm, 1% resistor. Connect the desired contact electrode to the Charge Plate Monitor detector plate and the resistor as shown in Figure 3-1. Connect the other electrode to ground such as the ground connection at the wall outlet. If a battery powered CPM is used, make sure it is also connected to ground. Leave the grounding clamp unconnected

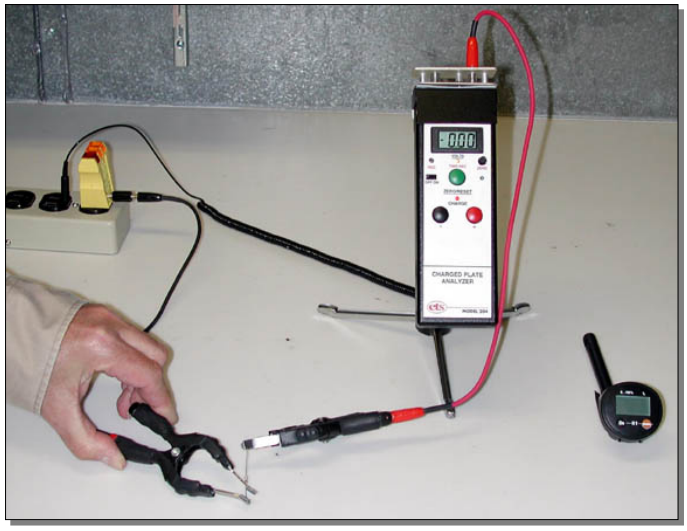

Figure 3-1: System verification test set up

Set the measurement parameters for a 1000 Volt charge. **NOTE:** The actual charging voltage is approximately 1100-1200 Volts or more, but the decay time measurement starts when the voltage on the part reaches 1000 Volts and stops at the 10% (100 Volt) cut off. Apply the charging voltage for approximately 2 seconds. Release the Charge button and quickly connect the grounded

electrode to the resistor. Repeat the measurement 3 times. Record the dissipation times. All readings should be ≤0.20 seconds or the minimum capability of the CPM.

If the instrumentation includes a grounding relay module then connect the green wire to the wall outlet and plug the cable **from** the grounding electrode into the module and clamp the electrode to the other resistor lead. Charge the system as above then depress the “GROUND” pushbutton and record the reading. All readings should be ≤0.20 seconds.

NOTE: Do not use the grounding function of the CPM to perform this test. This function only grounds the detector plate.

3. Connect the electrodes to the sample part as shown in Figure 3-2 or to the assembly as shown in Figure 3-3. Place the assembly on a highly insulative surface (>10^{12} Ohms/sq.) such as acrylic, Teflon™, polycarbonate etc. to ensure there is no secondary leakage path for the applied charging voltage to bleed off.

Figure 3-2: Test set up with grounding module

Figure 3-3: Assembly test set up with grounding module

4. Apply the charging voltage for approximately 2 seconds. Immediately ground the assembly by clamping the grounded electrode to the desired point. Repeat the measurement 3 times and record the results.

4.0 TEST RESULTS

The above test procedures were used to measure the resistance of automotive fuel system components and assemblies, and static dissipation of assemblies. Two different test instruments were used for each procedure. The results are as follows:

Part	Resistance-Ohms				Dissipation	
	Dr. Thiedig Milli-TO-2		ETS 872	EA3	ETS 204	
	@10V	@100V	@10V	@100V	Sec	Sec
10 Meg Resistor	1.0 Meg	9.96 Meg	9.9 Meg	1.0 Meg	0.13*	0.5*
Fuel Filter Assy.						
Hose-Hose (L)	5.0 Meg	1.6 Meg	4.7 Meg	2.0 Meg	0.13	0.5
Hose-Gnd Pt.	1.1 Meg	<1 Meg	330 Kilo	180 Kilo	0.13	0.5
Hose-Gnd Strap	2.2 Gig	8.1 Meg	1.9 Gig	25 Meg	0.13	0.5
Fuel Filter	140 Meg	22 Meg	23 Meg	3.5 Meg	0.13	0.5
Turn Electrodes 90°			24 Kilo	120 Kilo		
Hose w/Conn.	>1 Gig		>1 Terra	>1 Terra	>1 Terra	
10” Coated Tube	>1 Gig		>1 Terra	>1 Terra		
Elbow Conn.	<1 Kilo		<1 Meg	180	<10 Kilo	
Test Strips						
PPS-1	1.1 Kilo		<1 Meg	2.2 Kilo	<10 Kilo	
PPS-2	<1 Kilo		<1 Meg	4.2 Kilo	<10 Kilo	
PPS-3	<1 Kilo		<1 Meg	8.0 Kilo	<10 Kilo	
POM-1	1.4 Gig u/s**		1.1 Meg	310 Meg	13 Meg	
POM-2	23 Meg u/s		420 Kilo	2.8 Gig	13 Meg	
POM-3	5.5 Meg u/s		<1 Meg	350 Kilo u/s	<10 Meg	
POM-4	680 Meg u/s		7.4 Meg	2.5 Gig	60 Meg	

Notes:

* Dissipation times are the fastest times each CPM can measure
** u/s denotes an unstable resistance measurement
Kilo = 10^3
Meg = 10^6
Gig = 10^9
Terra = 10^{12}

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