

OHM-STAT[®] RT-1000

OWNERS MANUAL & OPERATION GUIDE

**RESISTIVITY, RESISTANCE, ELECTRICAL GROUND, RTT, RTG,
VOLUME RESISTANCE, TEMPERATURE, HUMIDITY METER.**

**WILL TEST MATERIALS, CHAIRS, SMOCKS FOR ELECTRICAL
PROPERTIES ACCORDING TO EOS 20/20 SPECIFICATIONS.**



SERIAL NUMBER: _____

COMPANY _____

Price: \$25.00 USD

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TABLE OF CONTENTS

Contents	Page.
Cover	
Table of contents	
Test Procedures	1
Features- Operations - Surface Resistivity	2
Concentric ring- surface resistance	3
Surface to ground- calibration	4
Specifications	5
Warranty	6.
Questions and answers	7-10
Calibration Procedure	11
ANSI/ESD S20.20-1999	12-29
ESD - STM 12.1 - 1997	30-38
ESD - S2.01 - 1995	39-51
RT 1000 Accessories	52-53



Static Solutions, Inc.

Ohm-Stat RT-1000 Megohmmeter Meter Test Kit Contents:

- 1 Ohm-Stat RT-1000 Resistance-Resistivity-Humidity-Temperature Meter
- 1 Blow Molded, Foam Lined Travel Case
- 1 Concentric Ring Probe. (Optional)
- 2 5 lb. 2.5 inch Diameter Test probes.
- 1 Chair Probe
- 2 Smock Probes
- 2 Coil cords. 6 foot Test Grounding Leads.
- 1 Grounding Cord and Clip
- 1 9-volt battery
- 1 Ground Test Adapter
- 1 Product Instruction Bulletin
- 1 AC Power Adapter- positive center, 120-volt input, and 9-12 volt 200 mA output.

Miniature, 220 volts adapter, hand and floor probes are available as options.

As with all high quality test equipment proper storage and correct use of the Ohm-Stat RT-1000 is required.

CAUTION: Because the AC power adapter will charge the battery, **ONLY USE** a rechargeable battery when operating the AC adapter with the meter.

Static Solutions Inc.

Ohm- Stat RT-1000

Digital Resistivity/Resistance/Temperature/Humidity Meter

Description:

The Ohm-Stat™ RT-1000 Resistance, resistivity, temperature, humidity Test kit is easy to operate, compact, lightweight, portable meter designed to measure temperature, humidity and electrical resistivity/resistance. Using both internal and external test probes, the meter will measure resistivity, resistance to ground, resistance between two points according to EOS/ ESD association standards- S4.1, S6.1, S7.1, S11.11 and European standard CECC-EN 1000/15. With the accessory probes the meter can test the electrical circuitry of the building, ESD chairs, and smocks. Additional probes are available to measure heel straps, wrist straps, and small parts using miniature probes, and a concentric ring probe.

Test Procedures

Specific industries, which require accurate measurements, will dictate the correct test procedures. The procedure outlined in the Product Test Bulletin is specifically used in the electronics industry where the EOS/ESD and CECC procedures predominate. It is recommended that the other industry procedures may be more appropriate for your industry. These include UL, ASTM, specifications such as MIL-HDBK-263, EIA-1S-5-A, ASTM D-257, and ASTM F-150. Failure to measure relative humidity and temperature at the time of testing is in non-compliance with ANSI/ESD-S7.1.



Figure 1
*Ohm-Stat RT-1000
Megohmmeter*

All materials must be tested on an insulated surface to avoid misleading measurements. This is especially true with non-homogeneous and multiplayer materials. It is possible to actually measure down through the dissipative surface layer and then along the inner conductive layer and back up through the dissipative layer. This is why it is technically not correct to include a surface resistivity layer measurement value for two layer materials. Always measure material thickness when measuring electrical properties because thickness, temperature, and relative humidity can and will affect the resistance/resistivity readings.

Ohm-Stat™ RT-1000 METER DESIGN FEATURES

A Test Button- The round black button will turn on the power. When depressed and held down with reasonable force the resistance/resistivity, humidity, and temperature values are displayed on the screen for approximately 30 seconds. HOLD THE BUTTON DOWN UNTIL THE VALUES ARE DISPLAYED. At the completion of the test the power will turn off automatically.

B Selector Switch- The switch selects the desired applied test voltage of either 10 or 100 volts.

10 volts should be used between 1×10^3 - 9.9×10^5 ohms. You can over ride the range by selecting the 10 or 100 volt switch per EOS standards.

100 volts should be used to measure between 1×10^6 - 1×10^{13} ohms per EOS standards.

If the battery is too low to give accurate readings the LCD will display "Low Battery"

If the resistivity is below 10^3 ohms/sq., the LCD will Display "less than 1K".

If the reading is over 10^{12} ohms/sq. the LCD will display "more than 2×10^{12} ."

If the reading is over 10^6 ohms/sq. the LCD will display "change to 100 volt setting" if the setting is set on 10 volts. If the reading is under 10^6 ohms/sq. the LCD will display "change to 10 volts" if the meter voltage switch is set on 100 volts.

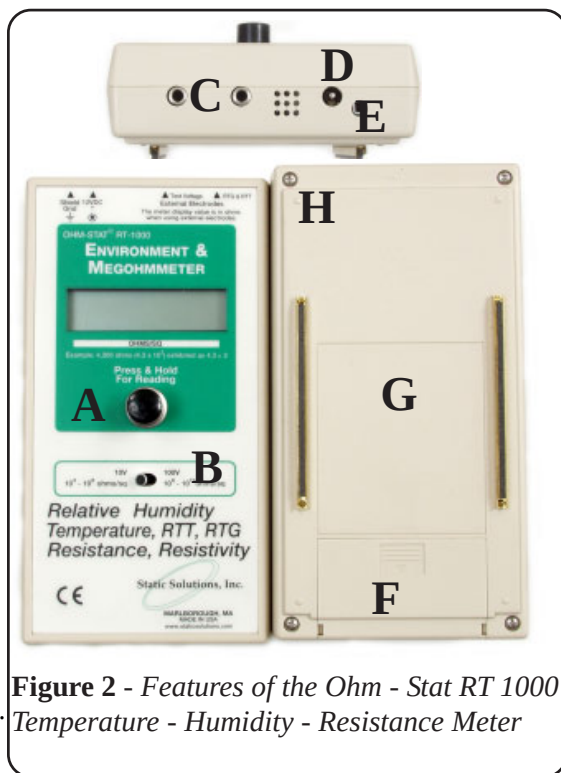


Figure 2 - Features of the Ohm - Stat RT 1000 Temperature - Humidity - Resistance Meter

C External Test Jacks- The external 3.5 mm monaural jacks on the top right of the meter are used to attach the two coil cords to the 2.5 inch-5 lb. probes. These probes are used to test resistance and RTT and RTG. When the 3.5 mm plugs are inserted into the jacks the parallel resistivity probes on the bottom of the meter are deactivated. Insert the banana plug end of the cords into the 5 lb, 2.5 inch probes.

D AC Power Adapter- This plug allows the meter to be used with a center positive 9-12 volts 200 mA output power adapter. The input may be either 110 volts or 220 volts AC.

E Ground Shield Jack- Because of the possibility of 60 cycles electrical noise and possible interference caused by the two external coil cords acting like antennae the straight wire ground cord is supplied. This shield ground jack is located on the top left on the meter. This interference occurs at the higher resistance values 10^{10} - 10^{12} ohms.

F Battery Compartment- This compartment houses a 9 volt battery which must be installed prior to use. Use a 9 volt alkaline battery for long life. Do not use the alkaline battery if the power battery is used. If the power adapter is used a rechargeable battery is recommended.

G Parallel Test Probes- These probes located on the bottom of the meter are used to measure surface resistivity in ohms/sq. units. These probes are made from a highly conductive, low durometer elastomer. Care should be taken to avoid harsh solvents and extreme abrasion. Occasional cleaning with a mild soap and water solution will extend the life of the probe feet. If damage does occur, these probes are replaceable for a nominal charge. The probes are fabricated with an internal and external brass rails.

H Case- The meter case is molded from a high impact ABS polymer. Simple cleaning with a mild soap and water solution will remove all dirt and debris.

Operation:

Prior to testing, ensure that surfaces to be tested are clean and free of contaminants.

Surface Resistivity:

Parallel Probe Resistivity Method

The parallel resistivity probe method, complies with ASTM D-257. It is used to give fast electrical resistivity measurements on flat homogeneous materials. It may be used on multiplayer materials, but this should be noted along with the temperature and humidity values on the data report.

- A.** Place the meter on the desired surface to be tested.
- A.** Move switch to the desired test voltage position, either 10 or 100 volts.
- B.** Press and hold down the test power button until the resistance/resistivity and temperature and humidity values appears on the LCD screen. This will occur in about 15-20 seconds as specified in ANSI/ESD standards.

Concentric Ring Probe Resistivity Method (Optional test probe accessory)

Insert both coil cords using the monaural plugs into the 3.5 mm meter jacks on the top right of the RT-1000 meter. Attach the banana plug coil cord terminations into the concentric ring probe. Place the probe onto the surface to be tested. Press the test button and wait until the values appear in approximately 15-20 seconds. The correct temperature, humidity, and resistivity will be displayed on the LCD screen. The resistivity value displayed **MUST** be multiplied by a factor of 10 to achieve the correct test value. These values will read in ohms/sq. e.g. 3.5×10^4 ohms/sq. (displayed value.) The actual resistivity value will be 3.5×10^5 ohms/sq.



Figure 3 - Concentric Ring Probe

Surface Resistance Measurements (RTT)

This procedure which complies with EOS/ESD-S4.1 measures resistance between two points independent of a groundable point. Procedures vary regarding sample preparation, probe preparation, and spacing of the 5 pound probes.

- A. Connect the monaural plug ends of the test leads into the 3.5 mm jacks of the meter. Connect the banana plug ends of the test coil cords into the 5 pound, 2.5 inch diameter probes.
- B. Place both probes on the material according to the ANSI EOS/ESD test procedures.
- C. Select the correct test voltage position. Over 1×10^6 ohms use 100 volts. Under 1×10^6 ohms use 10 volts. The meter will inform you on the LCD for incorrect voltage positions.
- A. Press and hold the test button until power is applied to the meter and a resistance, humidity, temperature value is displayed on the LCD screen. This may take 20-30 seconds. When the button is released the displayed value will remain on the screen automatically for 20-30 seconds with no battery drain. At high resistance values and to minimize line current interference the use of the enclosed shield ground cord is recommended.



Figure 4 - Ohm - Stat RT-1000 Point to Point (RTT) test.

Surface-To-Ground Measurements (RTG)

This procedure measures the surface resistance between a ground point on the material surface and specific positions on the material being tested. This procedure complies with the EOS/ESD S4.1 test standard.

- A. **Meter setup.** With both test leads connected to the meter attach the alligator clip to one banana plug and the other end to the 2.5 inch, 5 pound weight probe.
- B. Attach the alligator clip to a known electrical ground such as a ground snap on the mat or the electrical ground of the building. Position the probe on the surface to be tested in accordance with the desired test procedure.
- C. Press the test button until the resistivity, humidity, and temperature test values are displayed on the LCD screen. These readings will conform to: EIA, EOS/ESD, ANSI, IEC-93, CECC, and ASTM test procedures. When performing tests, especially with higher resistance materials, be sure the test lead wires do not touch each other or overlap and that your hands are not in contact with the probes or wires during the actual touching of the materials. This will ensure accurate readings and prevent interference cross talk.



Figure 5 Ohm Stat - RT 1000 Point to ground (RTG) test

Calibration and Maintenance

The **Ohm-Stat™ RT-1000** requires no service or maintenance except for an occasional cleaning of the rubber on the internal and external test probes. A mild soap and water solution will remove dirt or other harmful contaminants from both the rubber probes and the meter case. Harsher solvents will affect the rubber probes and therefore should not be used. When the meter is not used for an extended period of time remove the battery and the coil cords to prevent damage due to battery leakage and probe jack damage. Do not use a alkaline 9 volt battery with the AC/DC power converter. If a power converter is used a re-chargeable battery is recommended.

The **Ohm-Stat RT-1000** is calibrated to NIST traceable standards at the factory. The calibration is done by using NIST traceable 1% resistors, hygrometer and thermometer. This method assures many years of long life and accurate readings. Attaching 1% resistors to the probes will verify this accuracy.

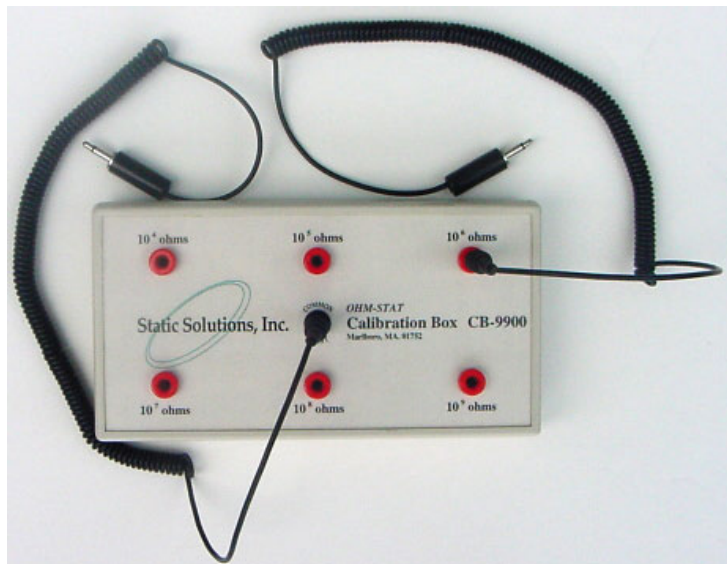


Figure 6 Ohm Stat CB - 9900 Calibration box

Resistivity Test Ranges

1 X 10^3 – 9 X 10^6 ohms @ 10 volts
 1 X 10^6 – 9 X 10^{12} ohms @ 100 volts

Power- Battery Supply

A 9 volt battery is supplied. If a rechargeable battery is used, the recharging can be done inside the meter.

The 12 volt power supply is both a adapter and a recharging device. With a 9 volt alkaline battery the expected life is approximately 30 hours or 5000 twenty second measurements.

Using an adapter not designed for this meter may cause serious damage negating the warranty on the meter. Only a 110 volt DC, center positive 200 mA adapter is recommended.

A low battery indicator will alert the user to replace a weak battery.

If a weak battery is not replaced the meter may continue to give test readings, but these readings should not be considered accurate.

Operating Conditions :

32°F-100°F (0°C-38°C)

Display:

Two inline, thirty two .20" characters are alpha numeric. The LCD displays all test results simultaneously.

Meter Weight :

10.2 oz. (289 mg.). Meter and battery only.

12 lbs. (5.476 kg.) including meter, adapter, probes, leads, and case.

Dimensions :

7.50 inch (19.05 cm) L
 4.00 inch (10.16 cm) W
 1.5 inch (3.81 cm) H.

Probes:

Two 2.87 inch (7.2 cm) long parallel, conductive rubber re-placeable probes on the bottom of the meter case. They conform to ASTM, ANSI, and CECC standards.

Two 5 pound (2.27 kg.), 2.5 inch (6.4 cm) diameter, conductive Shore A 50-60 durometer external rubber external probes-enclosed.

Two smock clip test probes- are enclosed

One 8 inch X 12 inch stainless steel probe to be used to test chairs and shoes are enclosed

One ground tester to check on the electrical ground is enclosed

OPTIONAL ACCESSORIES.

One 5 pound concentric ring probe conforming to EOS/ESD, ANSI and CECC standards.

One 2 inch diameter, 6 inch long, dual probe to be used to test the electrical resistance of shoes and wrist strap readings.

One miniature resistance probe.

Current Limit:

1 milliamp DC current for 10 volts

0.1 milliamp DC current for 100 volts.

Accuracy:

10^3 – 10^8 ohms +/-10%

10^9 - 10^{10} ohms +/-15%

10^{11} - 10^{12} ohms +/-25%

Zero:

Automatic zeroing.

Power Switch :

Momentary on, press button
 Automatic zeroing

Operating Conditions :

32°F-100°F (0°C-38°C)



Figure 8 Powered by AC (110 Volts or 220 Volts) or 9 volt battery

Warranty Exclusion:

The foregoing express warranty is made in lieu of other product warranties express and implied, including merchantability and fitness for a particular purpose which are specifically or directly disclaimed.

The express warranty will not apply to defects or damage due to neglect misuse, accidents, altercations, operator failure to properly maintain, follow instructions, or failure to clean or repair products.

Limit of Warranty:

In no event will Static Solutions, Inc. or seller be responsible or liable for special, incidental or consequential losses or damages, whether based on tort, contract, or the use or inability to use the product.

Before using, the product users shall determine the suitability of the product for their intended use. The users assume all risk and liability whatsoever in connection therewith.

Fulfillment of Static Solutions, Inc.'s warranty obligations will be the customer's exclusive remedy and Static Solutions, Inc. and seller's limit of liability for any breach of warranty or otherwise.

Any questions regarding these procedures or other questions should be directed to our Engineering staff or customer service representative by calling 508.480.0700. Static Solutions Inc. Static Solutions Inc. 331 Boston Post Road-East Marlboro. MA. 01752.

RT-1000 Question and Answers

1. Why is it important to measure temperature and humidity ?

Answer- The humidity and temperature affect the electrical properties of the material being tested. The combination of low humidity and low temperature will give the highest electrical resistance results or slowest dissipation times. At high humidity a thin layer of water is condensed or absorbed on or in the material being tested. This is true of hygroscopic additives added to a material to increase the electrical conductivity which is moisture absorbable. At elevated temperatures the mobility of free electrons is increased thereby increasing the materials conductivity. This is especially true for carbon black, metallic oxides, metals, and other materials added to a material which must be mobile or in close proximity. When the material is at a lower temperature built in stresses occur which might increase the resistance due to increased distance between the conductive additives. Thus, humidity and temperature must be known. It is possible to test or manufacture a material at high humidities and pass all the test specifications. But, when the customer receives the material and uses it at a lower humidities, or temperature the material fails to pass the specifications. Thus, causing rejects and loss of product. Another reason why one must measure and record this data is that ANSI/ESD Association and European CECC recognizes the environmental affects and specifies in their standards that they measured and recorded.

For example both ESD S4.1 ESD Protective Worksurfaces section 6.2.4 and ESD S7.1-1994 Resistive Characterization of Materials Floor Materials sections 5.2.4 and 5.3.3 "Also report temperature and relative humidity at the time of testing". ANSI/ESD/S11.11-1993 Surface resistance measurement of Static Dissipative Planar Materials section 11.0 B. "report the conditioning period, relative humidity, and temperature."

All parties must test and record the data using the same parameters in order to avoid problems. The manufacturer, distributor, sales person, and customer must understand the environmental humidity and temperature parameters in order to not accept out of specification materials or reject in specification materials. Both of these situations will cost money to rectify.

2. Why and when do you test at either 10 volts or 100 volts ?

Answer: In previous years people desiring to measure resistivity or resistance had to follow either the ASTM- D 264, ASTM- 991, or NFPA 56A or NFPA 99. In these procedures people had to test at either 500 or 1000 volts. This caused concern regarding safety to the person doing the tests. People wanting a smaller low cost meter measured the surface at 9 volts. 9 volts WILL NOT give the accuracy that you need to perform the tests. In addition a 9 volt meter does not conform to EOS and 20/20 specifications.. At 9 volts it is impossible to achieve accuracy at values higher than 10^7 ohms. These specifications require to measure both the humidity and temperature. What resulted was confusion. Everybody was doing their own tests. Finally the ESD Association got together to standardize the test procedures with all the organizations.

What was decided was at values higher than 10^6 ohms/square one must test at a constant 100 volts. At values lower than 10^6 ohms/sq. one must use 10 volts. This is explained in ANSI/ESD standards -S4.1, S7.1 and S11.11

3. Why is an alpha-numeric superior than an analog or LED display ?

Answer: Have you ever tried to interpret a value on an analog scale at high values, especially if your age is over 50 years old and need glasses. It is very difficult to see and read !! The problem with LED displays are that it is difficult to determine where you are on a specific decade. The advantage of a digital alpha-numeric display is that you can observe and track trends of a material over time and it is easy to read and interpret.

4. With the meter can you use rechargeable batteries ?

Answer: Yes, the adapter is both a converter and a in meter re-charger. It is recommended to use only a rechargeable battery with the power supply and do not use the power supply when using a conventional alkaline battery. It might cause leakage .

5. Can you use the meter without the external probes ?

Answer: Yes. The meter can be used with the built in parallel probes attached at the bottom the meter. This resistivity reading is in ohms/square. This is a fast and quick way to measure the surface resistivity. This is a good simulation of the ASTM D-257 test method with the meter power switch activated at a force of 5 pounds of pressure onto the built in parallel probes. Always remove the coil cords from the meter when not using the external probes or when you use the bottom parallel resistivity probes. Because there is no such thing as surface resistivity of two layer materials one can do a quick test for immediate evaluations.

6. When the button is released and the value continues to display will this wear down the battery ?

Answer: No. Once the button is released the display is saved by a capacitor on the screen for a short time. No additional power is used.

7. Is the meter manufactured in America, England or the Far East ?

Answer: The correct answer is America. Pride, quality, and quick delivery.

8. If I take consecutive readings do I have to re-zero the meter.

Answer: No. The meter is auto zeroing. There is no need to rezero.

9. What is RTT, RTG, volume resistance, resistivity ,concentric ring and bottom of meter parallel resistivity probes.) ?

Answer: RTT is resistance between two points. The values are in ohms. The procedure must conform to EOS specifications. The humidity and temperature must be recorded. RTG is resistance between ground and one point. The ground can be the common point ground which is on the mat or another common ground connected to the wrist straps. Resistance is a better way to determine if the product will work in actual usage, by actually duplicating the dissipation of static electricity from the worker or product to the earth ground. Resistance, either surface or volume is a better incoming quality control test since most of the products being tested is two layers and resistivity does not relate to two layer mat products. In a two layer mat material the path to ground goes from the surface down to the conductive layer across then up through the dissipative layer.

Volume resistance tests through the material layers –from the top through the bottom layer.

Resistivity is measured in ohms/square. The test area is usually a small square. The parallel probes on the bottom measures ohms/square. The concentric ring or guarded electrode does the same but it avoids stray readings around the ends of the probes and measure inside the two rings. To calculate the resistivity from resistance multiply the resistance measurements by 10. The conversion factor of 10 is derived from the geometry of the electrode assembly.

10. When is the concentric ring electrode used to measure the resistivity values.

Answer: Because there was a possibility of the applied voltage (either 10 or 100 volts) going around the parallel probes and giving an incorrect answer a concentric ring probe was developed and explained in EOS/ESD-S11.11-1993 part 6.1.2. When the concentric ring probe is used a multiplying factor of 10 must be used. Thus, one takes the reading in ohms (resistance) and multiply by 10 in order to derive the desired correct answer in ohms/square. (resistivity).

Resistivity is usually performed as a quick quality control measurement for smaller dimensions. Special miniature probes are available for really small limited space dimensions..

11. When the battery gets low can I still use the meter ?

Answer: Yes. The meter will display “low battery” if the battery gets low in power. But even in this situation the meter will still perform and will still display accurate results. The meter has incorporated a “cut-out” level in which the meter will stop functioning completely when the power level gets too low to maintain a constant 10 or 100 volts output. Yes, there will be power left in the battery due to a regulator to maintain this correct level.

12. If I measure high resistance materials will the applied voltage drop below 100 volts ?

Answer: No ! We are using a voltage converter which maintains constant 100 or 10 volts voltage over the complete resistance range. The EOS 20/20 specification says when measuring under 10^6 ohms use 10 volts and when you test materials over 10^6 ohms use 100 volts.

13. If I damage a parallel probe electrode can they be replaced ?

Answer: Yes. For a nominal charge they can be replaced. When cleaning use a soap and water solution.

14. In order to satisfy companies achieving ISO-9000 certification are our meters NIST and CE mark traceable ?

Answer: The meters come with a NIST certificate when ordered. After one year the meters can be sent back to Static Solutions for recalibration. The meters are CE mark tested.

15. I have to use the meter overseas . Can the meter be used with a 220-240 volts power supply ?

Answer: Yes. We supply a 120 volts adapter with the meter. In order to use 220 volts an easily purchased 12 volts DC 220 volt AC adapter can be purchased and used with the meter. Static Solutions can supply this adapter at a nominal charge. Be sure to use a 100-150 milliamp female 2.5 mm wide, 5.5 mm long positive center plug. Also make sure the wall plug will fit in the receptacle of the country where the meter will be used. It might make sense to use 9 volts alkaline batteries overseas in order to avoid problems. Do not use a power adapter when using a alkaline battery. It might leak or explode. When using a power adapter use a rechargeable battery.

16. If the meter fails to work can it be fixed /?

Answer: Under one year the meter is fully warranted and will be fixed at no charge as long as the meter was not abused or dropped. Contact the company at 508.480.0700 regarding a return authorization number after the warranty period expires.

17. Where can the meter be used ?

Answer: The meter can be used in all facets of material production including engineering, maintenance, quality control, incoming inspection, manufacturing, research, or sales departments.

18. What industries can be the meter be used ?

Answer: Photographic , medical, cleanroom, electronics, automotive, pharmaceutical, research and coatings industries.

19. What products can be tested with this meter ?

Answer: Any and all materials that are electrically conductive , dissipative, or antistatic between 1000 ohms and 10^{13} ohms. Items include floor mats, table mats, conductive floor tiles, coatings, floor finishes, bags, containers, smocks, footwear, heel grounders, wrist straps, and grounding straps.

20. What standards do this meter conform ?

Answer: The meter can test to the following standards: EOS/ESD-S4.1, S11.11, S7.1, NFPA-99A, ANSI, UL, ASTM-D-257, ASTM-F150, Military, EIA-541, and CECC (European)

21. I noticed when I brought the meter in from the cold car the temperature and humidity seemed to be incorrect. Why ?

Answer: It takes approximately ½ hour for the meter to climatize to different environmental conditions before taking a measurement. Allow the meter to stabilize to ensure the correct reading.

22. What precautions should I take to ensure correct readings especially at high resistances i.e. 10^{11} ohms, 10^{12} ohms.

Answer: Do not touch the coiled cords or external probes when taking a reading at high resistance values. In addition do not have the cords touch each other. The readings may be higher than the resistance of the wire or probe paint insulation.

23. What solutions should I use to clean the meter or probes ?

Answer: Use a mild detergent water solution. Stronger solvents will attack the meter case and or probe rubber.

24. Why do I need a ground cord ?

Answer: When you are in an electric field (60 cycles AC) or at a potential higher than ground it helps to bring the meter and circuit board to the same potential as the grounded material which is tested. The two cords act like an aerial and will receive this electrical magnetic and radio interference and cause errors in the measurement. Grounding will eliminate this interference.

25. The meter did not work when I removed the cords from the external probes and tried to measure resistivity. Why ?

Answer: You must remove the cords from the meter to activate the probes on the bottom of the meter. The cords must also be removed from the meter case. Merely detaching the cords from the probes will not activate the bottom parallel probes. Do not keep the coil cords in the meter when not using the external probes. Occasionally due to stress the jack will not return to the original position and the internal probes will not work and a code 20 or other error message will be displayed.

26. The external black rubber probes have tendency to mark white surfaces. What can I do to clean the surfaces especially in clean rooms.

Answer: Place the probes on the surface and not move them while testing. If the meters are going into as clean room cleaning off the surface after usage with alcohol is suggested.

27. I was carrying the case and it opened. Why ?

Answer: There are two safety locks on the case which must be fully latched in order to prevent premature opening during travel. Always check the case before carrying it offsite.

28. Can I charge the meter with the power supply ?

Answer: Yes and no. You can charge the battery in the case only if you use a rechargeable battery. You CANNOT use an alkaline battery with the AC adapter. It might cause problems and negates the warranty.

29. Can I use the meter to test chairs, and smocks. ?

Answer: First read the EOS specifications 12.1 and 2.1. This will explain the procedures. You must use the correct probes which are available from Static Solutions and are enclosed in the RT-1000 case.

30. What other accessories are available ?

Answer: Probes to measure miniature or small size parts, probes to measure shoes, probes to measure wrist straps, and probes to measure resistivity by the concentric ring procedure. We also enclose a probe to test whether the electrical ground is accurate.

A calibration box is also available. This CB-9000 is available from an authorized distributor of Static Solutions. The meter can be sent back to Static Solutions in order to be calibrated and issued a NIST certificate.

Any questions regarding these procedures or other questions should be directed to our Engineering staff or customer service representative by calling 508.480.0700. Static Solutions Inc. 331 Boston Post Road-East Marlboro, MA. 01752.

Ohm-Stat™ RT-1000

CALIBRATION INSTRUCTIONS

1. Purchase 1%- 10^3 - 10^{12} ohm value resistors, high accuracy relative humidity hygrometer, and a high accuracy thermometer. The resistors, hygrometer, and thermometer must be NIST calibrated with a certificate of traceability.
2. Open meter being careful not to disturb or break the two wires connecting the power button to the circuit board.
3. Observe on the right lower side of the meter printed circuit board three (3) calibration pots.
4. **ALLOW THE METER TO EQUILIBRATE AND NORMALIZE IN THE ENVIRONMENT FOR 2 HOURS BEFORE TESTING.**
5. Using the supplied coil cords attach the alligator clips to the banana plug ends of the cords.
6. Insert the 3.5mm ends into the meter jacks.
7. Attach the ends of the resistors to the ends of the alligator clips.
8. The top one is for humidity. The middle one is for resistivity. The bottom one is for temperature. Adjustment is done with a small screwdriver. Clockwise is to increase the value, counter clockwise is to decrease the value.
9. Press the power button and compare the resistor value, humidity, and temperature to the parameter to be calibrated.
10. Release the power button and slowly turn the correct adjustment pot.
11. Re-press the power button, and observe the LCD screen.
12. Re-press and adjust the pot if necessary.
13. Close case and tighten the 4 screws.
14. Press the power button to verify that the meter is working.
15. Record serial number and attach a NIST calibration certificate.
16. Record in data base for one year.

There is a conformal coating applied to the circuit board after calibration in order to prevent inaccurate readings due to high humidity. Turning the adjustment screw might be difficult. It will not hurt the meter.

***Should calibration traceable to the NIST be required, please call Static Solutions Inc. directly to arrange for calibration.

For additional information please contact:

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Marlborough, MA 01752
Tel: (508) 480-0700
Fax: (508) 485-3353

Email: contactus@staticolutions.com

Prepared and written on: January 5, 2007 by Lenard Cohen

ANSI/ESD S20.20-1999

ESD association standard

ANSI/ESD S20.20-1999

*for the Development of an
Electrostatic Discharge Control
Program for –*

*Protection of Electrical and Electronic
Parts, Assemblies and Equipment
(Excluding Electrically Initiated
Explosive Devices)*



*Electrostatic Discharge Association
7900 Turin Road, Bldg 3, Ste 2
Rome, NY 13440-2069*

An American National Standard
Approved August 4, 1999

ANSI/ESD-S20.20-1999

**ESD Association Standard for the Development of an
Electrostatic Discharge Control
Program for–**

**Protection of Electrical and Electronic
Parts, Assemblies and Equipment
(Excluding Electrically Initiated
Explosive Devices)**

Approved May 16, 1999



**Caution
Notice**

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Foreword

This standard covers the requirements necessary to design, establish, implement, and maintain an Electrostatic Discharge (ESD) Control Program for activities that: manufacture, process, assemble, install, package, label, service, test, inspect or otherwise handle electrical or electronic parts, assemblies and equipment susceptible to damage by electrostatic discharges greater than or equal to 100 volts Human Body Model (HBM). When handling devices susceptible to less than 100 volts HBM, more stringent ESD Control Program Technical Requirements may be required, including adjustment of program Technical Element Recommended Ranges. This document covers the control program requirements and offers guidance to protect and handle ESD sensitive (ESDS) items, based on the historical experience of both military and commercial organizations. References include, ESD Association, US Military and ANSI approved standards for material properties and test methods. The fundamental ESD control principles that form the basis of this document follow:

- A. All conductors in the environment, including personnel, must be bonded or electrically connected and attached to a known ground or contrived ground (as on shipboard or on aircraft). This attachment creates an equipotential balance between all items and personnel. Electrostatic protection can be maintained at a potential above a "zero" voltage ground potential as long as all items in the system are at the same potential.
- B. Necessary non-conductors in the environment cannot lose their electrostatic charge by attachment to ground. Ionization systems provide neutralization of charges on these necessary non-conductive items (circuit board materials and some device packages are examples of necessary non-conductors). Assessment of the ESD hazard created by electrostatic charges on the necessary non-conductors in the work place is required to ensure that appropriate actions are implemented, commensurate with risk.
- C. Transportation of ESDS items outside an Electrostatic Protected Area (hereafter referred to as "Protected Area") requires enclosure in static protective materials, although the type of material depends on the situation and destination. Inside a Protected Area, low charging and static dissipative materials may provide adequate protection. Outside a Protected Area, low charging and static discharge shielding materials are recommended. While these materials are not discussed in the document, it is important to recognize the differences in their application.

Any relative motion and physical separation of materials or flow of solids, liquids, or particle-laden gases can generate electrostatic charges. Common sources of ESD include personnel, items made from common polymeric materials, and processing equipment. ESD can damage parts by direct contact with a charged source or by electric fields emanating from charged objects that induce a charge on grounded or capacitively coupled to ground sensitive items. It is possible to determine device and item susceptibility by exposure to simulated electronic equivalent discharge circuits. The level of sensitivity determined by test using these models may not necessarily relate to the level of sensitivity in a real life situation. However, they are used to establish a baseline of susceptibility data for comparison of devices with equivalent part numbers from different manufacturers. Three different models are used for characterization of electronic components - Human Body Model (HBM), Machine Model (MM), and Charged Device Model (CDM). It is important to recognize that these models, if used alone, are difficult to apply in terms of specification setting activities. Examples of ESDS parts are microcircuits, discrete semiconductors, thick and thin film resistors, hybrid devices and piezoelectric crystals.

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Table of Contents

1. PURPOSE.....	1
2. SCOPE.....	1
3. REFERENCED PUBLICATIONS.....	1
4. DEFINITIONS.....	2
5. PERSONNEL SAFETY.....	2
6. ESD CONTROL PROGRAM.....	2
6.0.1. ESD Control Program Requirements	2
6.0.2. ESD Control Program Guidance	3
6.0.3. Tailoring	3
6.1. ESD CONTROL PROGRAM ADMINISTRATIVE REQUIREMENTS	3
6.1.1. ESD Control Program Plan	3
6.1.1.1. ESD Control Program Plan Requirement	3
6.1.1.2. ESD Control Program Plan Guidance	3
6.1.2. Training Plan	3
6.1.2.1. Training Plan Requirement	3
6.1.2.2. Training Plan Guidance	3
6.1.3. Compliance Verification Plan	3
6.1.3.1. Compliance Verification Plan Requirement	3
6.1.3.2. Compliance Verification Plan Guidance	4
6.2. ESD CONTROL PROGRAM PLAN TECHNICAL REQUIREMENTS	4
6.2.1. Grounding / Bonding Systems.....	4
6.2.1.1. Grounding / Bonding Systems Requirements	4
6.2.1.2. Grounding / Bonding Systems Guidance	4
6.2.2. Personnel Grounding.....	4
6.2.2.1. Personnel Grounding Requirements	4
6.2.2.2. Personnel Grounding Guidance	4
6.2.3. Protected Areas.....	4
6.2.3.1. Protected Areas Requirement.....	4
6.2.3.2. Protected Areas Guidance.....	5
6.2.4. Packaging	5
6.2.4.1. Packaging Requirements.....	5
6.2.4.2. Packaging Guidance	5
6.2.5. Marking	6
6.2.5.1. ESDS Assemblies and Equipment	5
6.2.5.2. Packaging.....	5
6.2.6. Equipment.....	5
6.2.6.1. AC Powered Tools	5
6.2.6.2. Battery Powered and Pneumatic Hand Tools	6
6.2.6.3. Automated Handlers.....	6
6.2.7. Handling.....	6
6.2.7.1. Handling Procedure Requirements	6
6.2.7.2. Handling Procedure Guidance	6
7. APPENDIX A- SENSITIVITY TESTING.....	9
7.1. ESD SENSITIVITY TESTING	9
7.1.1. Human Body Model Sensitivity:.....	9
7.1.2. Machine Model Sensitivity:.....	9
7.1.3. Charged Device Model Sensitivity:.....	9
7.2. ASSEMBLY, EQUIPMENT AND DESIGN HARDENING	10
7.2.1. Assembly, Equipment and Design Hardening Guidance:.....	10
7.2.2. Direct Contact, Non-Operating Assembly, Body/Finger or Hand/Metal Tests:.....	10
7.2.3. Direct Contact Operating Equipment Hand/Metal Test:	10
7.2.4. Indirect Contact, Operating Equipment Furniture Model Test:.....	10

8. APPENDIX B- RELATED DOCUMENTS.....11

8.1. MILITARY/U.S. GOVERNMENT: 11

8.2. INDUSTRY STANDARDS: 11

Table of Tables

TABLE 1 ESD CONTROL PROGRAM TECHNICAL REQUIREMENTS SUMMARY 7

TABLE 2 ESD SUSCEPTIBILITY TEST REFERENCES FOR DEVICES 9

TABLE 3 ESD SUSCEPTIBILITY TEST REFERENCES FOR ASSEMBLIES AND EQUIPMENT..... 10

ANSI/ESD Association Standard**ANSI/ESD20-1999****ESD Association Standard for the Development of an Electrostatic Discharge Control Program for****PROTECTION OF ELECTRICAL AND ELECTRONIC PARTS ASSEMBLIES AND EQUIPMENT (EXCLUDING ELECTRICALLY INITIATED EXPLOSIVE DEVICES)****1. PURPOSE**

The purpose of this Standard is to provide administrative and technical requirements, as well as guidance for establishing, implementing and maintaining an ESD Control Program (here after referred to as the "Program").

2. SCOPE

This document applies to activities that: manufacture, process, assemble, install, package, label, service, test, inspect or otherwise handle electrical or electronic parts, assemblies and equipment susceptible to damage by electrostatic discharges greater than or equal to 100 volts Human Body Model. This document does not apply to electrically initiated explosive devices, flammable liquids and powders.

3. REFERENCED PUBLICATIONS

Unless otherwise specified, the following documents of the latest issue, revision or amendment, form a part of this standard to the extent specified herein.

EOS/ESD ADV 1.0 EOS/ESD Association Glossary of Terms¹

ESD S1.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Wrist Straps¹

ESD ADV 2.0 ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items – Handbook¹

ESD STM 2.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items – Garments¹

ANSI EOS/ESD S 3.1 EOS/ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Ionization¹

ESD S 4.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Worksurfaces - Resistive Characterization¹

ESD STM 4.2 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Worksurfaces - Charge Dissipation Characteristics¹

ESD STM 5.1 ESD Association Standard for Electrostatic Discharge (ESD) Sensitivity Testing - Human Body Model (HBM) Component Level¹

ESD STM 5.2 ESD Association Standard for Electrostatic Discharge (ESD) Sensitivity Testing - Machine Model (MM) Component Level¹

ESD DS 5.3.1 ESD Association Standard for Electrostatic Discharge (ESD) Sensitivity Testing - Charged Device Model (CDM) Component Level¹

ANSI EOS/ESD S 6.1 EOS/ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Grounding - Recommended Practice¹

ANSI/ESD S 7.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Resistive Characterization of Materials - Floor Materials¹

EOS/ESD S 8.1 EOS/ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Symbols - ESD Awareness¹

ESD S 9.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Footwear - Resistive Characterization¹

ESD DSP 10.1 ESD Association Draft Standard for Protection of Electrostatic Discharge Susceptible Items – Automated Handling

ANSI/EOS/ESD S 11.11 EOS/ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Surface Resistance Measurement of Static Dissipative Planar Materials¹

¹ ESD Association, 7900 Turin Road, Bldg 3, Ste 2, Rome, NY 13440-2069, 315-339-6937

ANSI/ESD S20.20-1999

ESD DS 11.12 ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Volume Resistance Measurement of Static Dissipative Planar Materials¹

ESD ADV 11.2 ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items - Triboelectric Charge Accumulation Testing¹

ANSI/ESD S 11.31 ESD Association Standard for Evaluating the Performance of Electrostatic Discharge Shielding Materials - Bags¹

ESD STM 12.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Seating - Resistive Characterization¹

ESD DS 13.1 ESD Association Standard for Measuring Electrical Potential from Soldering/Desoldering Hand Tools¹

ESD ADV 53.1 ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items - ESD Protective Workstations¹

ESD STM 97.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Floor Materials and Footwear - Resistance Measurement in combination with a Person¹

ESD STM 97.2 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Floor Materials and Footwear - Voltage Measurement on a Person¹

ANSI C63.16 "American National Standard Guide for Electrostatic Discharge Test Methodologies and Criteria for Electronic Equipment"

IEC 1000-4-2, "Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment, Part 2; Electrostatic Discharge Requirements"

IEEE STD C62.38, "IEEE Guide on ESD: ESD Withstand Capability Evaluation Methods (for Electronic Equipment Subassemblies)"

MIL-STD-750 Method 1020, Military Standard, Test Methods for Semiconductor Devices, Electrostatic Discharge Sensitivity (ESDS) Classification²

MIL-STD-883 Method 3015, Department of Defense, Test Method Standard, Microcircuits, Electrostatic Discharge Sensitivity Classification²

MIL-STD-2073-1 Department of Defense, Standard Practice for Military Packaging²

MIL-PRF-19500 Performance Specification, General Specification for Semiconductor Devices²

QML-19500 Qualified Manufacturers List of Products Qualified Under Military Specification MIL-PRF-19500, General Specification for Semiconductor Device²

MIL-PRF-38535 Performance Specification, General Specification for Integrated Circuits (Microcircuits) Manufacturing²

QML-38535 Qualified Manufacturers list of Advanced Microcircuits Qualified Under Military Specification MIL-PRF-38535, General Requirements for Microcircuits Manufacturing²

VZAP, Electrostatic Discharge Susceptibility Data³

4. DEFINITIONS

The terms used in the body of this document are in accordance with the definitions found in EOS/ESD Association Glossary of Terms, EOS/ESD ADV 1.0.

5. PERSONNEL SAFETY

The Procedures and equipment described in this document may expose personnel to hazardous electrical conditions. Users of this document are responsible for selecting equipment that complies with applicable laws, regulatory codes and both external and internal policy. Users are cautioned that this document cannot replace or supersede any requirements for personnel safety.

Ground fault circuit interrupters (GFCI) and other safety protection should be considered wherever personnel might come into contact with electrical sources.

Electrical hazard reduction practices should be exercised and proper grounding instructions for equipment must be followed.

6. ESD CONTROL PROGRAM

6.0.1. ESD Control Program Requirements

The Program shall include both Administrative and Technical Requirements as described herein. The

² Defense Printing Service Detachment Office, Bldg 4D (NPM-DODSSP), 700 Robbins Ave., Philadelphia, PA 19111-5094, 215-697-5164

³ IIT Research Institute, 201 Mill, Rome, NY 13440, 315-336-2359

most sensitive level of the items to be handled in accordance with the Program shall be documented. The Organization shall establish, document, implement, maintain and verify the compliance of the Program in accordance with the requirements of this document.

6.0.2. ESD Control Program Guidance

The primary objective of a Program is to provide continuous ESD protection. Electrostatic control and protection entails implementation of Program requirements during design, production, inspection, test, storage, shipment, installation, use, maintenance, replacement and repair functions.

6.0.3. Tailoring

This document, or portions thereof, may not apply to all applications. Tailoring is accomplished by evaluating the applicability of each requirement for the specific application. Upon completion of the evaluation, requirements may be added, modified or deleted. Tailoring decisions, including rationale, shall be documented in the ESD Control Program Plan (hereafter referred to as the "Plan").

6.1 ESD CONTROL PROGRAM ADMINISTRATIVE REQUIREMENTS

6.1.1 ESD Control Program Plan

6.1.1.1. ESD Control Program Plan Requirement

The Organization shall prepare an ESD Control Program Plan that addresses each of the requirements of the Program. Those requirements are: The Plan, Training, Compliance Verification and ESD Control Program Plan Technical Requirements. The Plan is the principal document for implementing and verifying the Program. The goal is a fully implemented and integrated Program that conforms to internal quality system requirements. The Plan shall address the requirements as described herein and shall apply to all applicable facets of the Organization's work. The Plan shall contain the specific requirements for the organization and be evolutionary as technologies, processes or procedures change. If there is a contractual requirement for device or assembly testing, options for determining ESD Sensitivity include QPL-19500, QML-38535, VZAP data or manufacturer's data sheets. Efforts to identify and eliminate defects, and prevent their introduction, shall be a component of the Plan to reduce the cost and risk associated with ESD damage.

6.1.1.2. ESD Control Program Plan Guidance

The Plan should describe the scope of the Program; describe the tasks, activities, and procedures necessary to protect ESD sensitive items at or

above a specified sensitivity level; identify organizational responsibilities for the tasks and activities; and list directive or supportive documents used in the Program. The Plan should include a listing of the specific type of ESD protective materials and equipment used in the Program. A major element in an effective Plan is the assessment of the ESD susceptibility of parts, assemblies and equipment and their required protection levels. A common method for establishing ESD sensitivity limits is to use one or more of the three ESD models used for characterization of electronic items. These are HBM, MM, and CDM (see Appendix A). The selection of specific ESD control procedures or materials is at the option of the Plan preparer and should be based on risk assessment and the established electrostatic discharge sensitivities of parts, assemblies, and equipment. The Plan should ensure that the Organization and suppliers of ESD sensitive items have established and implemented a Program in accordance with this document.

6.1.2. Training Plan

6.1.2.1 Training Plan Requirement

Initial and recurrent ESD awareness and prevention training shall be provided to all personnel who handle or otherwise come into contact with any ESDS items. The type and frequency of ESD training for personnel shall be defined in the Training Plan. The Training Plan shall document the procedures for recording this training in personnel training records. Training methods and the use of specific techniques are of the Organization's option. The option that is selected shall include an objective evaluation technique to ensure trainee comprehension and training adequacy.

6.1.2.2. Training Plan Guidance

Recurrent ESD training for personnel is an integral part of the Program. ESD training includes initial and recurrent training required to reinforce program requirements and modifications based upon lessons-learned. New technologies and correction of deficiencies identified during reviews and audits should also be part of the training process. The training requirements should be developed in conjunction with the Organization's handling procedures for ESDS parts, assemblies and equipment.

6.1.3. Compliance Verification Plan

6.1.3.1 Compliance Verification Plan Requirement

A Compliance Verification Plan shall be established to ensure the organization's compliance with the requirements of the Plan. Formal audits or certifications shall be conducted in accordance with

ANSI/ESDS20.20-1999

a Compliance Verification Plan that identifies the requirements to be verified, and the frequency at which those verifications must occur. Test equipment shall be selected to make measurements of appropriate properties of the technical requirements that are incorporated into the ESD program plan.

6.1.3.2. Compliance Verification Plan Guidance

In addition to internal audits, external audits (Organization and supplier of ESDS items) should be performed to ensure compliance with planned requirements. Verifications should include routine checks of the Technical Requirements in the Plan. The frequency of verification checks should be based on the control item usage, its durability and associated risk of failure.

6.2. ESD CONTROL PROGRAM PLAN TECHNICAL REQUIREMENTS

Table 1 identifies and describes key Technical Requirements used in the development of a Program and Plan. Note that for each Technical Requirement there are required or optional implementing processes or methods (shown with an "R" or "O" in Table 1) from which to fulfill each Technical Requirement. In a case where there is a required implementing process or method within the Technical Requirements, the implementing process or method shall be used. If there are additional optional elements, they may or may not be implemented in the Plan. If a Technical Requirement only contains optional elements, (shown with an "O") then at least one of the options must be implemented by the Plan. The Plan shall include test methods, acceptance limits and periodic testing intervals. Area 1 shown on Table 1 is intended to designate permanent ESD controlled areas such as manufacturing, production or distribution facilities. Area 2 shown on Table 1 is intended to designate temporary ESD controlled areas such as field service or other remote locations that are not normally equipped as a Protected Area. Test methods used by the organization that differ from the test method or reference in Table 1 shall be documented. Additional guidance may be obtained in ESD ADV 2.0 ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items – Handbook

6.2.1. Grounding / Bonding Systems**6.2.1.1. Grounding / Bonding Systems Requirements**

Grounding/Bonding Systems shall be used to ensure that ESDS items, personnel and any other conductors (e.g. mobile equipment) are at the same

electrical potential. As a minimum, ESDS items, personnel and other related conductors shall be bonded or electrically interconnected.

6.2.1.2. Grounding / Bonding Systems Guidance

In most cases, the third wire (green) AC equipment ground is the preferred choice for ground⁴. When the third wire AC equipment ground is not available or impractical to use, personnel should be bonded or electrically connected to a conductive element of the ESDS item using a wrist strap or other grounding system to ensure that all elements are at the same electrical potential.

6.2.2. Personnel Grounding**6.2.2.1. Personnel Grounding Requirements**

All personnel shall be bonded or electrically connected to ground or contrived ground when handling ESD sensitive items. When personnel are seated at ESD protective workstations, they shall be connected to the common point ground via a wrist strap system.

NOTE: The Organization must be aware of local safety laws and/or codes when grounding personnel while working with energized equipment.

6.2.2.2 Personnel Grounding Guidance

The personnel grounding system in all cases includes the person, the control item(s) and connection to ground. A log should be maintained which verifies that personnel have tested their personal grounding devices. Personnel should check constant monitoring devices (when used) to ensure that they are functional and operating before ESDS products are handled. In addition, constant monitoring devices should be functionally checked periodically to ensure that they are operating as designed. ESD protective flooring, used with approved footwear, may be used as an alternative to the wrist strap system for standing operations. Footwear includes foot grounders, shoes or booties. When equipment ground or auxiliary ground systems are not available, bonding or electrical connections (contrived ground) may be used.

6.2.3. Protected Areas**6.2.3.1. Protected Areas Requirement**

Handling of ESDS parts, assemblies and equipment without ESD protective covering or packaging shall be performed in a Protected Area. Caution signs indicating the existence of the Protected Area shall

⁴ The color of third wire equipment ground can vary with local, national or international electric codes.

ANSI/ESD S20.20-1999

be posted and clearly visible to personnel prior to entry to the Protected Area. ESDS items shall be packaged in ESD protective packaging while not in a Protected Area. Access to the Protected Area shall be limited to personnel who have completed appropriate ESD training. Trained personnel shall escort untrained individuals while in a Protected Area. All nonessential insulators, such as those made of plastics and paper (e.g. coffee cups, food wrappers and personal items) must be removed from the workstation. Ionization or other charge mitigating techniques shall be used at the workstation to neutralize electrostatic fields on all process essential insulators (e.g. ESDS device parts, device carriers and specialized tools) if the electrostatic field is considered a threat.

6.2.3.2. Protected Areas Guidance

A Protected Area may be a single workstation (fixed or portable), laboratory, room, building or any other area with pre-designated boundaries that contains materials and equipment designed to limit electrostatic potentials. Humidity control may be a key element in an ESD control program. Propensity for charge generation and accumulation increases with a reduction in humidity.

All process essential insulators that have electrostatic fields that exceed 2,000 volts should be kept at a minimum distance of 12 inches from ESDS items. 2,000 volts is a measure of the electrostatic field at the point of measurement and is not necessarily directly related to the electrical potential of the item. The accurate measurement of electrostatic fields requires that the person making the measurement is familiar with the operation of the measuring equipment. Most hand held meters require that the reading be taken at a fixed distance from the object. Equipment manufacturers typically specify that the object being measured needs to have certain minimum dimensions. Objects smaller than the minimum dimensions may not provide an accurate reading. Additional guidance related to Protected Areas may be obtained in ESD ADV 2.0.

6.2.4. Packaging

6.2.4.1. Packaging Requirements

ESD protective packaging and package marking shall be in accordance with the contract, purchase order, drawing or other documentation. When the contract, purchase order, drawing or other documentation does not define ESD protective packaging, the Organization shall define ESD protective packaging requirements for ESDS items within the Plan. Packaging shall be defined for all material movement within Protected Areas, between job sites and field service operations.

6.2.4.2. Packaging Guidance

ESD protective packaging techniques vary widely. Some of these types and techniques include low charge generating bags and wraps, air space, dissipative wrap, static shielding, conductive shunts and the use of EMI/RFI shielding. All or some of these packaging types may be used in conjunction with one another to achieve a level of protection commensurate with the item being protected. If the user does not know the sensitivity of the items being used, static shielding packaging should be used. Materials include topically treated polyethylene sheets and film, specially coated corrugated cartons, carbon-loaded plastics, metalized plastic film and various foils. The objective of ESD protective packaging is to prevent a direct electrostatic discharge to the ESDS item contained within and allow for dissipation of charge from the exterior surface. In addition, the packaging should minimize charging of the ESDS item in response to an external electrostatic field and triboelectrification. Users should be aware that some packaging materials may be humidity dependent and may have limited shelf life. They may also lose static shielding properties by crumpling, puncturing and folding. Packaging materials may outgas, contaminate or shed particles that may cause production-related problems. It is important that the Organization evaluate ESDS protective packaging materials for process, storage and environmental compatibility.

6.2.5. Marking

6.2.5.1. ESDS Assemblies and Equipment

ESDS assemblies and equipment containing ESDS parts and assemblies should be marked with an ESD caution symbol, (i.e., EOS/ESD S8.1). The symbol should also be located on equipment in a position readily visible to personnel. In addition, the symbol should be located in a position readily visible when an ESDS assembly is incorporated into its next higher assembly.

6.2.5.2. Packaging

ESD protective packaging should be marked in accordance with EOS/ESD S8.1 or MIL-STD-2073-1 for Military applications.

6.2.6. Equipment

Further guidance regarding equipment can be found in ESD-ADV-2.0.

6.2.6.1. AC Powered Tools

The working part of AC powered tools should be capable of providing a conductive path to ground. New powered hand tools such as soldering irons

ANSI/ESDS20.20-1999

typically should have a tip to ground resistance of less than 1.0 ohm.

Note - This resistance may increase with use but should be less than 20.0 ohms for verification purposes.

6.2.6.2. Battery Powered and Pneumatic Hand Tools

Battery powered and pneumatic hand tools while being held should have a resistance to ground of less than 1×10^{12} ohms.

6.2.6.3. Automated Handlers

All conductive or static dissipative components of automated handling equipment should provide a continuous conductive path to ground, whether stationary or in motion. The equipment should minimize charge generation of the ESDS items that are handled. Where insulative materials are necessary in the device path, they should be designed to minimize electric fields and the charge imparted to devices being handled.

6.2.7. Handling**6.2.7.1. Handling Procedure Requirements**

ESD protective handling procedures shall be established, documented, and implemented. Handling procedures are required for all areas where ESDS items are manually or machine processed. When outside their protective covering or packaging, ESDS items shall be handled only in a Protected Area.

6.2.7.2. Handling Procedure Guidance

Handling procedures should address all operations and locations where ESDS items will be handled in protected and unprotected areas.

Table 1- ESD Control Program Technical Requirements Summary

(See paragraph 6.2 for further guidance regarding alternate test methods.)

Technical Requirement	Reference Paragraph	Implementing Process or Method	Area 1 Mfg.	Area 2 Field	Test Method, <i>Standard or Advisory</i>	Recommended Range ⁵
Grounding / Bonding Systems	6.2.1				ANSI EOS/ESD S 6.1	
		Equipment Ground	R	O	ANSI EOS/ESD S 6.1	< 1.0 ohm AC Impedance
		Auxiliary Ground	O	O	ANSI EOS/ESD S 6.1	< 1.0 ohm AC Impedance
		Equipotential Bonding	O	O	ESD ADV 2.0	< 1.0 X 10 ⁹ ohm ⁶
		Common Point Ground	R	O	ANSI EOS/ESD S 6.1	< 1.0 ohm AC Impedance
Personnel Ground	6.2.2					
		Wrist Strap System			ESD S 1.1	< 35 X 10 ⁶ ohm ⁷
		Seated Operations	R	R		
		Standing Operations	O	O		
		Flooring – Footwear System	O	O	ESD STM 97.1 or ESD STM 97.2	< 35 X 10 ⁶ ohm ⁶ or < 100 Volts ⁶
Protected Area	6.2.3					
		Work Surface	O	O	ESD S 4.1	< 1 X 10 ⁹ ohm
					ESD STM4.2	< 200 Volts ⁶
		Wrist Strap Cord	O	O	ESD S 1.1	0.8 X 10 ⁶ to 1.2 X 10 ⁶ ohm
		Footwear	O	O	ESD S 9.1	< 1 X 10 ⁹ ohm ⁷
		Flooring	O	O	ANSI ESD S 7.1	< 1 X 10 ⁹ ohm ⁷
		Seating	O	O	ESD STM 12.1	< 1 X 10 ⁹ ohm ⁷
		Ionization (other than room systems)	O	O	ANSI EOS/ESD S 3.1	< ±50 Volts Voltage Offset ⁶
		Ionization (room systems)	O	O	ANSI EOS/ESD S 3.1	< ±150 Volts Voltage Offset ⁵
		Shelving	O	O	ESD ADV 53.1	< 1 X 10 ⁹ ohm ⁷
		Mobile Equipment	O	O		< 1 X 10 ⁹ ohm ⁶
		Continuous Monitors	O	O	Manufacturer Specification	N/A

⁵ The values in the Recommended Range are obtained by using the Test Method, Standard or Advisory provided in this table. See paragraph 6.2 for further guidance regarding alternate test methods.

⁶ This is a proposed value that has not been substantiated by any standard.

⁷ This value differs from the value in current standards. There is work in progress to harmonize the value.

ANSI/ESDS20.20-1999

Technical Requirement	Reference Paragraph	Implementing Process or Method	Area 1 Mfg.	Area 2 Field	Test Method, Standard or Advisory	Recommended Range ⁵
		Signs	R	O	N/A	
	6.2.4	ESDS Item Packaging	R	R	See ESD Packaging Technical Requirement	N/A
	6.2.6	Equipment			ESD ADV 2.0	
	6.2.6.1	AC Powered Tools	O	O	ESD DS 13.1	< 1.0 ohm ⁶
	6.2.6.2	Battery Powered and Pneumatic Hand Tools	O	O		< 1 X 10 ¹² ohms ⁶
	6.2.6.3	Automated Handlers	O	O	ESD DSP 10.1	
		Garment	O	O	ESD STM 2.1	1 X 10 ⁵ to 1x10 ¹¹ ohms
		Protective Material Marking	O	O	ESD S8.1	
		Humidity	O	O	N/A	> 30% Rh < 70% ⁶
ESD Packaging	6.2.4					
		Conductive	O	O	EOS/ESD S11.11	< 1 X 10 ⁴ ohms
		Dissipative	O	O	EOS/ESD S11.11 ESD DS11.12	≥ 1 X 10 ⁴ to < 1 X 10 ¹¹ ohms
		Shielding	O	O	ESD S11.31	< 50 nJ ⁶
		Low Charging	O	O	ESD ADV 11.2	
		Protective Material Marking	O	O	EOS/ESD S8.1	

R-Required implementing process or method

O- Optional implementing process or method

7. APPENDIX A - SENSITIVITY TESTING

7.1. ESD Sensitivity Testing

Technical literature and failure analysis data exist that indicates ESD failures are due to a complex series of interrelated effects. Some of the factors that influence ESD sensitivity include the ESD current and energy envelope, the rise time of the ESD event, device design, fabrication technology and device package style. Energy sensitive devices are damaged by currents through the resistance of a bipolar junction, protection resistor, or protection MOS transistor. Voltage sensitive devices are damaged when the breakdown voltage is exceeded. ESD Sensitivity Testing of devices, whether performed using the Charged Device Model (CDM), Machine Model (MM) or the Human Body Model (HBM), provide ESD sensitivity levels for the comparison of one device to another using defined parameters. The ESD sensitivity of the device (defined in volts), as determined by using any of the defined models, may not be the actual failure voltage level in the manufacturing, process or user environment. Table 2 provides a reference for various standards and test methods for ESD sensitivity testing.

7.1.1. Human Body Model Sensitivity:

A source of ESD damage is the charged human body, as modeled by HBM standards. This testing model represents the discharge from the fingertip of a standing individual delivered to the conductive leads of the device. It is modeled by a 100 pF capacitor discharged through a switching component and 1,500 ohm series resistor into the device under test. The discharge itself is a double exponential waveform with a rise time of 2-10 nanoseconds and a pulse duration of approximately 150 nanoseconds. The use of a 1,500 ohm series resistor means this model approximates a current source. All devices should be considered as HBM sensitive. The HBM ESD sensitivity of devices may be determined by testing the device using one of the referenced test methods. HBM sensitivities can be found in RAC VZAP, Qualified Manufacturers, List of Products (QML-19500) or Qualified Manufacturer List (QML-38535).

7.1.2. Machine Model Sensitivity:

A source of damage for the MM is a rapid transfer of energy from a charged conductor to the conductive leads of the device. This ESD model is a 200 pF capacitor discharged through a 500 nH inductor directly into the device with no series resistor. Due to the lack of a series current limiting resistor, this model approximates a voltage source. In the real world this model represents a rapid discharge from items such as, charged board assembly, charged cables, or the conduction arm of an automatic tester. The discharge itself is a sinusoidal decaying waveform with a rise time of 5-8 nanoseconds and a period of approximately 80 nanoseconds.

7.1.3. Charged Device Model Sensitivity:

A source of damage for the CDM is the rapid discharge of energy from a charged device. The ESD event is totally device dependent, but its location relative to ground can influence the failure level in the real world. The assumption for this test model is that the device itself has become charged and rapid discharge occurs when the charged device's conductive leads contact a metallic surface, which is at a different potential. A major issue with the preparation of a CDM test standard is the availability of suitable instrumentation to measure the discharge event. The waveform rise time is often less than 200 picoseconds. The entire event can take place in less than 2.0 nanoseconds. Although very short in duration, current levels can reach several tens of amperes during discharge.

Table 2 - ESD Susceptibility Test References for Devices

ESD MODEL	ESD Standards and Methods for Susceptibility Testing of Devices
HBM	ESD STM5.1 MIL-STD-883 Method 3015 MIL-STD-750 Method 1020 MIL-PRF-19500 MIL-PRF-38535
MM	ESD-STM5.2
CDM	ESD DS5.3.1

7.2. Assembly, Equipment and Design Hardening

7.2.1. Assembly, Equipment and Design Hardening Guidance:

Assemblies and equipment should have protective circuitry or techniques to meet the desired design goals. Determining the ESD susceptibility of assemblies and equipment may be based on simulation modeling, or actual testing. Table 3 provides a quick reference for various test methods associated with assembly and equipment susceptibility testing.

7.2.2. Direct Contact, Non-Operating Assembly, Body/Finger or Hand/Metal Tests:

This model can be used to verify that assemblies will not be damaged during non-operating conditions by direct contact to input, output and interface connections. This threat applies to all types of assemblies, see Table 3.

7.2.3. Direct Contact Operating Equipment Hand/Metal Test:

This model can be used to verify that operating equipment will not be damaged (or non-recoverable faults will not be injected) by direct contact to operator accessible points and exposed surface areas during the normal maintenance process. This threat is limited to equipment subject to operator adjustments or maintenance activities during operation, see Table 3.

7.2.4. Indirect Contact, Operating Equipment Furniture Model Test:

This model can be used to verify that operating equipment in a home or office environment will not be damaged (or non-recoverable faults will not be injected) by indirect contact during normal activities performed within the proximity of the equipment. This threat applies to all electronic equipment in a home or office environment. See Table 3

Table 3 - ESD Susceptibility Test References for Assemblies and Equipment

ESD Assembly/Equipment Model	ESD Test Standard or Method
Body/Finger HBM	IEEE STD C62.38 (Sub-Assembly)
Hand/Metal HBM	IEC 1000-4-2 ANSI C63.16 (Equipment)
Furniture Model	ANSI C63.16 (Equipment)

8. APPENDIX B- RELATED DOCUMENTS

The following documents are listed for further reference. Some documents may be canceled. However, this listing provides a reference of documents reviewed during the preparation of this standard.

8.1. Military/U.S. Government:

FED-STD-101, "Federal Test Method Standard"

MIL-B-117, "Bags, Sleeves and Tubing--Interior Packaging"

MIL-PRF-81705, "Barrier Materials, Flexible, Electrostatic Free, Heat Sealable"

MIL-E-17555, "Electronic and Electrical Equipment, Accessories, and Provisioned Items (Repair Parts): Packaging of"

MIL-HDBK-263, "Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically-Initiated Explosive Devices)"

MIL-M-38510, "General Specification for Military Microcircuits"

MIL-P-82646, "Plastic Film, Conductive, Heat Sealable, Flexible"

MIL-PRF-87893, "Workstations, Electrostatic Discharge (ESD) Control"

MIL-STD-129, "Marking for Shipment and Storage"

MIL-STD-1285, "Marking of Electrical and Electronic Parts"

MIL-STD-1686, "Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)"

MMA-1985-79, Revision 3, "Standard Test Method for Evaluating Triboelectric Charge Generation and Decay"

8.2. Industry Standards:

ANSI/IEEE-STD-142, "IEEE Green Book (IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems)"

ANSI/EIA-625, "Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices"

ANSI/EIA-541, "Packaging of Electronic Products for Shipment"

ANSI/EIA-583, "Packaging Material Standards for Moisture Sensitive Items"

ESD-ADV3.2, "Selection and Acceptance of Air Ionizers"

ESDSIL, "Reliability Analysis Center (RAC) ESD Sensitive Items List"

EIA-471, "Symbol and Label for Electrostatic Sensitive Devices"

IEC 61340-5-1, "Protection of Electronic Devices from Electrostatic Phenomena – General Requirements"

EN 100015-1, "Basic Specification: Protection of Electrostatic Devices - Part 1 General Requirements"

ESD-STM12.1-1997

ESD Association Standard Test Method
for the protection of electrostatic
discharge susceptible items:

Seating – Resistive Measurement

Approved September 20, 1997
ESD Association



(This foreword is not part of ESD Association Standard Test Method STM12.1 - 1997)

Foreword

This standard test method is intended to provide test methods for evaluating seating used to control electrostatic discharge. This standard test method covers all types of seating including chairs and stools.

This standard test method is limited to defining procedures for measuring electrical resistance. Electrical resistance is one property that can be used to evaluate the electrostatic dissipation of seating intended for use in ESD controlled areas. Resistance, however, does not fully characterize seating. An additional property to be considered in the selection and use of seating includes triboelectric charge generation. A subsequent document is planned to address the antistatic properties of seating.

One source of electrostatic charge generation in a work environment is the separation of personnel from chairs, stools or other types of seating along with the movement of seating across the floor. This results in the generation of electrostatic charge that can accumulate on the seating and on personnel. The affect of this generation and accumulation of electrostatic charge can be minimized with the appropriate selection of seating.

To effectively control electrostatic discharge, seating must be used in combination with an ESD controlled floor or mat. Seating is not a primary means of controlling electrostatic charge build-up on personnel in an ESD protective work area. Personal wrist straps or other means of personnel grounding should be used for this purpose.

At the time the document was approved, the working group had the following members:

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Table of Contents

1. PURPOSE, SCOPE AND APPLICATION	1
1.1 PURPOSE.....	1
1.2 SCOPE.....	1
1.3 APPLICATION.....	1
2. REFERENCED DOCUMENTS.....	1
3. DEFINITIONS OF TERMS	1
4. PERSONNEL SAFETY	1
5. TEST METHODS.....	2
5.1 APPARATUS REQUIREMENTS.....	2
5.1.1 Resistance measuring apparatus (Meter)	2
5.1.2 Electrodes	2
5.1.3 Environmental test chamber	2
5.2 TEST PROCEDURES - QUALIFICATION TESTING.....	2
5.2.1 Specimen preparation.....	2
5.2.2 Cleaning of specimens	2
5.2.3 Humidity conditioning	2
5.2.4 Measurements	3
5.2.5 Reporting of test results	3
5.3 TEST PROCEDURE - ACCEPTANCE TESTING	3
5.3.1 Specimen preparation.....	3
5.3.2 Cleaning of specimens	3
5.3.3 Humidity conditioning	3
5.3.4 Measurements	3
5.3.5 Reporting of test results	3
5.4 TEST PROCEDURE - PERIODIC TESTING.....	3
5.4.1 Reporting of test results	3
6. RESISTANCE GUIDELINES	4
7. OTHER CONSIDERATIONS	4

Table of Figures

FIGURE 1 RESISTANCE TO GROUNDABLE POINT TEST POSITIONS.....	5
FIGURE 2 SEATING COMPONENT TEST POSITIONS.....	6
FIGURE 3 SEATING RESISTANCE CHARACTERIZATION DATA SHEET.....	7

ESD Association Standard Test Method

ESD-STM12.1-1997

ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items -

SEATING - RESISTANCE MEASUREMENT

1. Purpose, scope and application

1.1 Purpose

This standard test method provides test methods for measuring the electrical resistance of seating used for the control of electrostatic charge. The standard test method provides test methods for the qualification of seating prior to installation or application, as well as test methods for evaluating and periodically checking seating after installation or application.

1.2 Scope

The test methods established here are designed to measure seating with resistances to a groundable point of 1.0×10^3 to 1.0×10^{10} ohms. The resistances considered here are measured from various components of the seating to a groundable point such as a conductive caster or a drag chain. Resistivity measurements are not within the scope or purpose of this standard test method.

1.3 Application

This standard test method relies on resistance measurements utilizing standard instruments to provide a means of evaluating seating.

Use of this document or the procedures defined herein DO NOT APPLY to facilities where ordnance, flammable materials or explosives are stored or handled, unless the methods described in this standard test method are evaluated specifically for these areas.

2. Referenced documents

EOS/ESD-ADV1.0, Glossary of Terms¹

ANSI/EOS/ESD-S4.1, Standard for Protection of Electrostatic Discharge Susceptible Items - Work Surfaces¹

¹ ESD Association, 7900 Turin Rd, Bldg 3, Ste 2, Rome, NY, 13440-2069, 315-339-6937

ESD-S7.1, Standard for Protection of Electrostatic Discharge Susceptible Items - Floor Materials¹

EOS/ESD-S8.1, Standard for Protection of Electrostatic Discharge Susceptible Items - ESD Awareness Symbols¹

ANSI/EOS/ESD S6.1, Standard for protection of Electrostatic Discharge Susceptible Items - Grounding-Recommended Practice¹

American Society for Testing and Materials², ASTM D2240-86, Test for Rubber Property - Durometer Hardness

3. Definitions of terms

The following definitions shall apply for the purposes of this standard test method in addition to those specified in the ESD Glossary of Terms:

Groundable point, seating: Conductive caster or drag chain used to provide an electrical path from seating to a static control floor or mat.

Resistance to groundable point: The resistance in ohms measured between a single electrode placed on a surface and a groundable point.

Static control seating: Chairs used in conjunction with a static control floor or static control floor mat, that are intended to control the generation, accumulation and dissipation of electrostatic charge associated with the seating.

4. Personnel Safety

4.1 The procedures and equipment described in this document may expose personnel to hazardous electrical conditions. Users of this document are responsible for selecting equipment that complies with applicable laws, regulatory codes and external and internal policy. Users are cautioned that this document cannot replace or supercede any requirements for personnel safety. The ultimate responsibility for personnel safety resides with the end user of this document.

² American Society for Testing and Materials (ASTM) 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, 610-832-9500

ESD-STM12.1-1997

4.2 Ground Fault Circuit Interrupters (GFCI) and other safety protection should be considered wherever personnel might come into contact with electrical sources.

4.3 Electrical hazard reduction practices should be exercised and proper grounding instructions for the equipment must be followed when performing these tests.

5. Test methods

This section describes the test methods for measuring the electrical resistance of ESD protective seating for qualification, acceptance and periodic testing.

5.1 Apparatus requirements**5.1.1 Resistance measuring apparatus (Meter)**

A self-contained resistance meter (such as a megohmmeter) or power supplies and current meters in the appropriate configuration for resistance measurement with $\pm 10\%$ accuracy shall be utilized. This apparatus shall be capable of open circuit voltages of 10V and 100V with $\pm 10\%$ tolerances.

Note: Both test leads should be capable of being isolated from ground. AC line powered resistance measuring devices may give erroneous results due to undefined ground paths. Battery powered equipment is recommended.

5.1.2 Electrodes

Two cylindrical 2.27 kg (5 pound) metal electrodes shall have a diameter of 63.5mm (2.50 inches), each having contacts of electrically conductive material with a Shore-A (IRHD) durometer hardness of 50-70 (ASTM Method D2240-1986).²

Note: These electrodes conform to ANSI/EOS/ESD - S4.1-1¹ with the following exceptions:

- The resistance of each electrode shall be less than 100 ohms when measured at 10 volts or less on a bare metallic surface.
- The electrodes shall be insulated from the operator by a resistance greater than 1×10^{10} ohms when measured at 100V. This may be accomplished by either an insulating sleeve over the electrode or body or by the operator using an insulative glove or material. The operator should

exercise caution when making measurements to avoid alternate resistance paths to ground.

One bare metal plate, with suggested dimensions of 127 mm x 254 mm x 1.6 mm thick (5" x 10" x 0.062" thick), or of sufficient thickness to support the weight of the seating without becoming distorted.

5.1.3 Test environment

A controlled environment or an enclosed chamber (of sufficient size to hold at least one chair) capable of controlling relative humidity to $12 \pm 3\%$ RH and $50 \pm 5\%$ RH, and temperature to $23 \pm 3^\circ\text{C}$ ($73 \pm 5^\circ\text{F}$) shall be used. The humidity indicating instrumentation shall be accurate to $\pm 3\%$ RH in the operational range.

5.2 Test procedures - Qualification Testing

This procedure shall be used to qualify seating as ESD protective.

5.2.1 Specimen preparation

Number of specimens - 3, labeled from 1 to 3.

Each specimen of seating shall be configured in the manner in which it will be used in the intended application.

5.2.2 Cleaning of specimens

Seating surfaces - Clean per manufacturer's instructions.

Casters or other groundable point - Clean surfaces with a minimum 70% isopropanol-water solution using a clean, low linting cloth.

Clean the electrodes with a minimum 70% isopropanol-water solution using a clean, low-linting cloth. Allow the electrodes to air dry.

5.2.3 Humidity conditioning and testing

Place the specimen(s) in the test environment preset to $12 \pm 3\%$ RH and $23 \pm 3^\circ\text{C}$ ($73 \pm 5^\circ\text{F}$) for 48 hours minimum. Perform the tests in 5.2.4. If the test environment holds less than the required number of seating units, repeat this procedure until all the samples have been conditioned and tested. Reset the test environment to $50 \pm 5\%$ RH and $23 \pm 3^\circ\text{C}$ ($73 \pm 5^\circ\text{F}$) for 48 hours minimum. Repeat the tests in 5.2.4.

ESD-STM12.1-1997

5.2.4 Measurements

Connect the measuring apparatus to the specimen as follows:

- a. Place the seating such that one of the groundable points (casters, glides or drag chain) rests on the bare metal plate.
- b. Connect the meter leads to each of the electrodes (Figure 1).
- c. In lieu of electrode B, the meter may be connected directly to the bare metal plate using a clip lead.
- d. Set the meter test voltage to 10V. Place electrode-A at position 1 on the seat (Figure 2). Hold the electrode so that it is perpendicular to the surface being measured and with sufficient force to obtain a stable reading.
- e. Apply the test voltage and record the resistance after the measurement has stabilized or after 15 seconds has elapsed. Record the data as shown in the suggested data sheet in Figure 3.
- f. When the measured resistance is greater than 1×10^6 ohms, repeat the measurement using a test voltage of 100V. Record the data as shown in the suggested data sheet.
- g. Repeat the measuring sequence on the seat for electrode positions 2 through 5 using the selected groundable point (Figure 2).
- h. Test the remaining applicable seating components using the positions shown in Figure 2.
- i. Return the electrode to position 1 on the seat and repeat this measurement from position 1 to all remaining groundable points.
- j. Repeat the measurement sequence for specimens 2 and 3.

5.2.5 Reporting of test results

Report all values in ohms for resistance to groundable points. Also report test voltage, test date, temperature and relative humidity at time of testing, actual duration of conditioning and test equipment used. Summarize test data by reporting minimum, maximum, mean and median values for all seating

components (seat, back rest, rear of back rest and arms). Report test data for the foot rest and base as recorded.

5.3 Test procedure - acceptance testing

This procedure shall be used to evaluate new seating or to recertify existing seating.

5.3.1 Specimen preparation

Follow the procedure in 5.2.1.

5.3.2 Cleaning of specimens

Follow the procedure in 5.2.2.

5.3.3 Humidity conditioning

Condition the specimens at ambient or user-specified conditions for 48 hours minimum.

5.3.4 Measurements

Follow the procedure in 5.2.4.

5.3.5 Reporting of test results

Report all values in ohms for resistance to groundable point. Also report test voltage, test date, temperature and relative humidity at the time of testing and test equipment used. Summarize test data by reporting minimum, maximum, mean and median values for all seating components (seat, back rest, rear of back rest and arms). Report the foot rest and base measurements as recorded.

5.4 Test procedure - periodic testing

This procedure shall be used to periodically check seating already installed in an ESD protective area.

- a. Test seating in the configuration being used. Do not clean the seating.
- b. Follow the procedure in 5.2.4, except perform the test by placing electrode-A at only position-1 of each seating component.
- c. Failure to meet test specifications of any component during the periodic test shall require the seating unit to be retested in accordance with 5.2.2 and 5.2.4 after corrective action has been taken.

5.4.1 Reporting of test results

Report all values in ohms for resistance to groundable point. Also report test voltage used, test date, temperature and relative humidity at time of testing and test equipment used.

ESD-STM12.1-1997

5.2.4 Measurements

Connect the measuring apparatus to the specimen as follows:

- a. Place the seating such that one of the groundable points (casters, glides or drag chain) rests on the bare metal plate.
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- c. In lieu of electrode B, the meter may be connected directly to the bare metal plate using a clip lead.
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- h. Test the remaining applicable seating components using the positions shown in Figure 2.
- i. Return the electrode to position 1 on the seat and repeat this measurement from position 1 to all remaining groundable points.
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Follow the procedure in 5.2.4.

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Report all values in ohms for resistance to groundable point. Also report test voltage, test date, temperature and relative humidity at the time of testing and test equipment used. Summarize test data by reporting minimum, maximum, mean and median values for all seating components (seat, back rest, rear of back rest and arms). Report the foot rest and base measurements as recorded.

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This procedure shall be used to periodically check seating already installed in an ESD protective area.

- a. Test seating in the configuration being used. Do not clean the seating.
- b. Follow the procedure in 5.2.4, except perform the test by placing electrode-A at only position-1 of each seating component.
- c. Failure to meet test specifications of any component during the periodic test shall require the seating unit to be retested in accordance with 5.2.2 and 5.2.4 after corrective action has been taken.

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Report all values in ohms for resistance to groundable point. Also report test voltage used, test date, temperature and relative humidity at time of testing and test equipment used.

ESD-STM12.1-1997

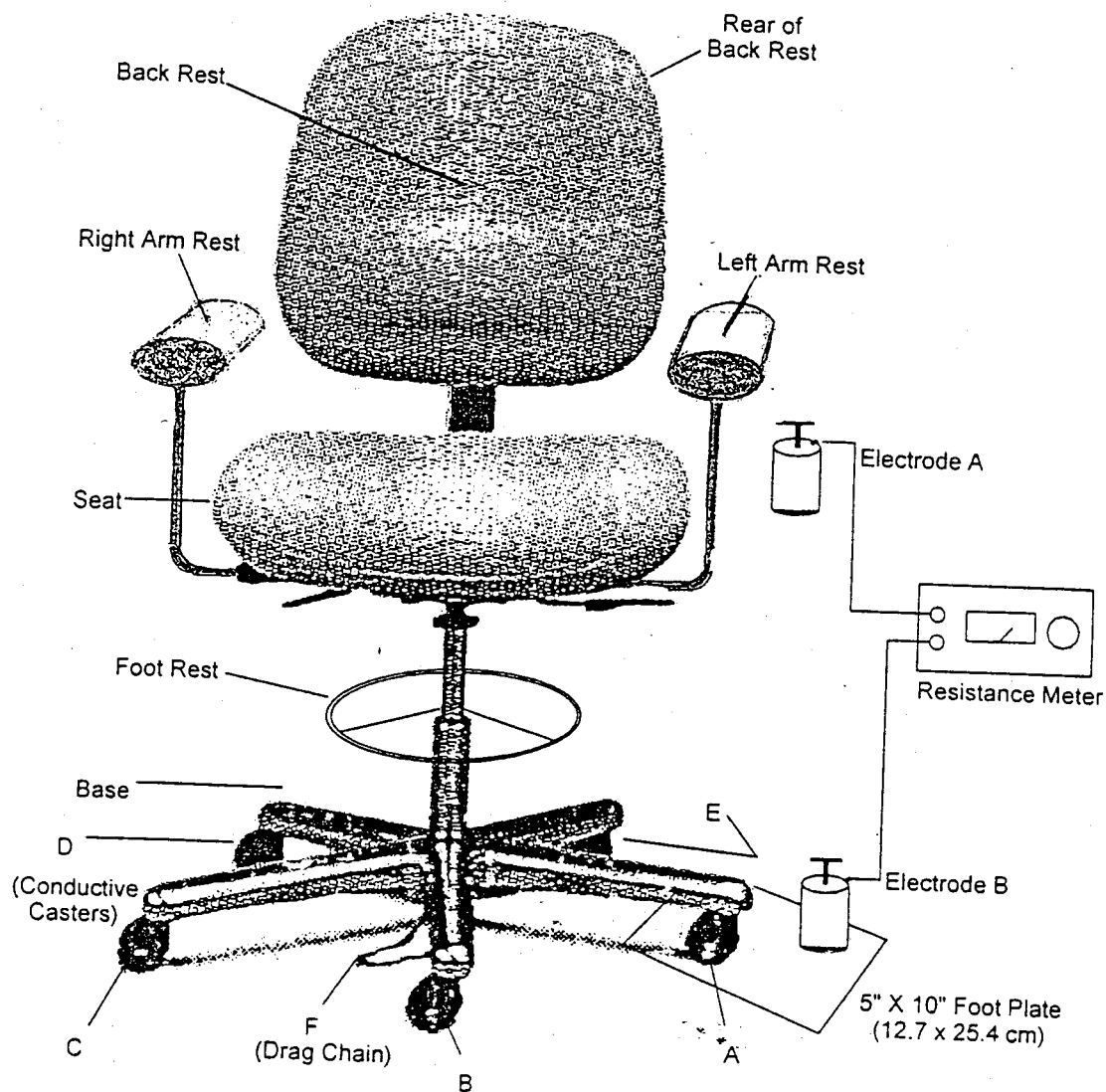
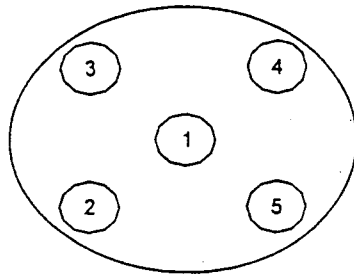
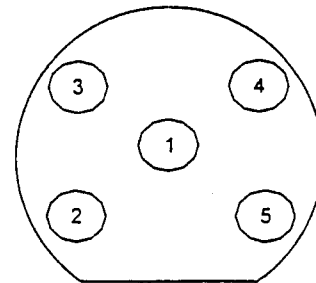


Figure 1 – Resistance to Groundable Point Positions

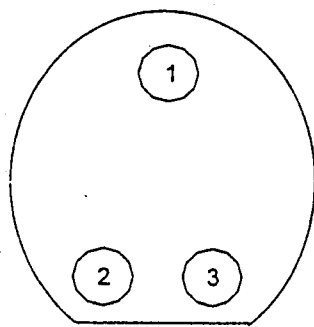
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Seat



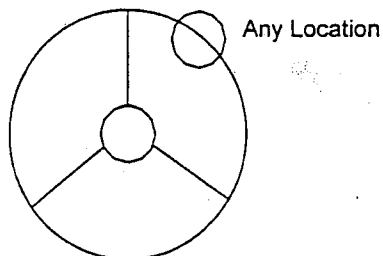
Back Rest



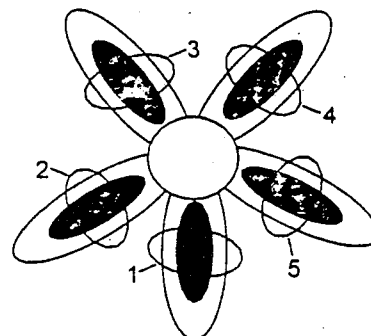
Rear of Back Rest



Arm Rest



Foot Rest



Base with Plastic Covering
Note: If base is bare metal
test only at Position-1.

Figure 2 - Seating Component Test Positions

ESD-S2.1-1995

ESD association standard

*for the Protection of
Electrostatic Discharge
Susceptible Items -*

Garments

Static Solutions, Inc.

"Strategies, Solutions, Innovation"



TM

*Electrostatic Discharge Association
7902 Turin Road, Suite 4
Rome, NY 13440*

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Comments and Recommendation: This Draft Standard has been developed by the Standards Committee of the ESD Association. Users of this standard having comments or recommendation for change in this proposed document are encouraged to forward their comments to the Standards Committee Chair at the address listed below for discussion at the next meeting of the committee.

ESD Association
Attn: Standards Committee Chair
7902 Turin Road, Suite 4
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Foreword

This draft standard provides test methods for evaluating the resistance of garments used to control electrostatic charge for the electronics industry. This draft standard is limited to defining procedures for measuring electrical resistance of garments. It does not address electrical resistance through a person or in combination with a person connected to ground. However, resistance may not fully characterize a garment's performance. Additional documents may cover procedures for evaluating these properties.

A common source of electrostatic charge is clothing made from synthetic fibers resulting in an accumulation of charge on a person's clothing. The effect of this charge can be minimized by evaluating and selecting an appropriate garment. To effectively control electrostatic charges, the garment should be grounded.

This document may be used in part to cover specific applications. To fully characterize a garment, field attenuation and tribocharging may need to be considered, but these procedures are beyond the scope of this document.

At the time the document was approved, the subcommittee had the following members:

Sheryl Zayic, Chair Boeing Defense & Space Group	Kay Adams, Secretary Tech Wear, Inc.
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8. APPENDIX A

The electrical integrity of the groundable point to the garment material should be measured. This can be accomplished using the point to point method described herein. Place one electrode on the groundable point and the second electrode on the panel attached to the groundable point. Complete the test as described herein.

Table of Contents

1. PURPOSE, SCOPE, AND APPLICATION	1
1.1 PURPOSE.....	1
1.2 SCOPE.....	1
1.3 APPLICATION.....	1
1.3.1 Sleeve-to-sleeve.....	1
1.3.2 Point-to-point.....	1
2. REFERENCE DOCUMENTS	1
3. DEFINITION OF TERMS.....	1
4. PERSONNEL SAFETY	2
5. TEST METHODS.....	2
5.1 TEST EQUIPMENT REQUIREMENTS.....	2
5.1.1 Resistance Measuring Equipment.....	2
5.1.2 Clamps/Electrodes (Sleeve to Sleeve).....	2
5.1.3 Electrodes (Point to Point).....	2
5.1.4 Environmental Test Chamber.....	2
5.1.5 Support Surface.....	2
5.2 TEST PARAMETERS.....	2
5.2.1 Sample Preparation.....	2
5.2.1.1 Sample Sketch.....	3
5.2.2 Humidity.....	2
5.2.2.1 Low Humidity.....	3
5.2.2.2 Moderate Humidity.....	3
5.2.3 Test Sample Quantity.....	3
5.3 SLEEVE TO SLEEVE TEST PROCEDURE.....	3
5.4 POINT TO POINT TEST PROCEDURE.....	3
6. TEST DATA REPORTING	3
7. RECOMMENDED ELECTRICAL RESISTANCE RANGE	3
8. NOTES	4
8.1 GARMENTS WITH GROUNDABLE POINTS	4

Table of Figures

FIGURE 1A CLAMPS/ELECTRODES	5
FIGURE 1B TEST SETUP SLEEVE TO SLEEVE	6
FIGURE 1C TEST SETUP POINT TO POINT	7

ESD Association Standard Test Method

ESD-STM2.1-1997

**ESD Association
Standard Test Method for the
Protection of Electrostatic Discharge
Susceptible Items****GARMENTS****1. Purpose, Scope, and Application****1.1 Purpose**

This document provides specific test methods for evaluating electrical resistance of static control garments.

1.2 Scope

This document defines the test methods for determining the electrical resistance from sleeve-to-sleeve and point-to-point of static control garments.

1.3 Application

The test methods defined in this document utilize standard instruments to measure the resistance of static control garments. These methods are intended as qualification test procedures. They can also be used as periodic tests to ensure ongoing electrical integrity of the garment under ambient conditions.

1.3.1 The sleeve-to-sleeve method (Fig 1a & 1b) is intended to test the integrity of the electrical resistance across the seams of the garment.

1.3.2 The point-to-point test method (Fig 1c) is intended to test the electrical resistance between any two points on the garment, which may include the electrical resistance across the seams of the garment.

2. Reference Documents

EOS/ESD ADV1.0, EOS/ESD Glossary of Terms¹

¹ ESD Association, 7900 Turin Rd, Bldg 3, Ste 2, Rome, NY 13440, 315-339-6937

ANSI/EOS/ESD S4.1, EOS/ESD Standard for Protection of Electrostatic Discharge Susceptible Items – ESD Protective Worksurfaces

ANSI/EOS/ESD S6.1, EOS/ESD Standard for Protection of Electrostatic Discharge Susceptible Items - Grounding -Recommended Practice

EOS/ESD S11.11, Surface Resistance Measurement of Static Dissipative Planar Materials

3. Definition of Terms

The following definitions shall apply for the purpose of this draft standard in addition to those specified in the EOS/ESD Glossary of Terms.

Garment System:

Any electrically interconnected components of static control apparel.

Point-to-Point Resistance:

The resistance in ohms measured from one point to another on the surface of the same panel or two different panels of a garment.

Sleeve-to-Sleeve Resistance:

The resistance in ohms measured from the sleeve opening of the garment to the other sleeve opening of the same garment.

Static Control Garments:

Personnel garments that are designed for electrostatic charge control.

4. Personnel Safety

4.1 The procedures and equipment described in this document may expose personnel to hazardous electrical conditions. Users of this document are responsible for selecting equipment that complies with applicable laws, regulatory codes and external and internal policy. Users are cautioned that this document cannot replace or supercede any requirements for personnel safety. The ultimate responsibility for personnel safety resides with the end user of this document.

ESD-STM2.1-1997**5.2.2.1 Low Humidity**

The test sample shall be preconditioned at $12 \pm 3\%$ RH and 23 ± 3 degrees C for a minimum of 48 hours prior to performing the test at these environmental conditions.

5.2.2.2 Moderate Humidity

The test sample shall be preconditioned at $50 \pm 5\%$ RH and 23 ± 3 degrees C for a minimum of 48 hours prior to performing the test at these environmental conditions.

5.2.3 Test Sample Quantity

Test all samples for each style and manufacturer when using this test procedure as a qualification test.

5.3 Sleeve to Sleeve Test Procedure

- a) Precondition the test samples per 5.2.2.1
- b) Hang garment from each sleeve with electrically isolated clamps. Clamps shall be placed over the sleeves as shown in Figure 1b.
- c) The resistance measurement shall be made by applying the voltage lead (positive) to one clamp and attaching the sensor lead (negative) to the other clamp.
- d) Apply the test voltage of 100V for a maximum of 15 seconds (or until reading stabilizes) and record the results.
- e) Repeat this Sleeve to Sleeve Resistance Measurement procedure (5.3b through 5.3d) with the remaining two (minimum) garment samples.
- f) Precondition the test samples per 5.2.2.2.
- g) Repeat this Sleeve to Sleeve Resistance Measurement procedure (5.3b through 5.3e) with the remaining two (minimum) garment samples at moderate humidity.

5.4 Point to Point Test Procedure

- a) Precondition the test samples per 5.2.2.1.
- b) Place the garment on an insulative surface per 5.1.5.
- c) Place one electrode on a panel of the sample.
- d) Place the second electrode on another panel of the same sample. (Figure 1c)
- e) Apply the test voltage of 100V for a maximum of 15 seconds or until reading stabilizes and record results.
- f) Repeat 5.4d through 5.4e for all panels.
- g) Repeat 5.4b through 5.4f for all test samples.
- h) Precondition samples per 5.2.2.2.
- i) Repeat 5.4b through 5.4g for all samples.

6. Test Data Reporting

Record all resistance values in ohms. Record the voltage levels, humidity, and temperature for each test sample. Record type of test equipment used. Record test date.

7. Recommended Electrical Resistance Range

The recommended electrical resistance range is 1×10^5 ohms to 1×10^{11} ohms. Values less than 1×10^5 ohms may constitute an electrical hazard.

ESD-STM2.1-1997

4.2 Ground Fault Circuit Interrupters (GFCI) and other safety protection should be considered wherever personnel might come into contact with electrical sources.

4.3 Electrical hazard reduction practices should be exercised and proper grounding instructions for the equipment must be followed when performing these tests.

5. Test Methods

This section defines the test methods for measuring the sleeve-to-sleeve and point-to-point electrical resistance of a static control garment or garment system.

5.1 Test Equipment Requirements**5.1.1 Resistance Measuring Equipment**

Self-contained resistance meters (i.e. megohmmeter) or power supplies and current meters in the appropriate configuration for resistance measurement within a $\pm 10\%$ accuracy shall be utilized. The equipment shall be capable of open circuit voltage of 100 ± 10 volts D.C. Both test leads must be isolated from ground.

5.1.2 Clamps/Electrodes (Sleeve to Sleeve)

The electrodes shall consist of two flat electrically conductive plates (e.g. stainless steel) with a dimension of 50.8 mm X 25.4 mm (2 inches X 1 inch) each as shown in figure 1a. The clamps shall be electrically conductive with sufficient pressure to suspend the garment, see figure 1b.

5.1.3 Electrodes (Point to Point)

Use electrodes in accordance with ANSI/EOS/ESD S4.1. (Two cylindrical 2.27 kg (5 pound) electrodes with a diameter of 63.5 mm (2.5 inches) each having contacts of electrically conductive material with a Shore-A (IRHD) durometer hardness of 50-70. The resistance between the two electrodes should be less than

100 kilohms when measured at 10 volts on a metallic surface. Electrodes that meet ASTM F-150 and NFPA 99 also meet these characteristics.)²

5.1.4 Environmental Test Chamber

A closed chamber capable of controlling relative humidity (RH) at $12 \pm 3\%$ RH and $50 \pm 5\%$ RH and temperature at 23 ± 3 degrees C. The humidity indicating instrumentation shall be accurate to $\pm 3\%$ RH in the operation range and traceable to national standards, such as National Institute of Standards and Technology (NIST) in the United States or international standards.³

5.1.5 Support Surface

The support surface shall be a smooth flat insulative surface. Surface resistance of the support surface shall be greater than 1.0×10^{13} ohms when tested in accordance with EOS/ESD S11.11.

5.2 Test Parameters**5.2.1 Sample Preparation**

The test sample shall be processed through 3 cycles of the garment material manufacturer's prescribed cleaning process prior to performing the test.

5.2.1.1 Sample Sketch

Tester should examine the garment's construction and make a general sketch showing separate FRONT and BACK panels used to fabricate the garment. Number the panels for measurement identification purposes from #1 through #n. Identify the sleeves as LEFT and RIGHT.

5.2.2 Humidity

The test samples shall be tested at two humidity conditions.

² American Society for Testing and Materials (ASTM) 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, 610-832-9500

³ National Institute of Standards and Technology, Bldg 820, NIST North, Gaithersburg, MD 20899, 301-948-1784

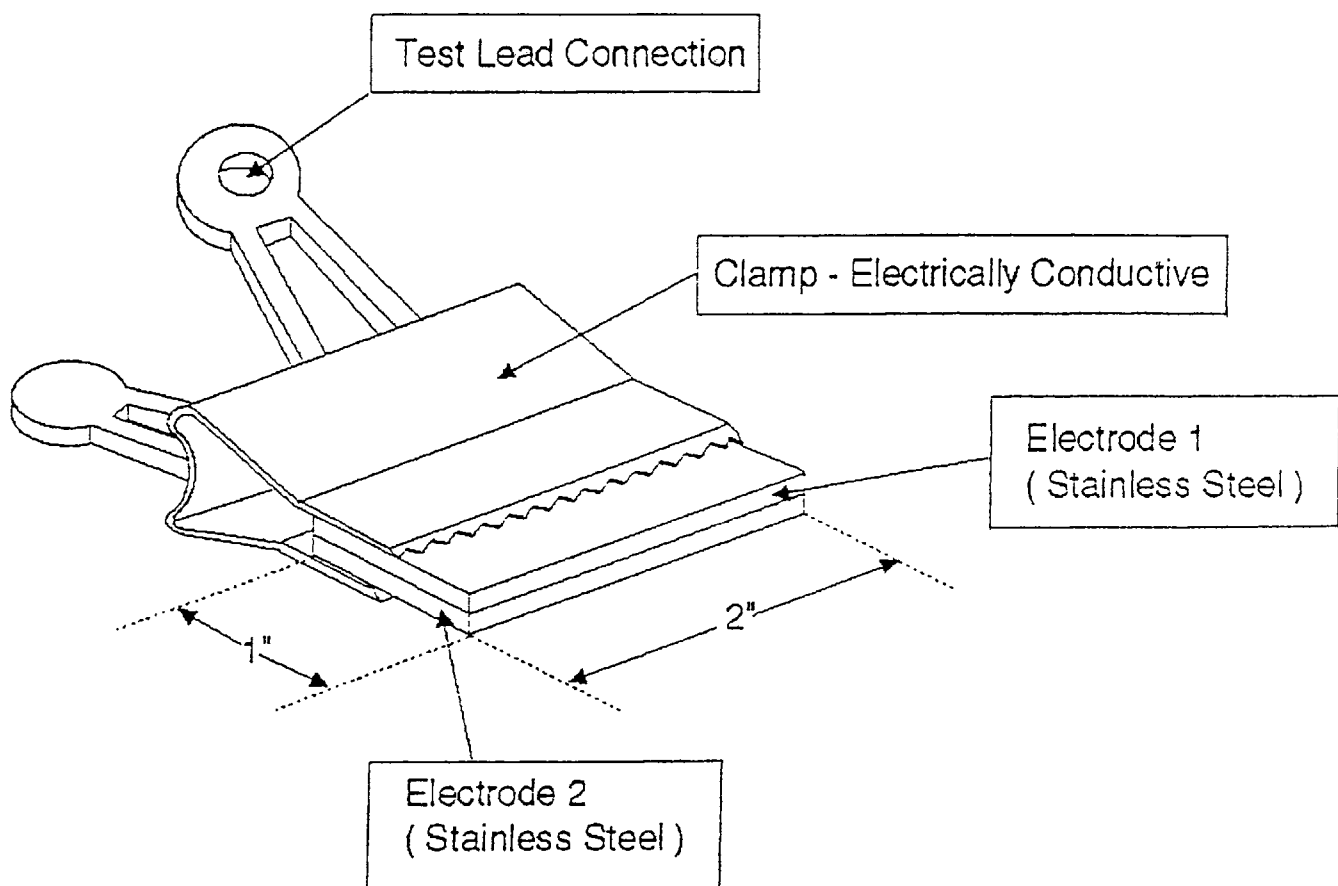
ESD-STM2.1-1997**8. NOTES:****8.1 Garments with Groundable Points**

If the garment has an identified groundable point, the electrical integrity of the groundable point to the garment material shall be measured. This can be accomplished using the point-to-point method described herein. Place one electrode on the groundable point and the second electrode on the panel attached to the groundable point. Complete the test as described herein.

ESD-STM2.1-1997

(Figure 1a)

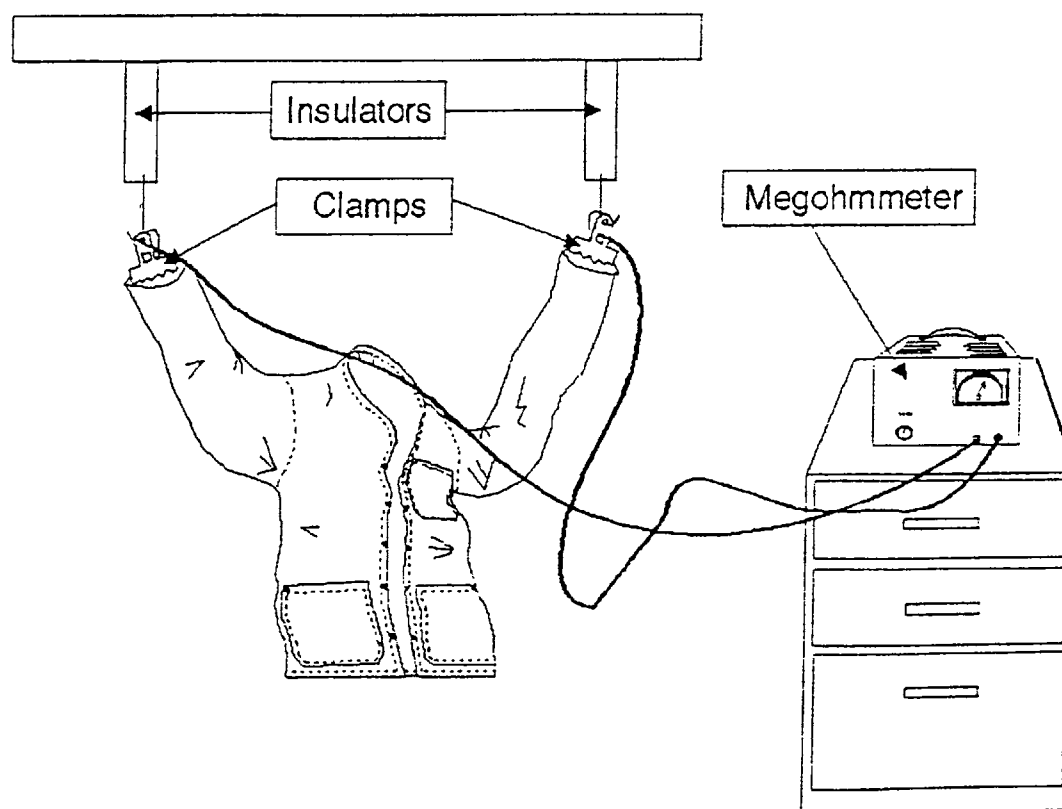
CLAMPS / ELECTRODES



NOTE: Electrode 1 & Electrode 2 shall be stainless steel and each have a minimum area of two square inches on the same contacting surfaces.

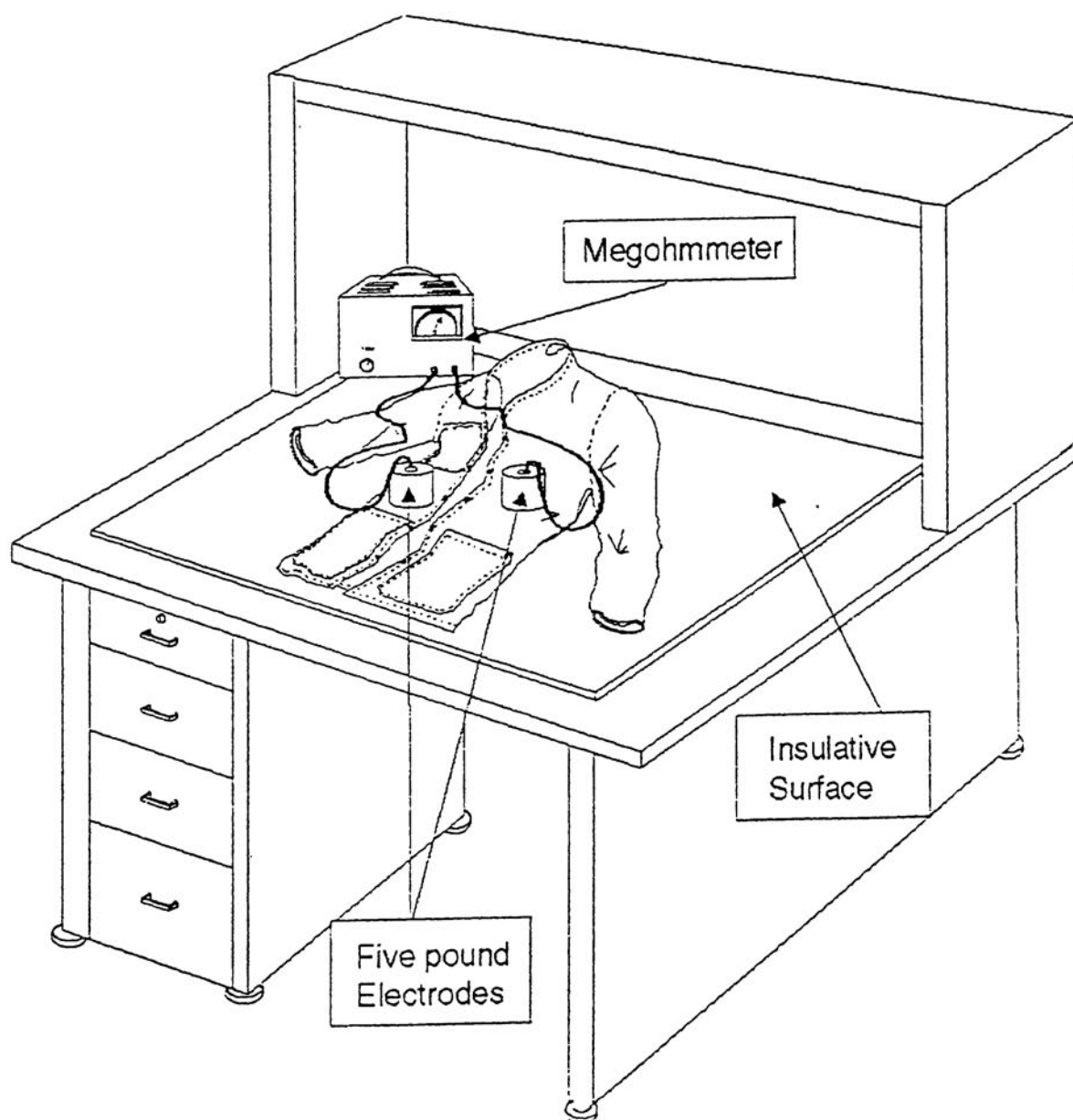
ESD-STM2.1-1997

(Figure 1b)

TEST SET - UP
SLEEVE TO SLEEVE

ESD-STM2.1-1997

(Figure 1c)

TEST SET - UP
POINT TO POINT



Ohm-Stat RT-1000 Resistivity Humidity Temperature, Meter and Accessories



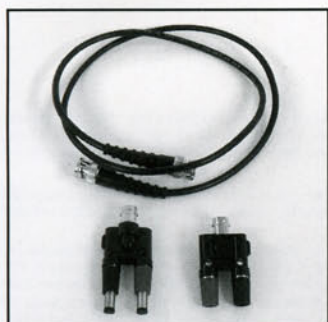
Ohm-Stat RT-1000 Meter

- Measures resistivity, resistance (RTT and RTG)
- Volume Resistance
- Measures temperature and humidity
- High impact traveling case included
- LCD digital display
- External 2 five pound weight probes included
- Built in internal parallel resistivity probes included
- Chair and smock probes included
- Measures at 10 and 100 volts
- NIST and CE mark included
- Ground tester included
- Made in US warranty included



Ohm-Stat MP-6533/FP-1745 Footwear Personnel Tester

- Metal hand probe included
- Stainless steel foot plate to test shoes, person, chairs
- Measure body resistance through shoes and human body
- Measure resistance through shoes to plate
- NIST included
- Calibration included
- Works with RT-1000 and most high quality meters with two external jacks



Ohm-Stat MP-1234 miniature probes

- Two miniature conductive rubber external probes
- One shielded BNC coaxial molded cable with gold center pin
- Two female banana jacks to fit any high quality resistance/resistivity meters such as Static Solutions Ohm-Stat RT-1000 meter
- NIST included
- Made in USA and UL listed
- Calibration certificate included
- Will measure resistance of all small surfaces according to ESD S11.11
- Replaceable probes
- Conforms to all EOS and CE test procedures



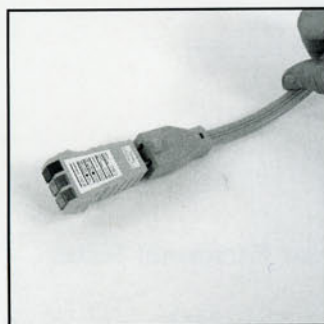
Ohm-Stat CP-1111 concentric ring probe

- Made from conductive rubber shore 50-60
- Two concentric rings will measure surface resistivity
- Five pound weighted probe coated with insulative paint
- Calibrated
- Made in USA
- Warranty
- Value priced
- Will work with all high performance meter i.e. RT-1000
- Test according to ESD S11.11 and ESD S11.12

Static Solutions, Inc.

**Ohm-Stat RP-4323 resistance probes**

- Two (two) five pound probes
- Coated with insulative paint (not dissipative PVC sleeves)
- Conductive rubber, durometer 50-60 Shore A scale
- Easy to carry insulative handles
- Made in USA
- NIST certificate
- Conforms to EOS/ESD standards
- Will work with all high quality meters
- Warranty
- Available with high quality cables
- Use for resistance testing of floors, work surfaces, floor mats, paints and floor finishes

**Ohm-Stat GT-4872 ground/circuit tester**

- Tests ground for all 110 volt electrical circuits
- Will determine the correctness of all electrical grounds
- Easy to use LED lights
- Warranty
- Low cost for EOS 20/20 protection
- Identify electrical problems
- Test according to EOS/ESD 6.1

**GC-5621 Garment Clips**

- Measure resistance of ESD garments
- Stainless steel surface areas
- Test according to ESD-STM2.1-1997
- Use with Ohm-Stat RT-1000 resistivity meter
- Made in USA
- One year warranty

Warranty: Static Solutions, Inc. expressly warrants that for a period of (1) one year from the date of purchase any Static Solutions, Inc. product will be free of defects in materials and will function within its specifications. Within the warranty period, the product will be repaired or replaced at Static Solutions, Inc.'s option with no cost to the customer as long as Static Solutions, Inc. receives notice during the warranty period. Defective products must be shipped prepaid to Static Solutions, Inc.'s factory. Call Static Solutions, Inc. customer service at 508-480-0700 for a return authorization number. Include a copy of the invoice, packing slip, or other proof of purchase.

Warranty Exclusion: The foregoing express warranty is made in lieu of other product warranties express and implied, including merchantability and fitness for a particular purpose which are specifically or indirectly disclaimed. The express warranty will not apply to defects or damage due to neglect, misuse, accidents, alterations, operator error, failure to properly maintain, follow instruction, or failure to clean or repair products.

Limit of Warranty: In no event will Static Solutions, Inc. or seller be responsible or liable for special, incidental or consequential losses or damages, whether based on tort, contract, or the use of or inability to use, the product. Before using the product users shall determine the suitability of the product for their intended use. The users assume all risk and liability whatsoever in connection therewith. Fulfillment of Static Solutions, Inc.'s warranty obligations will be the customer's exclusive remedy and Static Solutions, Inc. and seller's limit of liability for any breach of warranty or otherwise.



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