ESD TR53-01-18
Revision of ESD TR53-01-15

ESD Association Technical Report

ESD TR53-01-18

for the Protection of Electrostatic Discharge Susceptible Items

Compliance Verification of ESD Protective Equipment and Materials

Electrostatic Discharge Association
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FOREWORD

This technical report describes the test procedures and instrumentation that can be used to periodically verify the performance of ESD protective equipment and materials. After ESD protective equipment and materials are installed and in their actual use locations, these compliance verification test procedures are recommended to provide a baseline for comparison with future compliance verification tests. The objective of these test methods is to identify if significant performance changes in ESD equipment and materials have occurred over time and to verify the compliance of ESD protective items within the ESD Control Plan.

The wide variety of ESD protective equipment and materials, and the environment in which they are used may require test setups different from those described in this technical report. Users of this technical report may need to adapt the test procedure and setups (as required) to produce meaningful data for their own application. Organizations who perform these tests will also need to determine the time interval between compliance verification and sample size based on how critical the ESD protective equipment and materials are to their static control program.

All test procedures in this document are based on current standards, standard test methods, and standard practices currently published by the ESD Association.

This technical report was originally designated ESD TR53-01-06 and was published in 2006. ESD TR53-01-15 was a revision of ESD TR53-01-06 and was approved on February 6, 2013. ESD TR53-01-18 is a revision of ESD TR53-01-15 and was approved for publication on May 31, 2018.

At the time ESD TR53-01-18 was prepared, the 53.0 Compliance Verification subcommittee had the following members:

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TABLE OF CONTENTS

ESD Association Technical Report for the Protection of Electrostatic Discharge Susceptible Items – Compliance Verification of ESD Protective Equipment and Materials

1.0 PURPOSE

The purpose of this technical report is to provide compliance verification test procedures and troubleshooting guidance for ESD protective equipment and materials. Test results may be used for the compliance verification plan requirements of ANSI/ESD S20.20 or those of the user.

2.0 SCOPE

This document describes compliance verification testing for the following ESD Protective Equipment and Materials:

- Grounding / Bonding Systems
- Worksurfaces
- Wrist Straps
- Footwear
- Flooring
- Seating
- Air Ionizers
- Mobile Equipment
- Electrical Soldering/Desoldering Hand Tools
- Constant (Continuous) Monitors
- Garments
- Packaging
- Process Required Insulators
- Isolated Conductors

3.0 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 SHALL BE FOLLOWED.

THE RESISTANCE MEASUREMENTS OBTAINED THROUGH THE USE OF THIS TEST METHOD SHALL NOT BE USED TO DETERMINE THE RELATIVE SAFETY OF PERSONNEL EXPOSED TO HIGH AC OR DC VOLTAGES.

4.0 TEST EQUIPMENT

If user defined required limits are outside the specifications of the test equipment, the user should define test equipment that will measure their specific requirements. Test equipment should be used and calibrated according to the manufacturer's recommendations.

4.1 AC Outlet Analyzer

An AC outlet analyzer can be used to indicate the correct wiring of the equipment-grounding conductor. Please note that some AC outlet analyzers may not be able to differentiate ground and neutral wire reversals, hot and neutral wire reversals, and hot and ground wire reversals, or determine if the impedance to ground of the equipment-grounding conductor is within the company specification.

4.2 AC Circuit Tester (Impedance Meter)

The meter should be capable of measuring the impedance of the equipment-grounding conductor from a receptacle (power outlet used for establishing the AC equipment ground) to the neutral bond at the main service equipment panel. The meter should also verify wiring orientation.

4.3 Charged Plate Monitor (CPM)

4.3.1 A Charged Plate Monitor (CPM) as described in ANSI/ESD STM3.1, which consists of an ion collecting plate, a means to charge the ion collecting plate, a means to monitor the ion collecting plate voltage and a timer to measure discharge time. The conductive plate shall be 152 mm by 152 mm (6 inches by 6 inches), and the total capacitance of the test circuit, with plate, while the instrument is in its normal operating mode, shall be 20 pF ± 2 pF.

4.3.2 A portable verification kit (as described in ANSI/ESD SP3.3) may be used for the compliance verification of air ionizers. Portable verification kits are commercially available and typically consist of four components: 1) electrostatic field meter, 2) detachable (isolated conductive) plate, 3) plate charger, and 4) ground cord.

4.4 Concentric Ring Electrode Assembly

The electrode assembly consists of two concentric rings made of conductive materials that make contact with the material under test.

The contact surface material of the electrode assembly shall be a conductive material having a hardness of 50 to 70 on the Shore-A Durometer scale.

The conductive material shall have a volume resistivity of less than 10 ohm-cm.

The inner electrode shall be a solid disk, 30.48 ± 0.64 mm (1.2 ± 0.025 inches) in diameter.

The outer electrode shall be a ring having an inner diameter of 57.15 ± 0.64 mm (2.25 ± 0.025 inches). The width of the outer ring shall be 3.18 ± 0.254 mm (0.125 ± 0.010 inches).

The total weight of the complete electrode assembly shall be 2.27 kg ± 56.7 grams (5 pounds ± 2 ounces).

The electrode assembly described in ANSI/ESD STM11.11 meets these specifications.

4.5 DC Ohmmeter

The meter should be capable of measuring a D.C. resistance of 0.1 ohm through 1.0 megohm (or other added resistance value) with an accuracy of ± 10% of the value being measured.

4.6 Electrostatic Field Meter

A non-contacting sensing instrument used to measure the electric field that results from the static charge on a material. The meter shall be capable of measuring from 0 to ± 2000 volts/inch (78,740 volts/meter) or greater.

4.7 Non-contact Electrostatic Voltmeter

A non-contacting sensing instrument used to measure the surface potential that results from the static charge on a material. The meter shall be capable of measuring from 0 to ± 2000 volts or greater.

4.8 Foot Electrode

A conductive metal plate that is at least 305 mm x 305 mm (12 inches x 12 inches).

4.9 Hand-Held Electrode

A stainless steel, brass or copper round or tubular stock, approximately 2.5 cm (1 inch) in diameter x 7.5 cm (3 inches) or greater in length, with a banana plug receptacle or screw connector attached to one end of the cylinder. All dimensions are nominal.

4.10 High Impedance Contact Electrostatic Voltmeter

A contact sensing instrument with a measurement range of at least 0 to ± 35 volts DC or AC peak, a measurement accuracy of less than ±1%and an input capacitance less than 1.0×10^{13} farads with an input impedance greater than 1.0×10^{14} ohms.

4.11 Insulative Support Surface

A planar (flat) surface, when used for specimen support, shall have a surface resistivity greater than 1.0×10^{13} ohms/square when measured per ASTM D257 or a surface resistance greater than 1.0×10^{12} ohms when measured per ANSI/ESD STM11.11.

For test methods using 2.27 kg (5 pounds), 6.35 cm (2.5 inches) electrodes, an alternate method to verify the properties of the insulative support surface may be used by measuring the resistance point-to-point of the material with the electrodes spaced at least 15 cm (6 inches) apart (edge-to-edge). A resistance point-to-point of at least one order of magnitude greater than the upper limit of the item being measured is required.

4.12 Integrated Checker

A purpose-built instrument intended to indicate a specific resistance parameter that is capable of measuring from 1.0×10^{4} ohms to at least 1.0×10^{11} ohms.

4.13 Resistance Measurement Apparatus

A meter that is capable of making measurements or making indications from 1.0×10^{a} ohms to 1.0×10^{b} ohms. Typically the measurements will be made at 10 volts or 100 volts but instruments with other voltages may be used if correlated to the product qualification meter or laboratory meter before use.

(NOTE: “a” should be one order of magnitude below the lowest measurement and “b” should be one order of magnitude above the highest measurement.)

4.14 Resistance Measurement Electrode(s)

Cylindrical electrode, 2.27 kg ± 2.5% (5 pounds ± 2.5%) with a diameter of 63.5 mm ± 5% (2.5 inches ± 5%) having a contact of electrically conductive material with a Shore-A (IRHD) durometer hardness between 50 and 70. The resistance between two electrodes should be less than 1.0×10^{3} ohms when measured at 10 volts on a metallic surface.

The electrode described in ANSI/ESD STM4.1 meets these specifications.

NOTE: Over time, conductive rubber materials used as the contact surface of the probes can warp. This could cause measurements to change. At this time there is no standardized method to verify if this has occurred but the user should be aware of this phenomenon.

4.15 Two-Point Probe

A two-point probe consists of an insulated metal body with a Teflon® insulator inserted into each end. One insulator holds test leads; the other holds receptacles that accept spring-loaded pins. One receptacle is surrounded by a cylindrical insulator, which is surrounded by a metal shield. The pins are gold plated and have a spring force of 0.465 kg (16.4 oz.) ± 10% at a travel of 4.32 mm (0.170 inches). The pin tips are machined to accept friction fitted 3.18 mm (0.125 inches) diameter electrically conductive rubber electrodes. The rubber has a Shore-A (IRHD) durometer hardness of 50-70 (ASTM Method D2240). The electrodes are 3.18 mm (0.125 inches) long. Electrode volume resistivity is < 500 ohm-cm.

The two-point probe described in ANSI/ESD STM11.13 meets these specifications.

5.0 GROUNDING / BONDING SYSTEMS

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD S6.1, Grounding

ANSI/NFPA 70, National Electric Code

5.1 Objective

The objective of this compliance verification test procedure is to verify that the various grounding/ bonding systems of an ESD protective workstation (and/or ESD protected area) are within the maximum resistance value allowed by the user's specification.

A properly configured ESD protective workstation will have all ESD worksurfaces, fixtures, handling equipment and personnel grounding devices connected to a common point ground. The common point ground is connected to the ESD grounding / bonding reference point, which in most cases will be the AC equipment ground. If an auxiliary ground is used, it should be electrically bonded to the AC equipment ground (see ANSI/ESD S6.1 for details).

5.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- DC Ohmmeter
- AC Outlet Analyzer
- AC Circuit Tester (Impedance Meter)
- Two test leads of sufficient length

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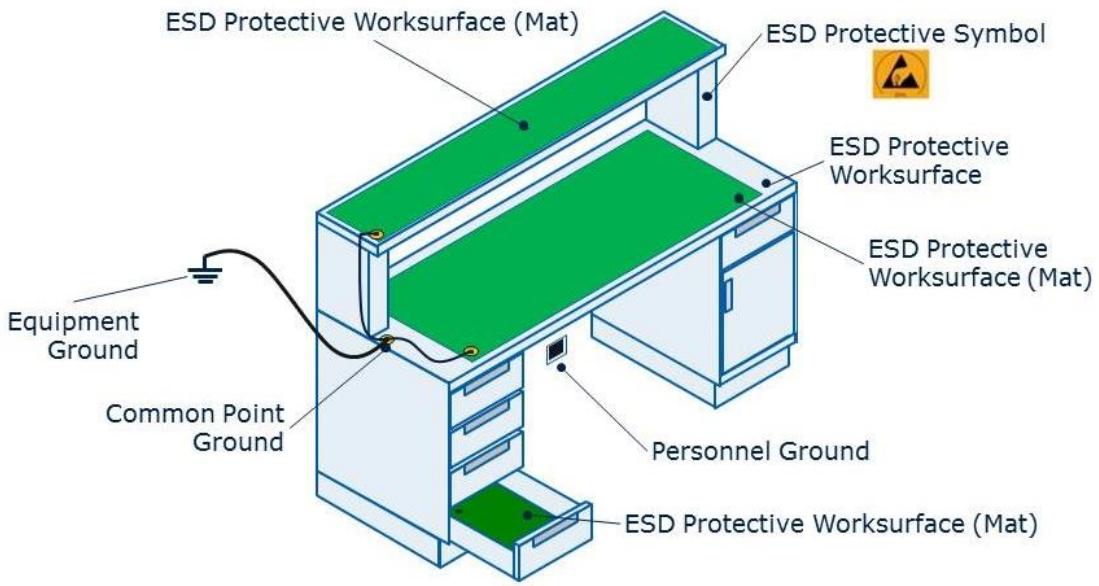

Figure 1: ESD Protective Workstation

5.3 Test Procedure

5.3.1 Electrical Receptacles

Grounding procedures must remain consistent with the National Electric Code (NEC) and other applicable codes. The receptacle wiring verification test is intended to check for the proper wiring of the equipment grounding conductor that is used as the ESD grounding / bonding reference point.

An AC outlet analyzer can be used to indicate the correct wiring of the equipment-grounding conductor. Please note that some AC outlet analyzers may not be able to differentiate ground and neutral wire reversals, hot and neutral wire reversals, and hot and ground wire reversals, or determine if the impedance to ground of the equipment-grounding conductor is within the company specification.

An AC circuit tester can be used to verify the integrity of the electrical circuit wiring as needed.

5.3.1.1 Connect the AC circuit tester (impedance meter) to the AC outlet or receptacle containing the equipment grounding conductor that will be used for the ESD grounding / bonding reference point.

5.3.1.2 Verify the following conditions:

- Neutral and equipment grounding conductor wires are present and not connected to each other at the receptacle (outlet).
- Hot and neutral wires are not reversed.
- Hot and equipment-grounding conductors are not reversed.
- Impedance of the equipment-grounding conductor is within the maximum resistance value allowed by the user's specification.

5.3.2 Personnel Groundable Points

5.3.2.1 Operate the DC ohmmeter according to the manufacturer's instructions.

5.3.2.2 Connect two test leads to the DC ohmmeter.

5.3.2.3 Connect or place one test lead to the personnel groundable point (personnel ground) and the other test lead to the ground reference.

5.3.2.4 Note the resistance.

5.4 Troubleshooting

5.4.1 Electrical Receptacle Failures

Any AC outlet or directly connected equipment (hard wire) that fails the receptacle wiring verification tests must be corrected by qualified personnel before further use or testing.

5.4.2 Personnel Groundable Point Failures

- Visually and mechanically confirm that all termination hardware and grounding wires are not inadvertently loose, broken, or disconnected.
- Test the resistance of the personnel groundable point to common point ground.
- Test the resistance of the common point ground to AC Grounding/Bonding Reference Point.

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

6.0 WORKSURFACES

This compliance verification test procedure is in part based on the following publication(s):

ESD ADV53.1, ESD Protective Workstations

ANSI/ESD STM4.1, Worksurfaces – Resistance Measurements

ANSI/ESD S6.1, Grounding

6.1 Objective

The objective of this compliance verification test procedure is to verify that the ESD worksurface is electrically bonded to the ground reference and is within the minimum and maximum resistance allowed by the user's specification.

This periodic test procedure can also be used for the measurement of shelves, drawers and other grounded ESD protective storage equipment surfaces.

6.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- An integrated checker or meter, whether it is a single meter or a collection of instruments that are capable of measuring at least 1.0 x 10^{10} ohms with a test voltage of 10 and 100 volts (± 10%) DC open circuit or under load.
- One resistance measurement electrode
- Two test leads of sufficient length
- DC Ohmmeter

6.3 Test Procedure

6.3.1 Do not clean the ESD worksurface immediately prior to verification.

6.3.2 Remove all ESD sensitive items from the ESD worksurface.

6.3.3 Conductive items and AC-powered equipment that are part of the workstation and have separate paths to the ground reference should remain connected to their grounds as the ESD worksurface is being verified.

6.3.4 Connect one end of the first test lead to the resistance measurement electrode, and the other end of the first test lead to the integrated checker or meter.

6.3.5 Connect one end of the second test lead also to the integrated checker or meter, and the other end of the second test lead to ground reference.

6.3.6 Place the resistance measurement electrode in the center of the ESD worksurface.

6.3.7 Apply 10 volts and wait 5 seconds, or for the integrated checker or meter to stabilize. If the indicated resistance is less than 1.0×10^6 ohms, note the resistance. If the indicated resistance is equal to or greater than 1.0×10^6 ohms, switch the integrated checker or meter to 100 volts and retest. Note the resistance after the integrated checker or meter stabilizes or after 15 seconds.

NOTE: Switching the test voltage to 100 volts may result in a resistance reading of less than 1.0×10^6 ohms. When this occurs the reading made with the 100 volt test voltage is used.

6.3.8 Tests should include those ESD worksurface areas that are subject to wear or are visibly dirty.

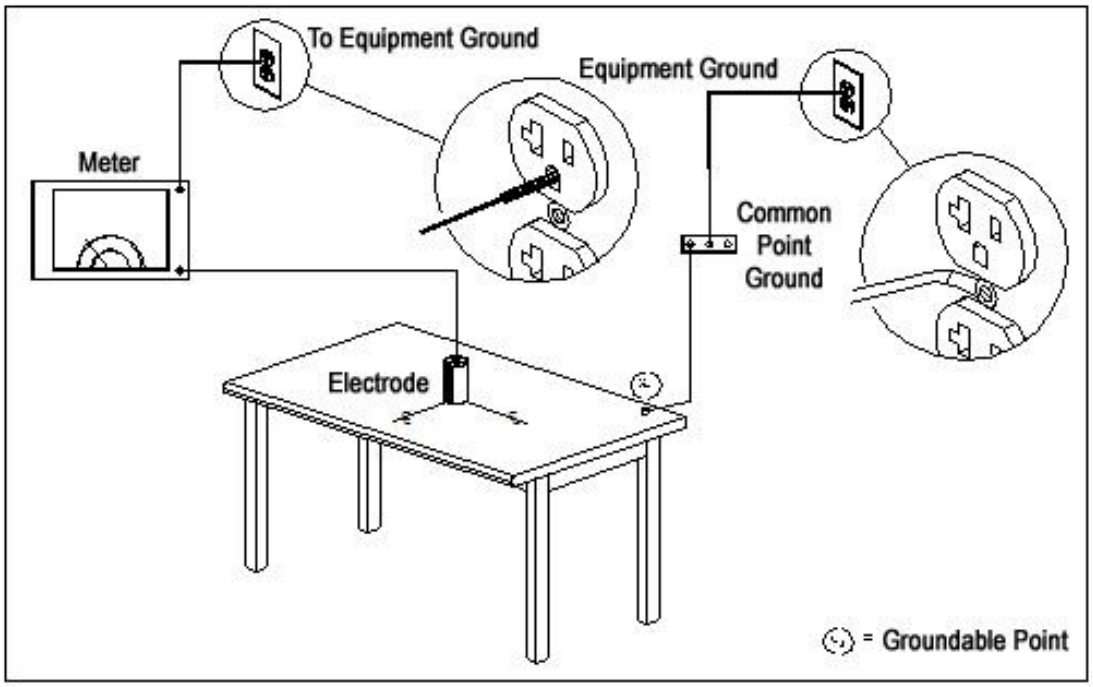

Figure 2: ESD Worksurface Test

6.4 Troubleshooting

6.4.1 Visual / Mechanical Check

- Visually and mechanically confirm that all termination hardware and grounding wires are not loose, broken, or disconnected.

- Examine the ESD worksurface to ensure it is not soiled or worn, which could cause increased surface resistance. If soiled, clean the ESD worksurface with an approved cleaner. Ensure the surface is completely dry before retesting. Periodic cleaning is recommended to maintain proper electrical function of all ESD worksurfaces.
- When checking ESD worksurface mats:
  - Check the connection of the mat fastener to the mat.
  - Check the connection of the ground cord to the mat fastener.
  - Check the connection of common point ground to the ground cord.
  - Check the connection of equipment ground to common point ground.

6.4.2 Electrical Test

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the electrode for dirt buildup. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean electrode, allow the electrode to dry before retesting.
- With an integrated checker or meter, test the resistance of the ESD worksurface to the groundable point. Over time the mechanical connection between the groundable point and the mat might become loose. Ensure that there is a good connection between the groundable point and the mat surface. With a DC ohmmeter, test the resistance of the groundable point to common point ground.
- With a DC ohmmeter, test the resistance of the common point ground to equipment ground.
- Ensure the worksurface material has not deteriorated. To determine this condition, the resistance between two locations on the top of the worksurface (point-to-point) can be performed per ANSI/ESD STM4.1 using an integrated checker or meter and two electrodes with test leads.

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

7.0 WRIST STRAPS

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD S1.1, Wrist Straps

7.1 Objective

The objective of this compliance verification test procedure is to verify that the total series resistance of all of the elements in the wrist strap system is within the minimum and maximum resistance allowed by the user's specification.

7.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- An integrated checker capable of measuring above the required limit of 3.5×10^7 ohms.
- Hand-held electrode
- One test lead of sufficient length

7.3 Test Procedure

7.3.1 Integrated Checker

7.3.1.1 Place the wristband (with your personal ground cord attached) on wrist per your company's procedure. Adjust the wristband if necessary to ensure a snug fit.

7.3.1.2 If applicable, set the wrist strap / footwear integrated checker to the wrist strap setting.

7.3.1.3 Insert/attach the loose end of the ground cord into the integrated checker.

7.3.1.4 With the hand on which the wrist strap is being worn, press and hold the metal contact / test plate until the PASS / FAIL light illuminates and remains illuminated.

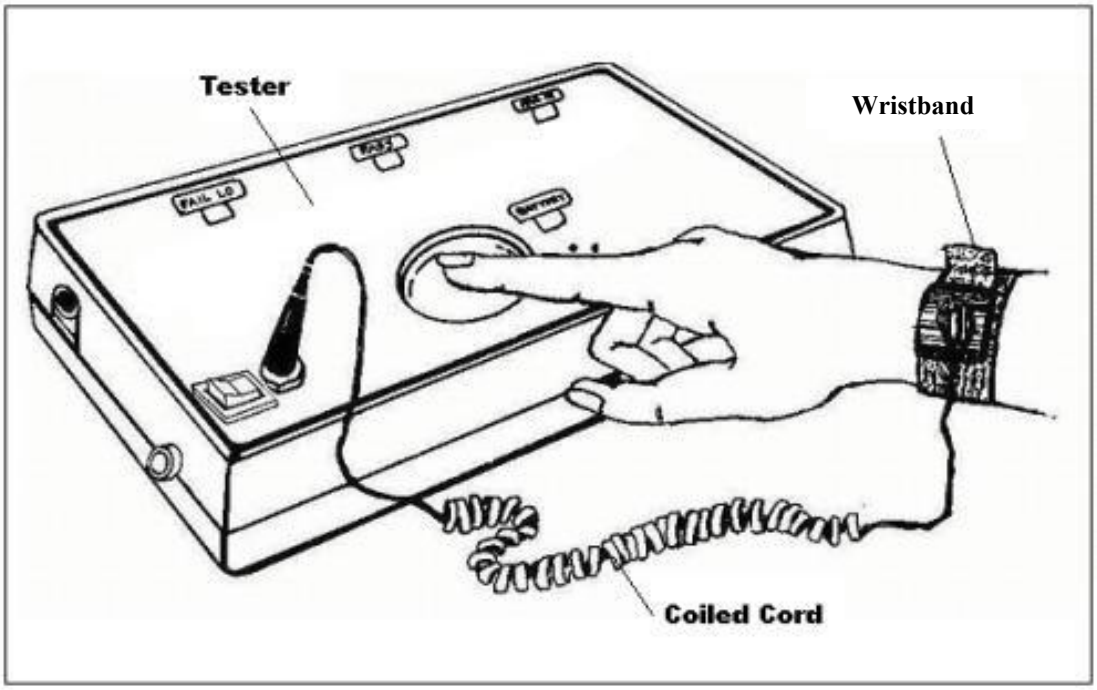

Figure 3: Wrist Strap Test Using Integrated Checker

7.3.2 Meter

7.3.2.1 Place the wristband (with your personal ground cord attached) on wrist per your company's procedure. Adjust the wristband if necessary to ensure a snug fit.

7.3.2.2 Attach the ground cord to the common terminal (-) of the meter.

7.3.2.3 Connect one end of the test lead to the hand-held electrode and connect the other end of the test lead to the positive terminal (+) of the meter.

7.3.2.4 Hold the hand-held electrode with the hand on which the wrist strap is being worn.

7.3.2.5 Energize the meter using 10 volts.

7.3.2.6 Wait for the meter to stabilize.

7.3.2.7 Measure the resistance of the wristband and ground cord system.

7.3.2.8 When using a cloth wristband, it is recommended to periodically test the fabric. This can be performed by pinching the cloth between the thumb and forefinger or by separating the buckle from the skin while testing the wrist strap.

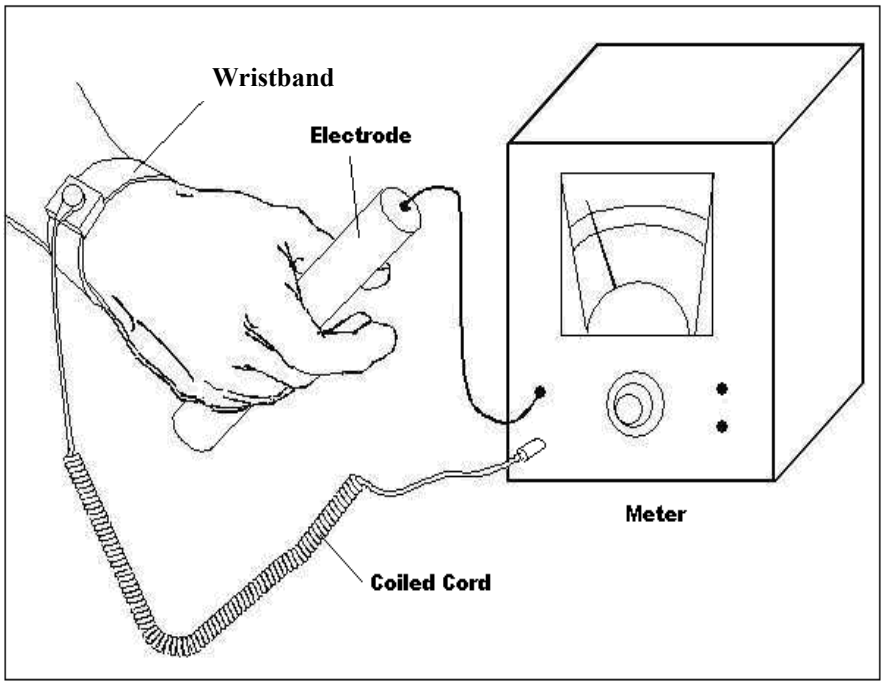

Figure 4: Wrist Strap Test Using Meter

7.4 Troubleshooting

- Verify the test equipment is operating properly, check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the wristband to ensure that it is correctly sized and adjusted snugly to the skin.
- Examine the wristband to ensure it is not soiled.
- Replace the wristband with a new wristband and repeat the test procedure.
- Replace the ground cord with a new ground cord and repeat the test procedure.
- If the steps above are not effective, the person's skin may have a high electrical resistance. Changes in weather can affect the person's skin contact resistance. Some wristbands have a propensity to trap moisture underneath the wristband and can be more effective for people with dry skin. The use of a skin lotion or gel compatible with process requirements may reduce the person's skin contact resistance. If skin lotions and gels are used, more frequent testing during the work shift may be required to ensure their continued effectiveness.

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

8.0 FOOTWEAR

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD STM9.1, Footwear – Resistive Characterization

ESD SP9.2, Footwear – Foot Grounders Resistive Characterization

ANSI/ESD STM97.1, Floor Materials and Footwear – Resistance Measurement in Combination with a Person

8.1 Objective

The objective of this compliance verification test procedure is to verify that the resistance of the footwear system (person and footwear only) is within the minimum and maximum resistance allowed by the user's specification. Footwear may consist of shoes, foot grounders and booties.

8.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- An integrated checker capable of indicating a failure above the required limit (limits not to exceed 1.0 x 10^9 ohms).
- Foot electrode
- Two test leads of sufficient length

8.3 Test Procedure

8.3.1 Integrated Checker

8.3.1.1 Place the ESD footwear on feet per your company's procedure.

8.3.1.2 Place one foot on the integrated checker's foot electrode ensuring the other foot is not in contact with foot electrode or adjacent ESD Flooring. Some integrated checkers may use a dual-foot electrode to allow separate testing of each foot's resistance.

8.3.1.3 Press the integrated checker's contact plate with either hand until the PASS / FAIL light illuminates and remains illuminated.

8.3.1.4 Repeat for other foot; note that some integrated checkers that have dual-foot electrodes may do this measurement automatically.

8.3.2 Meter

8.3.2.1 Place the ESD footwear on feet per your company's procedure.

8.3.2.2 Connect one end of the first test lead to the hand-held electrode, and the other end of the first test lead to the positive terminal (+) of the meter.

8.3.2.3 Connect one end of the second test lead to common terminal (-) of the meter, and the other end of the second test lead to foot electrode.

8.3.2.4 Hold the hand-held electrode with either hand.

8.3.2.5 Place one foot on the foot electrode ensuring the other foot is not in contact with the foot electrode or adjacent ESD flooring.

8.3.2.6 Apply 10 volts and wait 5 seconds for the meter to stabilize. If the indicated resistance is less than 1.0 x 10^6 ohms, note the resistance and repeat for the other foot. If the indicated resistance is equal to or greater than 1.0 x 10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds. Repeat for the other foot.

NOTE: Switching the test voltage to 100 volts may result in a resistance reading of less than 1.0 x 10^6 ohms. When this occurs the reading made with the 100 volt test voltage is used.

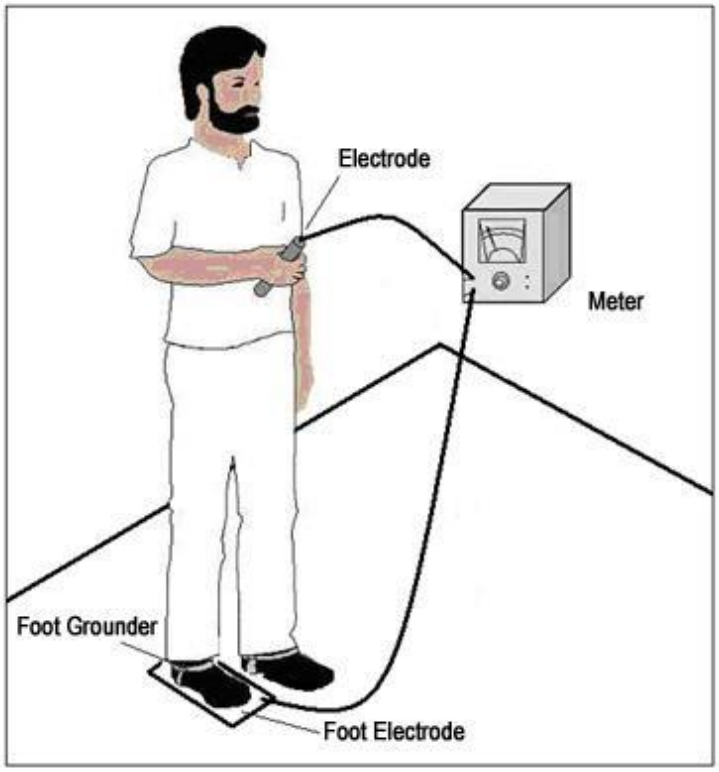

Figure 5: ESD Footwear Test Using Meter

8.4 Troubleshooting

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Ensure ESD footwear is worn properly.
- Examine the ESD footwear to ensure that its sole is not soiled or worn, which could add resistance to the ESD footwear system. If necessary, clean the ESD footwear with an approved cleaner and allow the ESD footwear to dry before retesting.
- Changes in weather can affect the person's skin contact resistance. The use of a skin lotion or gel, compatible with process requirements, may reduce the person's skin contact resistance.
- If necessary, replace the ESD footwear with new ESD footwear and repeat the procedure.

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

9.0 FLOORING

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD S7.1, Floor Materials – Characterization of Materials

9.1 Objective

The objective of this compliance verification test procedure is to verify that the resistance of the ESD flooring is within the minimum and maximum resistance allowed by the user's specification.

An ESD floor may be a permanently or portable installed floor, floor with ESD floor finish, coatings, paints or floor mat(s).

9.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- Integrated checker or meter, whether it is a single meter or a collection of instruments that are capable of measuring at least 1.0 x 10^{10} ohms with a test voltage of 10 and 100 volts (± 10%) DC open circuit or under load.
- One electrode
- Two test leads of sufficient length

9.3 Test Procedure

9.3.1 Do not clean the ESD floor immediately prior to verification.

9.3.2 Connect one end of the first test lead to the electrode, and the other end of the first test lead to the integrated checker or meter.

9.3.3 Connect one end of the second test lead also to the integrated checker or meter, and the other end of the second test lead to ground reference.

9.3.4 Place the electrode on the ESD floor surface.

9.3.5 Apply 10 volts and wait 5 seconds for the meter to stabilize. If the indicated resistance is less than 1.0 x 10^6 ohms, note the resistance. If the indicated resistance is equal to or greater than 1.0 x 10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: Switching the test voltage to 100 volts may result in a resistance reading of less than 1.0 x 10^6 ohms. When this occurs, the reading made with the 100 volt test voltage is used.

9.3.6 Tests should include those ESD flooring areas that are subject to wear or are visibly dirty.

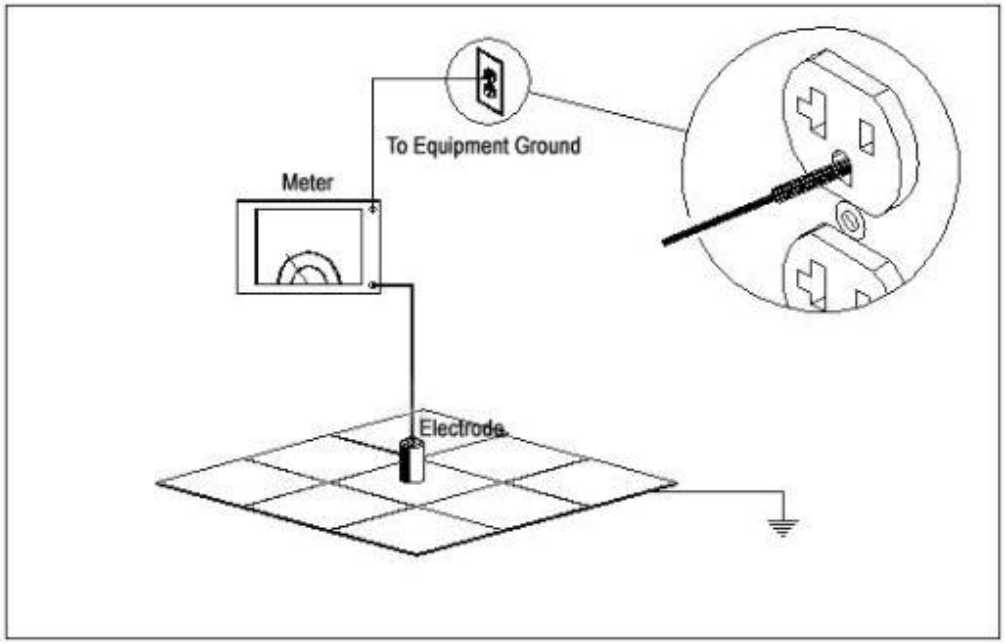

Figure 6: ESD Flooring Test

9.4 Troubleshooting

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the ESD floor for excessive dirt / surface contamination. Remove surface contamination at the test site by following the manufacturer's recommendations.
- Examine the electrode for dirt buildup. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean electrode, allow the electrode to dry before retesting.
- Using an integrated checker or meter and two resistance measurement electrodes with test leads, perform a resistance point-to-point test to verify the ESD floor material is the proper resistance.
- When measuring ESD floor mats:
  - Check the connection of the mat fastener to the mat.
  - Check the connection of the ground cord to the mat fastener.
  - Check the connection of common point ground to the ground cord.
  - Check the connection of equipment ground to common point ground.
- 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.

ESD equipment and materials that cannot be brought into compliance should be taken out of service.

10.0 SEATING

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD STM12.1, Seating – Resistive Measurement

10.1 Objective

The objective of this compliance verification test procedure is to verify that the resistance of the ESD chair grounding system (chair through grounded ESD flooring) is within the minimum and maximum resistance allowed by the user's specification.

10.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- An integrated checker or meter, whether it is a single meter or a collection of instruments that are capable of measuring at least 1.0 x 10^{10} ohms with a test voltage of 10 and 100 volts (± 10%) DC open circuit or under load.
- One resistance measurement electrode
- Two test leads of sufficient length

10.3 Test Procedure

10.3.1 Place the ESD protective chair on an installed ESD floor. Do not clean the ESD floor or chair immediately prior to verification.

10.3.2 Connect one end of the first test lead to the resistance measurement electrode and connect the other end of the first test lead to the integrated checker or meter.

10.3.3 Connect one end of the second test lead also to the integrated checker or meter and connect the other end of the second test lead to ground reference.

10.3.4 Place / hold the resistance measurement electrode on the center of the seat panel of the chair (center the electrode on any worn areas).

NOTE: When holding the electrode, ensure the operator is not a parallel resistance path that can reduce the resistance measurement. The electrode should be insulated from the operator by a resistance greater than 1.0×10^{10} ohms when measured at 100 volts. This may be accomplished by using either an insulative sleeve over the electrode or body, or by the operator using an insulative glove or similar material.

10.3.5 Apply 10 volts and wait 5 seconds for the meter to stabilize. If the indicated resistance is less than 1.0×10^6 ohms, note the resistance. If the indicated resistance is equal to or greater than 1.0×10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: If the resistance reading is below 1.0×10^6 ohms at 100 volts after the 10 volt reading, the reading at 100 volts is the measurement used.

10.3.6 Optionally the following areas of the chair can be checked

- Center of the seat back
- Foot ring (if so equipped)
- Arm rests (if so equipped)

10.3.7 Tests should include those areas on the ESD chair that are subject to wear or are visibly dirty.

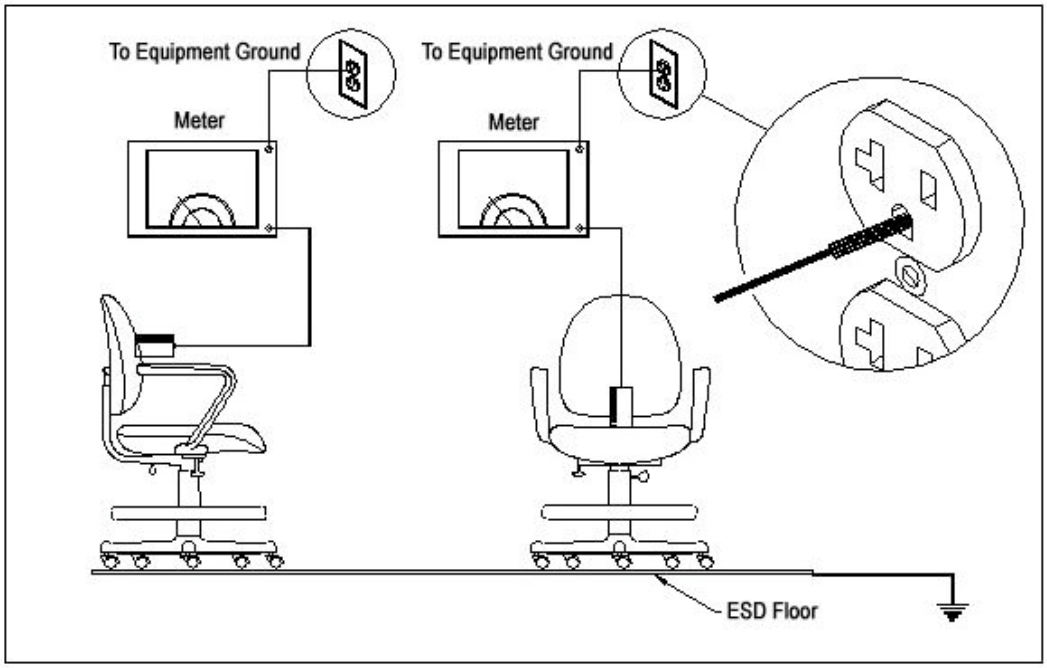

Figure 7: ESD Chair Test

10.4 Troubleshooting

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the electrode for dirt buildup. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean electrode, allow the electrode to dry before retesting.
- Verify the resistance of the ESD floor surface to reference ground. If the ESD flooring surface resistance is high, clean the floor with an approved cleaner. Allow the floor to dry before retesting. If the floor passes after cleaning, retest the chair. If the floor fails, go to troubleshooting in the flooring section.
- Clean the groundable point (i.e., wheels / casters / drag chain) with approved cleaner and allow drying before retesting. Verify that the resistances of the chair's components have an appropriate resistance using two electrodes (point-to-point resistance testing). This testing will help isolate a defective component (or connection between the chair's components).
- Clean / vacuum the cloth seat, or clean the vinyl seat with an approved cleaner (allow the vinyl to dry) and retest.

ESD equipment and materials that cannot be brought into compliance should be taken out of service.

11.0 AIR IONIZERS

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD STM3.1, Ionization

ANSI/ESD SP3.3, Periodic Verification of Air Ionizers

11.1 Objective

The objective of this compliance verification test procedure is to verify that the discharge times and offset voltage (ion balance) of air ionizers is in compliance with the user's specification.

The test steps in this periodic test procedure are common for the following classes of ionizers: room, laminar flow hood, worksurface and automated equipment (bench top and overhead), and compressed gas (gun or nozzle).

11.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- A charged plate monitor (as specified in ANSI/ESD STM3.1) or a portable verification kit (as specified in ANSI/ESD SP3.3).
- A stopwatch or other suitable timer is typically used to measure discharge times with portable verification kits.

11.3 Test Procedure

11.3.1 Initial Test Setup

Measurements should be made at the location where ESD sensitive items are to be ionized.

Air ionizer heaters and air filters (if so equipped) should be left in their normal conditions during test.

11.3.2 Discharge Time Test

11.3.2.1 Turn the test equipment on and allow it to stabilize per the manufacturer's recommendations.

11.3.2.2 Momentarily ground the isolated conductive plate and set (or verify) zero voltage.

11.3.2.3 After the isolated conductive plate is disconnected from ground do not zero (or charge) the portable verification instrument in the presence of the ion field.

11.3.2.4 Charge the isolated conductive plate to a convenient voltage more than the initial test voltage for each polarity (e.g., ± 1200 to ± 1500 volts).

11.3.2.5 Ensure the isolated conductive plate is facing the air ionizer's airflow.

11.3.2.6 The discharge time measurement begins when the test plate voltage has decayed to the initial test voltage (typically ± 1000 volts) and stops when the test plate voltage has decayed to the final test voltage (typically ± 100 volts).

11.3.2.7 Repeat steps above for the opposite polarity.

11.3.2.8 Note the discharge time in seconds for each polarity.

11.3.3 Offset Voltage Test (Balance)

11.3.3.1 Turn the test equipment on and allow it to stabilize per the manufacturer's recommendations.

11.3.3.2 Momentarily ground the isolated conductive plate and set (or verify) zero voltage.

11.3.3.3 After the isolated conductive plate is disconnected from ground do not zero the portable verification instrument in the presence of the ion field.

11.3.3.4 Place the isolated conductive plate facing the air ionizer's airflow.

11.3.3.5 Wait for the reading to stabilize.

11.3.3.6 Note the offset voltage (balance).

11.4 Troubleshooting

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Check that the test equipment is properly grounded.
- Check that there are no large conductive objects in the area that could cause ion attraction to their surface.
- Check that items in the work area are not blocking the airflow.
- Check fans for proper operation.
- Check air filters for clogging with dust and dirt. Clean or replace air filter as necessary.
- After removing electrical power, check emitter points (they should be clean and not bent or broken). Clean or replace if necessary, following the manufacturer's instructions. Allow emitter points to dry before retesting.
- Check electrical equipment grounds for grounding integrity.

- If applicable, adjust the offset voltage (balance) of the ionizer following the manufacturer's instructions.
- If applicable, check alpha sources for service life date. Replace if necessary, following the manufacturer's instructions.
- If applicable, check the alpha source's case to ensure it is properly grounded per the manufacturer's instructions.

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

12.0 MOBILE EQUIPMENT

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD S6.1, Grounding – Recommended Practice

ESD ADV53.1, ESD Protective Workstations

ANSI/ESD STM4.1, Worksurfaces – Resistance Measurements

12.1 Objective

The objective of this compliance verification test procedure is to verify that the resistance of the mobile equipment (such as carts) grounding system (mobile equipment through grounded floor) is within the minimum and maximum resistance allowed by the user's specification.

Mobile equipment that is grounded with a ground cord should be tested according to the Worksurfaces section of this document.

12.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- Integrated checker or meter, whether it is a single meter or a collection of instruments that are capable of measuring at least 1.0 x 10^{10} ohms with a test voltage of 10 and 100 volts (± 10%) DC open circuit or under load.
- Resistance Measurement Electrode
- Two test leads of sufficient length

12.3 Test Procedure

12.3.1 Place the mobile equipment on a grounded ESD protective floor.

12.3.2 Do not clean the ESD floor immediately prior to verification.

12.3.3 Remove all ESD sensitive items from the mobile equipment.

12.3.4 Connect one end of the first test lead to the electrode, and the other end of the first test lead to the integrated checker or meter.

12.3.5 Connect one end of the second test lead also to the integrated checker or meter, and the other end of the second test lead to ground reference.

12.3.6 For each mobile equipment working surface, place the electrode on the center of the working surface.

12.3.7 Apply 10 volts and wait 5 seconds for the meter to stabilize. If the indicated resistance is less than 1.0 x 10^6 ohms, note the resistance. If the indicated resistance is equal to or greater than 1.0 x 10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: If the resistance reading is below 1.0 x 10^6 ohms at 100 volts after the 10 volt reading, the reading at 100 volts is the measurement used.

12.3.8 Tests should include those areas on the mobile equipment that are subject to wear or are visibly dirty.

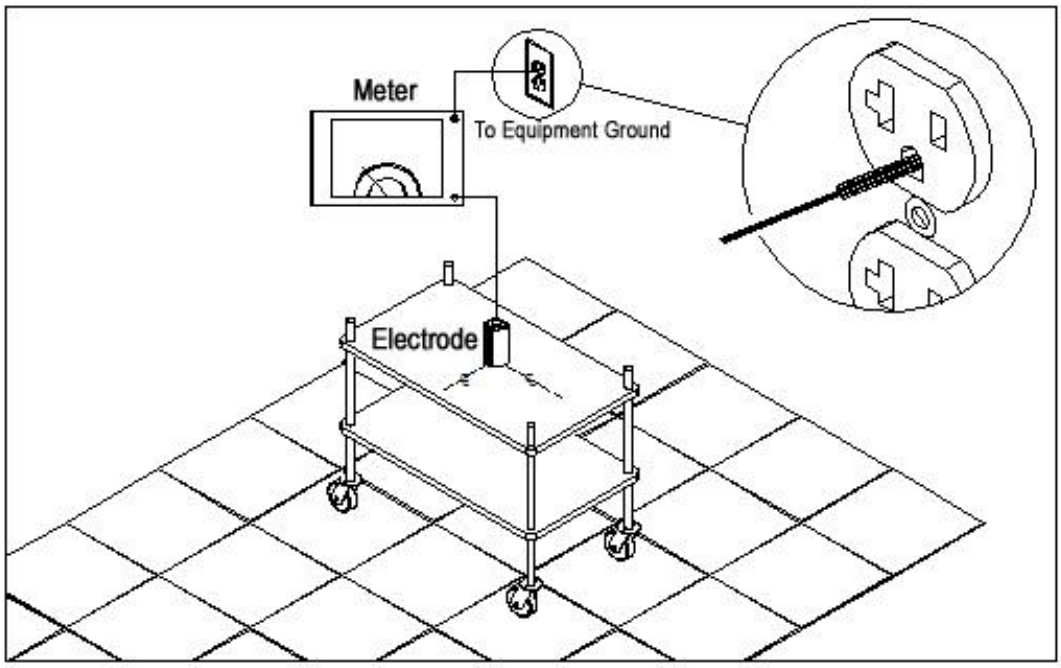

Figure 8: ESD Mobile Equipment Test

12.4 Troubleshooting

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Verify that the floor resistance to ground meets defined requirements.
- Verify the components of the cart are not electrically isolated.
- Visually check to ensure that the groundable point(s) (for example drag chain / cables / casters / wheels, etc.) used to ground the mobile equipment to the floor are not soiled and are attached securely (clean accordingly, if necessary).
- Examine the grounding connections of the mobile equipment working surfaces.
- Examine the groundable point(s) on the mobile equipment to ensure that they are not soiled or worn, which could add resistance to the mobile equipment grounding system. If soiled, clean the groundable point(s) on the mobile equipment with an approved cleaner, and repeat the procedure.
- Examine the electrode for dirt buildup. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean electrode, allow the electrode to dry before retesting.

- Drag chains/cables have been known to be unreliable for grounding mobile equipment (see ESD TR20.20 - Handbook for further guidance).

ESD equipment and materials that cannot be brought into compliance should be taken out of service.

13.0 ELECTRICAL SOLDERING/DESOLDERING HAND TOOLS

This compliance verification test procedure is in part based on the following publication(s):

ESD STM13.1, Electrical Soldering/Desoldering Hand Tools

ESD TR20.20, Handbook

13.1 Objective

The objective of this compliance verification test procedure is to verify that non-RF soldering and desoldering hand tools are within the user's specifications. This is accomplished by means of two tests. One for resistance to ground (two methods, hot and cold iron), and the second for current leakage to ground as measured by tip voltage. It is recommended that both tests be conducted.

13.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- Test Electrode

  The test electrode shall be single-sided or double-sided printed copper clad circuit board material (commonly referred to as 2 oz. copper clad), or solid copper, 1.6 mm (0.062 inch) thick, or equivalent. Tin the electrode prior to use. To tin the electrode, apply a small amount of solder to a small area near the end of the electrode that will be used as the point of contact for measurements.

  NOTE: The electrode is designed to be able to sustain heat incurred while being wet with solder from the hot soldering iron tip of the unit under test. This electrode is designed to be replaceable since it will deteriorate after repeated testing. The length of interconnecting wires should be kept as short as possible to ensure the highest accuracy in test results.

- An integrated checker

  NOTE: If an integrated checker is not available testing may be performed using a collection of instruments as defined in ANSI/ESD S13.1 capable of measuring 0-100 ohms and 0-20 millivolts.

13.3 Test Procedure

Precautions – The following steps involve working with items having very hot surfaces (test electrodes and soldering iron tips).

13.3.1 Soldering Iron Tip Voltage Test Procedure

13.3.1.1 Set the function selector of the tester to the mVAC position.

13.3.1.2 Connect the power cord of the soldering iron under test in accordance with the tester's instruction manual. Turn the soldering iron under test on and allow it to stabilize.

13.3.1.3 Touch the tip of the soldering iron to the sensor point of the tester.

13.3.1.4 Evaluate the indicated voltage against the maximum voltage requirement.

13.3.2 Soldering / Desoldering Hand Tools Resistance to Ground

13.3.2.1 Set the function selector of the tester to the resistance position.

13.3.2.2 Connect the power cord of the soldering iron under test in accordance with the tester's instruction manual. Turn the soldering iron that is under test on and allow it to stabilize.

13.3.2.3 Touch the tip of the soldering iron to the sensor point of the tester.

13.3.2.4 Note the resistance reading.

13.3.3 Soldering / Desoldering Hand Tools Resistance to Ground-Cold Iron

13.3.3.1 Use an ohmmeter with a set of sharp pointed leads that accepts alligator clips and is capable of measuring 0.1 to 10 ohms with ± 1.0% accuracy

13.3.3.2 Disconnect the iron from the AC power outlet and let it cool to room temperature.

NOTE: Be sure the solder tip or element is installed into the handle securely.

13.3.3.3 Attach the positive lead of the ohmmeter with an alligator clip to the safety grounding prong of the unplugged power cord.

13.3.3.4 Press the negative meter probe firmly against the tinned surface of the soldering iron's tip.

13.3.3.5 Note the resistance.

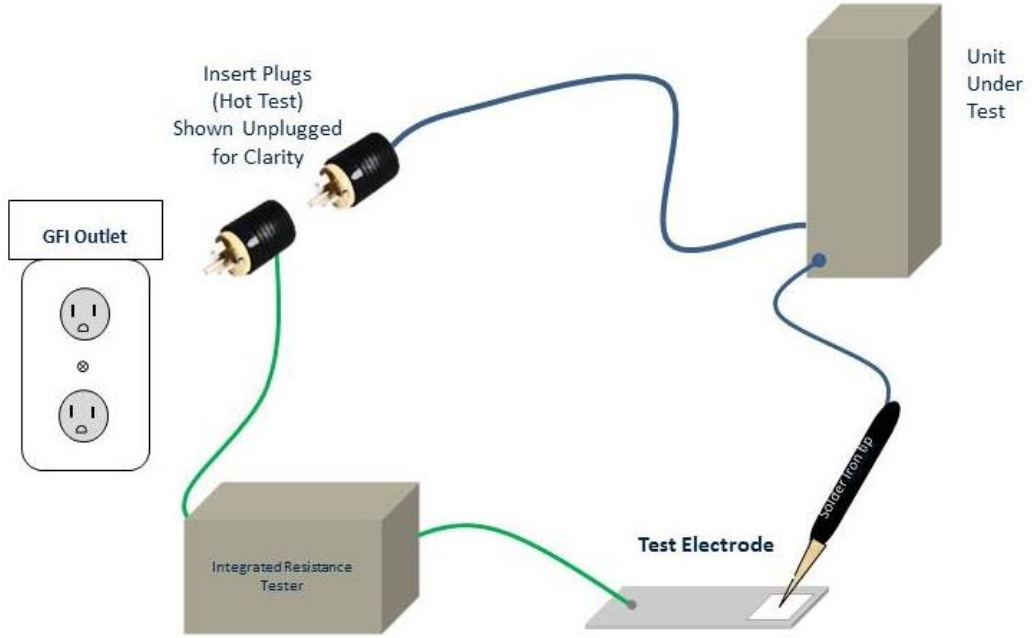

Figure 9: Resistance Measurement Pictorial

13.4 Troubleshooting

- Visually and mechanically confirm that all leads, cables, and wires are not inadvertently loose, broken, or disconnected.
- Check for proper tip cleaning and element installation into the handle.

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

14.0 CONSTANT (CONTINUOUS) MONITORS

14.1 Objective

The objective of this compliance verification test procedure is to verify that the constant (continuous) monitor is operating as designed.

Constant (continuous) monitors are designed to provide ongoing testing of the wrist strap system. While a number of technologies are utilized, the goal remains consistent; electrical connections are tested between the ground point, ground cord, wrist strap and body while the wearer handles ESD sensitive items. Constant monitors may also provide a monitoring circuit for the ESD worksurface connection to the ground reference.

NOTE: Work station monitors do not eliminate the need to perform work station resistance tests.

Compliance verification of the constant (continuous) monitor should be performed to ensure that it is properly functioning within its operating parameters.

14.2 Test Equipment

Consult the manufacturer regarding verification equipment.

14.2.1 Constant (continuous) monitor functions can be verified at the workstation through verification instruments available through the manufacturer of the constant monitor device.

14.2.2 In addition to the functional check, the user should also verify that the operator, workstation elements, etc. that are monitored are properly grounded during use of the monitoring system.

14.3 Test Procedure

Compliance verification of the constant monitor device should follow the manufacturer's instructions.

14.4 Troubleshooting

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Follow the manufacturer's recommendations for failed devices.

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

15.0 GARMENTS

Three categories of garments are considered in this section.

- ESD Category 1 garment; a **static control garment** may suppress or otherwise affect an electric field from clothing worn underneath the garment without being attached to ground. However, without grounding, a charge may accumulate on conductive or dissipative elements of a garment, if present, resulting in a charged source.
- ESD Category 2 garment; a **groundable static control garment,** when connected to ground, provides a higher level of suppression of the effects of an electric field from clothing worn underneath the garment.
- ESD Category 3 garment; a **groundable static control garment system** provides a ground path for a person that suppresses the electrical field from clothing worn underneath the garment and also bonds the skin of the test subject to an identified ground path. Groundable static

control garment systems may also be used in conjunction with a continuous or constant monitoring system in a manner similar to those used in continuous monitoring of wrist straps in an ESD protected area (EPA).

The following subsections describe the various compliance verification tests used to ensure the garment is functioning to meet the requirements of the ESD control program.

15.1 Groundable Static Control Garment System and Panel to Groundable Point Test

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD S1.1, Wrist Straps

ANSI/ESD STM2.1, Garments

15.1.1 Objective

The objective of this compliance verification test procedure is to verify that the total series resistance of all of the elements (including ground cord) in the groundable static control garment system is within the minimum and maximum resistance allowed by the user's specification.

ESD garments may consist of clean room frocks, clean room coveralls, lab coats, jackets, and smocks.

15.1.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- An integrated checker capable of measuring above the required limit. (Limits not to exceed 3.5×10^7 ohms.)
- Hand-held electrode
- Two test leads of sufficient length
- Some integrated checkers require manual selection to wrist strap resistance test ranges.
- NOTE: Verify that the upper resistance of the integrated checker for wrist strap is the same as the upper limit for groundable static control garment systems.

15.1.3 Test Procedure

15.1.3.1 Integrated Checker

15.1.3.1.1 Put on a garment and properly snap or button it per your company's procedure. Ensure the wristbands are snug to the skin. If an adjustable wristband is used, adjust to ensure a snug fit.

15.1.3.1.2 Attach ground cord to the garment's ground cord connection.

15.1.3.1.3 If applicable, switch the wrist strap / footwear integrated checker to the wrist strap setting.

15.1.3.1.4 Insert/attach the loose end of the ground cord into the integrated checker.

15.1.3.1.5 Press and hold the metal contact / test plate with either hand until the PASS / FAIL light illuminates and remains illuminated.

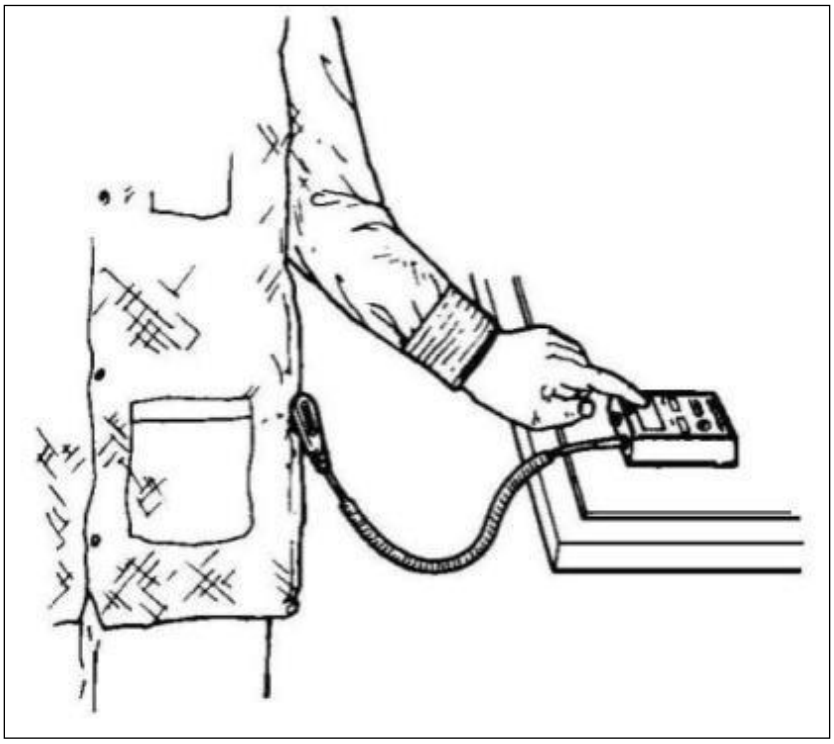

Figure 10: Groundable Static Control Garment System - Using Integrated Checker

15.1.3.2 Meter

15.1.3.2.1 Put on a garment and properly snap or button it per your company's procedure. Ensure the wristbands are tight to the skin. If an adjustable wristband is used, adjust to ensure a snug fit.

15.1.3.2.2 Attach the ground cord to the garment's ground cord connection.

15.1.3.2.3 Connect the loose end of the ground cord to the common terminal (-) of the meter.

15.1.3.2.4 Connect one end of the test lead to the hand-held electrode and connect the other end of the test lead to the positive terminal (+) of the meter.

15.1.3.2.5 Hold the hand-held electrode with either hand.

15.1.3.2.6 Apply 10 volts and wait 5 seconds for the meter to stabilize. If the indicated resistance is less than 1.0 x 10^6 ohms, note the resistance. If the indicated resistance is equal to or greater than 1.0 x 10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: If the resistance reading is below 1.0 x 10^6 ohms at 100 volts after the 10 volt reading, the reading at 100 volts is the measurement used.

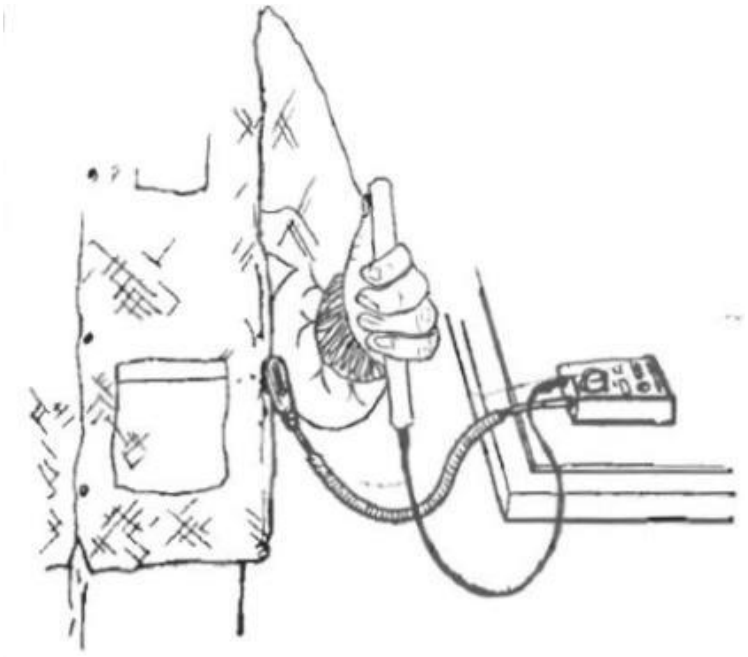

Figure 11: Test Setup – Groundable Garment in Combination with a Person-Hand-Held Probe and Meter

15.1.4 Troubleshooting

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the garment cuff to ensure that it is correctly sized and adjusted to be snug to the skin.
- Examine the garment and cuff area to ensure it is not soiled or torn.
- If the steps above are not effective, the person's skin may have a high electrical resistance. Changes in weather can affect the person's skin contact resistance. The use of a skin lotion or gel compatible with process requirements may reduce the person's skin contact resistance around the cuff area. If skin lotions and gels are used, more frequent testing during the work shift may be required to ensure their continued effectiveness.
- Examine the seams between panels to ensure they are not soiled or torn.
- Replace the old ground cord with a new ground cord and repeat the procedure.
- Replace the garment with a new garment and repeat the procedure.

ESD equipment and materials that cannot be brought into compliance should be taken out of service.

15.2 Static Control Garments and Groundable Static Control Garments Point-To-Point Method

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD STM2.1, Garments

15.2.1 Objective

The objective of this compliance verification test procedure is to verify that the sleeve-to-sleeve (or cuff-to-cuff) resistance of garments is within the minimum and maximum resistance allowed by the user's specification.

ESD garments may consist of clean room frocks, clean room coveralls, lab coats, jackets, and smocks.

15.2.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- A meter, whether it is a single meter or a collection of instruments that are capable of measuring at least 1.0 x 10^{12} ohms with a test voltage of 10 volts and 100 volts (± 10%) DC open circuit or under load.
- Two resistance measurement electrodes
- Two test leads of sufficient length
- Insulative support surface (sufficiently large enough for garments).

15.2.3 Test Procedure

15.2.3.1 Connect the two resistance measurement electrodes to the test leads and connect the test leads to the integrated checker or meter.

15.2.3.2 Place the garment on the insulative support surface.

15.2.3.3 Set the electrodes on each sleeve (or each cuff) of the garment. Ensure the sleeves are separated from the body of the garment.

15.2.3.4 Apply 10 volts and wait 5 seconds for the meter to stabilize. If the indicated resistance is less than 1.0 x 10^6 ohms, note the resistance. If the indicated resistance is equal to or greater than 1.0 x 10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: If the resistance reading is below 1.0 x 10^6 ohms at 100 volts after the 10 volt reading, the reading at 100 volts is the measurement used.

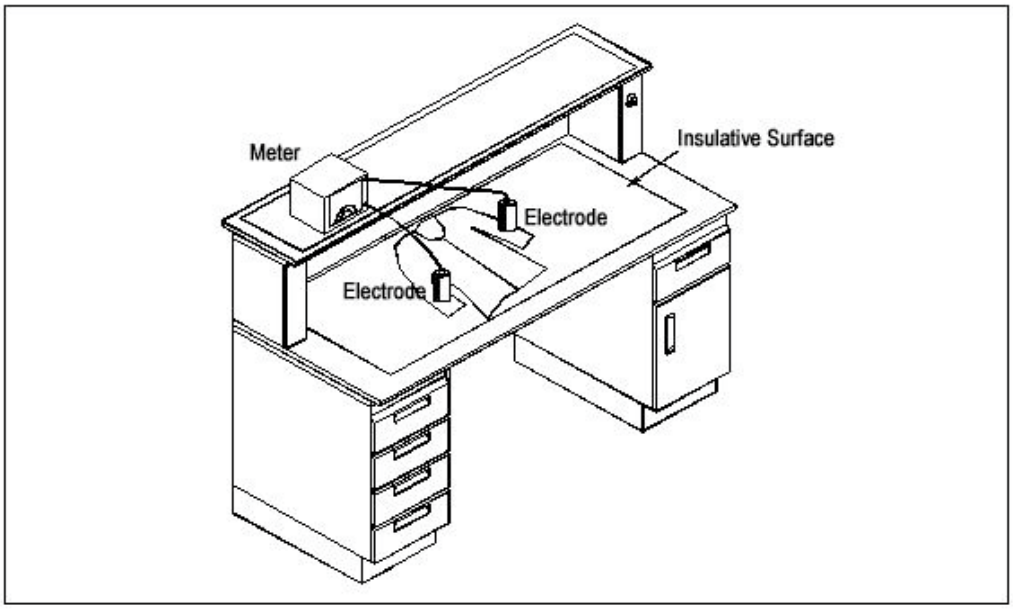

Figure 12: Garment (Point-to-Point) Test

15.2.4 Troubleshooting

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the electrodes for dirt buildup. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean electrodes, allow the electrodes to dry before retesting.
- Examine the garment (e.g., seams between panels) to ensure it is not soiled or torn.
- Review laundry process:
    - High temperatures from washing, drying or ironing may damage the carbon fibers in the garment.
    - Fabric softeners used in the laundry process may coat the fibers.
    - Chlorine bleach may damage conductive fibers (especially silver based fibers).

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

15.3 Static Control Garments and Groundable Static Control Garments Hanging Clamp Method

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD STM2.1, Garments

15.3.1 Objective

The objective of this compliance verification test procedure is to verify that the sleeve-to-sleeve (or cuff-to-cuff) resistance of garments is within the minimum and maximum resistance allowed by the user's specification.

ESD garments may consist of clean room frocks, clean room coveralls, lab coats, jackets, and smocks.

15.3.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- Integrated checker or meter, whether it is a single meter or a collection of instruments that are capable of measuring at least 1.0 x 10^{12} ohms with a test voltage of 100 volts (± 10%) DC open circuit or under load.
- Insulative hanging apparatus (meeting the electrical requirements of the insulative support surface).
- Two clamp electrodes (see figure below)
- Two test leads of sufficient length

15.3.3 Test Procedure

15.3.3.1 Using insulative hanging apparatus hang garment from each sleeve with electrically isolated clamp electrodes.

15.3.3.2 Clamp Electrodes shall be attached as follows;

- For garments equipped with cuffs, attach to the cuffs
- For garment not equipped with cuffs, attach to the end of the sleeves.

15.3.3.3 The resistance measurement shall be made by applying the voltage lead to one clamp and attaching the sensor lead to the other clamp.

15.3.3.4 Apply 10 volts and observe the reading after 5 seconds. If the reading is less than 1.0 x 10^6 ohms, note the resistance. If the reading is greater than or equal to 1.0 x 10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: Switching the test voltage to 100 volts may result in a resistance reading of less than 1.0 x 10^6 ohms. When this occurs the reading made with the 100 volt test voltage is used.

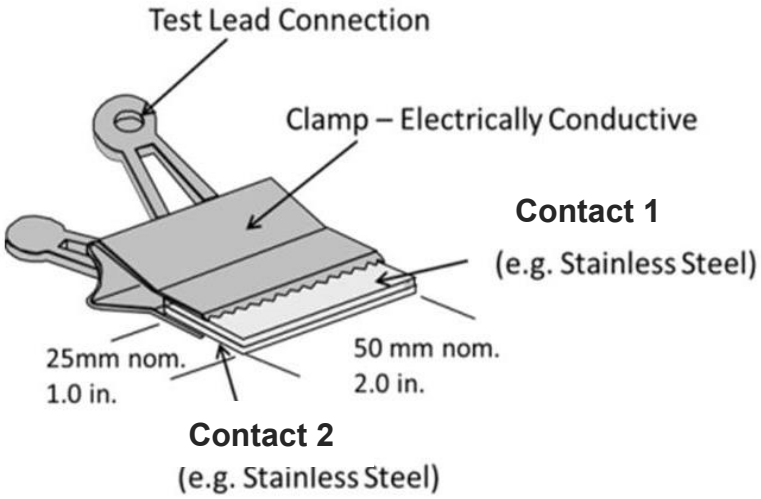

Figure 13: Clamp Electrode for Hanging Garment Test

Figure 14: Alternate Point-To-Point Resistance Measurement

15.3.4 Troubleshooting

- Verify the test equipment is operating properly and check/service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the electrodes for dirt buildup. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean electrodes, allow the electrodes to dry before retesting.
- Examine the garment (e.g., seams between panels) to ensure it is not soiled or torn. Review laundry process:
    - High temperatures from washing, drying or ironing may damage the carbon fibers in the garment.
    - Fabric softeners used in the laundry process may coat the fibers.
    - Chlorine bleach may damage conductive fibers (especially silver based fibers).

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

16.0 PACKAGING

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD S541, Packaging Materials for ESD Sensitive Items

ANSI/ESD S8.1, Symbols - ESD Awareness

ANSI/ESD STM11.11, Surface Resistance Measurement of Static Dissipative Planar Materials

ANSI/ESD STM11.12, Volume Resistance Measurement of Static Dissipative Planar Materials

ANSI/ESD STM11.13, Two-Point Resistance Measurement

16.1 Objective

The objective of this periodic test procedure is to verify the surface or volume resistance of ESD protective packaging that is used in the manufacturing process. ESD protective packaging may consist of waffle packs, bags, totes, bins, and storage boxes, trays, cushion wrap, foam, tubes, tape and reel, shrink-wrap, and any other material used to facilitate in-process material handling.

A well-designed compliance verification program addresses ESD protective packaging because the static control properties of many types of packaging may deteriorate with time and use. These tests cannot be used for shielding effectiveness or energy penetration.

16.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- Integrated checker or meter
- Insulative support surface
- Concentric Ring Electrode
- Two-Point Measurement Electrode
- Conductive metal electrode
- Two Resistance Measurement Electrodes

16.3 Test Procedure

16.3.1 Surface Resistance Using an Integrated Checker or Meter

16.3.1.1 Place the package on the insulative support surface to ensure making measurements that concur with product qualification or acceptance testing data. Measurement on dissipative or conductive surfaces will tend to bias the measurements and may provide erroneous results.

NOTE: Caution is needed when using the insulative support surface for testing inside of an active EPA. All ESDS items should be moved a distance greater than 30 cm (12 inches) from the testing area.

16.3.1.2 Place test electrodes of the integrated checker or meter near the center of the package (or on worn areas).

16.3.1.3 Apply the test voltage and observe the reading

NOTE: If testing bag materials, the inside surface as well as the outside should be tested for surface resistance properties.

16.3.2 Surface Resistance Using a Concentric Ring

16.3.2.1 Place the concentric ring probe near the center of the package (or on worn areas).

16.3.2.2 Apply 10 volts and observe the reading after 5 seconds. If the reading is greater than 1.0×10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: If the resistance reading is below 1.0×10^6 ohms at 100 volts after the 10 volt reading, the reading at 100 volts is the measurement used.

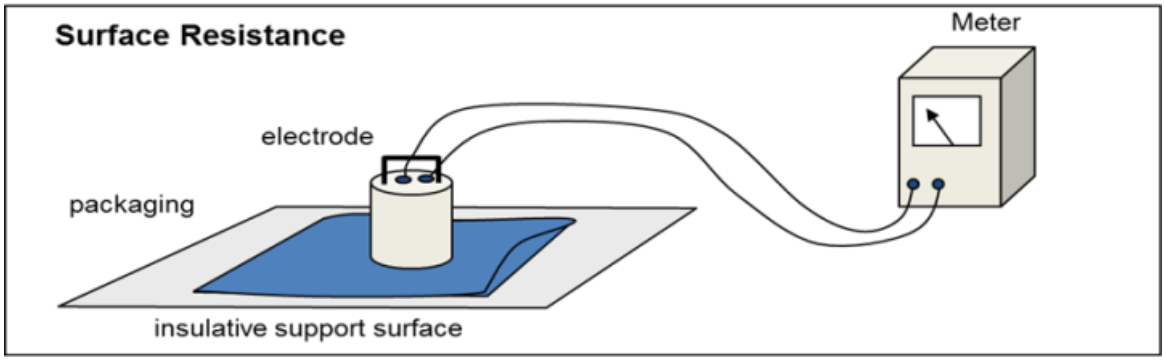

Figure 15: Set-up for Test Method using a Concentric Ring Electrode

16.3.3 Surface Resistance Using a Meter and Two-Point Probe

16.3.3.1 Place the package on the insulative support surface to ensure making measurements that concur with product qualification or acceptance testing data. Measurement on dissipative or conductive surfaces will tend to bias the measurements and may provide erroneous results.

NOTE: Caution is needed when using the insulative support surface for testing inside of an active EPA. All ESDS items should be moved a distance greater than 30 cm (12 inches) from the testing area.

16.3.3.2 Place the test electrodes near the center of the package (or on worn areas). It also is appropriate to place the probe into recessed areas as needed.

16.3.3.3 Apply 10 volts and observe the reading after 5 seconds. If the reading is less than 1.0×10^6 ohms, note the resistance. If the reading is greater than or equal to 1.0×10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: If the resistance reading is below 1.0×10^6 ohms at 100 volts after the 10 volt reading, the reading at 100 volts is the measurement used.

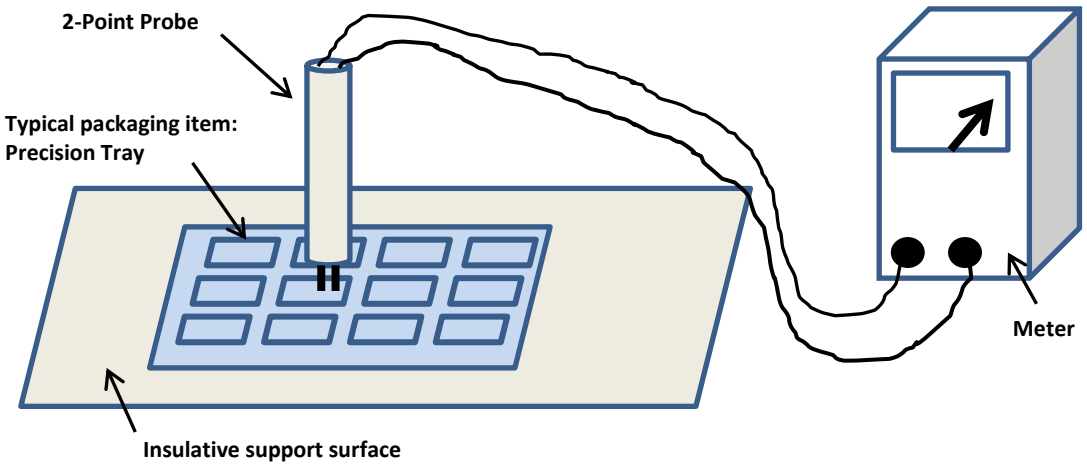

Figure 16: Set-up for Test Method using a Meter and Two-Point Probe

16.3.4 Point to Point Resistance using Resistance Measurement Electrode(s)

16.3.4.1 Place one electrode near the center of the package (or on worn areas) and the second electrode on one corner (or as near as possible).

16.3.4.2 Apply 10 volts and observe the reading after 5 seconds. If the reading is greater the 1.0×10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: If the resistance reading is below 1.0×10^6 ohms at 100 volts after the 10 volt reading, the reading at 100 volts is the measurement used.

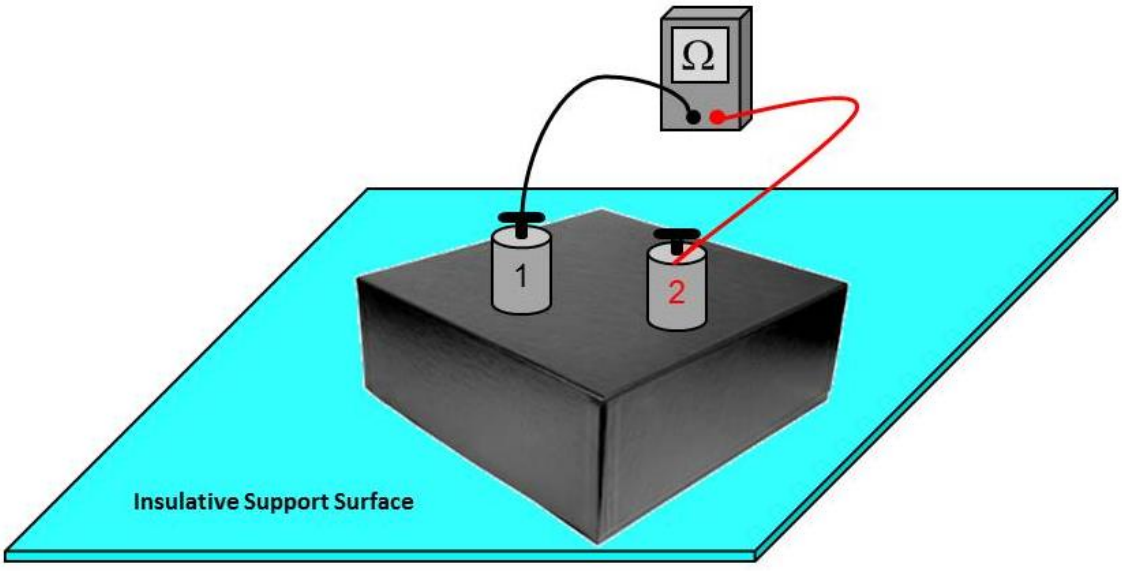

Figure 17: Set-up for Test Method Using Resistance Measurement Electrode(s)

16.3.5 Volume Resistance Using a Resistance Meter

NOTE: This procedure can only be used for volume conductive or static dissipative packaging.

16.3.5.1 Place the ESD packaging on the conductive metal electrode.

16.3.5.2 Place a resistance measurement electrode or concentric ring electrode in the center of the ESD packaging. When using a concentric ring electrode, the meter should be connected to the inner electrode.

16.3.5.3 Apply 10 volts and observe the reading after 5 seconds. If the reading is less than 1.0×10^6 ohms, note the resistance. If the reading is greater than or equal to 1.0×10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: If the resistance reading is below 1.0×10^6 ohms at 100 volts after the 10 volt reading, the reading at 100 volts is the measurement used.

16.3.5.4 Repeat the test for the other samples.

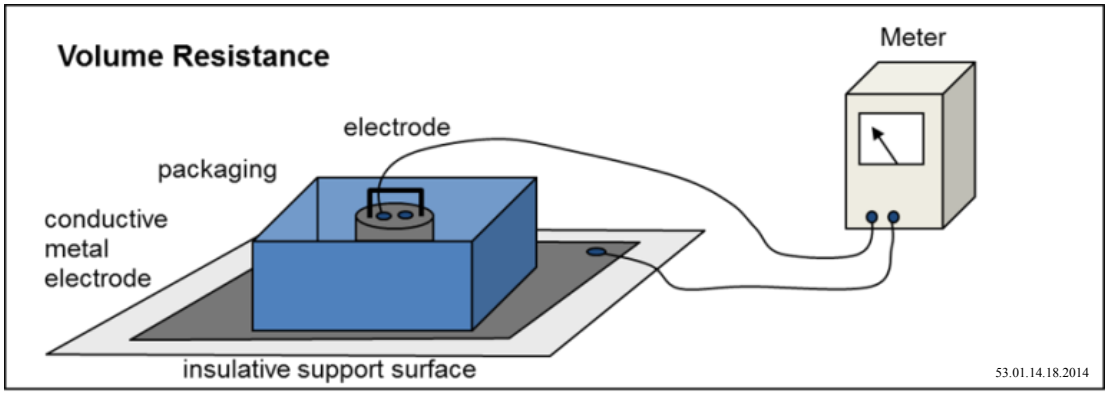

Figure 18: Set-up for Volume Resistance Test Method

16.4 Troubleshooting (Surface and Volume Resistance)

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Packaging with coated surfaces may lose their static control properties if washed or subjected to other chemicals.
- If the tester reads open circuit, check the wires for continuity and connections to terminations. Confirm that the tester's battery is fully charged and that the tester output voltage is correct.
- When measuring packaging with high resistance values, the test wires may pick up interference (line voltage, 60 Hz noise, etc.) causing measurement problems. Move the test set-up to an area with less interference.
- Check the relative humidity of the area. A reduction in humidity could cause an increase in the volume resistance of some packaging.

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

17.0 PROCESS REQUIRED INSULATORS

The use of electrostatic field meters and electrostatic volt meters are referenced in the following publication(s):

ESD TR20.20, Handbook

17.1 Objective

The objective of this compliance verification test procedure is to verify that process required insulators do not exceed the maximum electrostatic field strength or electrostatic potential allowed by the user's specification.

NOTE: Nonessential insulators should be removed from the process environment.

17.2 Test Equipment

- Electrostatic Field Meter
- Non-contact Electrostatic Voltmeter

17.3 Test Procedure Measuring Field Strength on Process Required Insulators

17.3.1 Press or activate the "on" button.

17.3.2 Provide a ground source for the case of the meter.

17.3.3 Zero the Meter - Electrostatic field meters and non-contact electrostatic voltmeters must be zeroed following the manufacturer's instructions before actually making a field strength measurement. This is an important step in that it sets the instrument to zero.

17.3.4 Position the meter at the appropriate distance from the object being measured per the manufacturer's instructions.

17.3.5 Allow the meter to stabilize. The output of the meter may be in volts or volts/inch.

17.3.6 Record the meter reading.

NOTE: The field strength varies with distance. Repeated measurements may provide more complete information on the item being measured.

NOTE: When taking measurements, some materials which are in contact with, or in proximity to a grounded surface, may exhibit a phenomenon known as "field suppression" causing the meter to indicate a lower level of charge than actually may exist on the material. These materials are best measured while separated from other items when possible.

NOTE: Most standard handheld electrostatic field meters are designed and calibrated to measure an object with a minimum surface area of approximately 10.16 cm (4 inches) in diameter. Measuring the electric field present on an item significantly smaller in size could result in an inaccurate electric field strength measurement. The electric field strength on smaller surface areas should still be considered as an indicator that an item has a static charge. The actual electric field may be greater than indicated. Electrostatic voltmeters with specially designed probes or sensors are capable of more accurately measuring static charge of smaller objects.

17.4 Troubleshooting

- Verify the test equipment is operating properly, check / service the battery (if battery operated), following the manufacturer's operating instructions for proper operation.
- If a process required insulator is found with a field strength that exceeds the maximum requirement, then:
    1) Determine whether the highly charged insulator can be replaced with a static dissipative material of the same form and function - if so be sure to ground the static dissipative item upon installation.
    2) Reduce the charge on the insulator by use of an ionizer.
    3) Treat the surface with topical antistat.

- The process required insulator can be moved a minimum of 30 cm (12 inches) from ESDS, if it can be used while maintaining this distance. Caution must be taken to avoid contacting the sensing plate of the field meter. This includes fingers, gloves or any object. Any foreign residue or material on the meter's sensing plate may affect its ability to properly and accurately measure electric field strength.

18.0 ISOLATED CONDUCTORS

18.1 Objective

The objective of this compliance verification test procedure is to verify that difference in potential between any process required isolated conductor(s) and the contacted ESDS item does not exceed the maximum voltage allowed by the ANSI/ESD S20.20 or defined by user's specification.

NOTE: It is recommended that the voltage potential of the ESDS item be considered.

NOTE: Nonessential isolated conductors should be removed from the process environment.

18.2 Test Equipment

- High impedance contact electrostatic voltmeter
- Non-contact electrostatic voltmeter

18.3 Test Procedure for Measuring Potential of Process Required Isolated Conductors

18.3.1 Operate the High impedance contact voltmeter or Non-contact electrostatic voltmeter in accordance with manufacturer's instructions, including any procedures for zeroing and grounding.

NOTE: High impedance contact electrostatic voltmeter measuring instrumentation is more accurate as compared to a non-contact electrostatic voltmeter.

18.3.2 Measure the potential on the isolated conductor under normal operating conditions where charging mechanism are expected.

18.3.3 Position the meter so that it contacts the item being measured per the manufacturer's instructions.

18.3.4 Allow the meter to stabilize.

18.3.5 Record the meter reading.

18.4 Troubleshooting

- Verify the test equipment is operating properly, check / service the battery (if battery operated), following the manufacturer's operating instructions for proper operation.
- If a process required isolated conductor is found with a potential that exceeds the maximum requirement, then:
  1) Determine if it is possible to ground or equipotentially bond the conductor
  2) Reduce the charge on the isolated conductor by use of an ionizer.
- Caution must be taken to avoid contacting the sensing plate of the non-contact volt meter. This includes fingers, gloves or any object. Any foreign residue or material on the meter's sensing plate may affect its ability to properly and accurately measure object's potential.

(This annex is not part of ESD Association Technical Report ESD TR53-01-18)

ANNEX A (INFORMATIVE) - GLOVES AND FINGER COTS - IN-USE RESISTANCE

This compliance verification test procedure is in part based on the following publication(s):

ANSI/ESD S1.1, Wrist Straps

ANSI/ESD SP15.1, In-Use Resistance Testing of Gloves and Finger Cots

A.1 Objective

This document provides test procedures for measuring the electrical resistance of gloves or finger cots together with personnel in a system.

A.2 Test Equipment

Reference Section 4.0 – Test Equipment in the beginning of this document.

- Integrated checker or meter, whether it is a single meter or a collection of instruments that are capable of measuring resistance values greater than the user's specified requirements. Some integrated checkers require manual selection to wrist strap or footwear resistance test ranges.
- Hand-held electrode
- One test lead of sufficient length
- Constant Area and Force Electrode (CAFE) described in Figure 1 in ANSI/ESD SP15.1.

A.3 Test Procedure

A.3.1 Integrated Checker

a) Install glove or finger cot on hands per user's procedure.

b) Place the wristband (with ground cord attached) on wrist per user's procedure. Adjust the wristband if necessary to ensure a snug fit. Some gloves may have a ground point and ground cord can be attached directly to the glove.

c) Switch the wrist strap integrated checker to the proper setting.

d) Insert / attach the loose end of the ground cord into the integrated checker.

e) Wear the glove and wait a minimum of 15 seconds to begin the electrical testing.

With the hand on which the glove or finger cot is being worn, press and hold the metal contact / test plate until the PASS / FAIL light illuminates and remains illuminated.

Figure 19: Wrist Strap Test Wearing a Glove Using Integrated Checker

A.3.2 Constant Area and Force Electrode (CAFE)

a) Place the glove or finger cots on hands per user's procedure.

b) Use a meter capable of applying a voltage of 10 and 100 volts.

c) Attach the wristband to the hand that will wear the glove. Attach the wrist strap cord without the one megohm resistor to one input of the resistance meter. Ensure that the wristband makes a good connection with the skin.

d) Attach the CAFE to the other input of the resistance meter.

e) Wear the glove and wait a minimum of 15 seconds to begin the electrical testing.

f) Balance the CAFE on the fingerprint side of the thumb or finger of choice of the hand wearing the glove.

g) Apply 10 volts and observe the reading after 5 seconds. If the reading is less than 1.0×10^6 ohms, note the resistance. If the reading is greater than or equal to 1.0×10^6 ohms, switch the meter to 100 volts and retest. Note the resistance after the meter stabilizes or after 15 seconds.

NOTE: Switching the test voltage to 100 volts may result in a resistance reading of less than 1.0×10^6 ohms. When this occurs, the reading made with the 100 volt test voltage is used.

Figure 20: Test Wearing a Glove Using Constant Area and Force Electrode

A.4 Troubleshooting

- Verify the test equipment is operating properly and check / service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the wristband to ensure that it is correctly sized and adjusted snugly to the skin.
- Examine the glove, finger cot, and wrist band to ensure it is not soiled.
- Replace the soiled item and repeat the procedure.
- Replace the ground cord and repeat the procedure.
- If the steps above are not effective, the person's skin may have a high electrical resistance. Changes in weather can affect the person's skin contact resistance. The use of a moisturizing lotion or gel compatible with process requirements may reduce the person's skin contact resistance. If moisturizing lotions and gels are used, more frequent testing during the work shift may be required to ensure their continued effectiveness.

Defective ESD equipment and materials that cannot be brought into compliance should be taken out of service.

(This annex is not part of ESD Association Technical Report ESD TR53-01-18)

ANNEX B (INFORMATIVE) - TEST FREQUENCY

The objective of the compliance verification test methods listed in this document is to identify if significant changes in ESD equipment and materials performance have occurred over time.

Test frequency limits are not listed in this document, as each user will need to develop their own set of test frequencies based on the critical nature of those ESD sensitive items handled and the risk of failure for the ESD protective equipment and materials.

Examples of how test frequencies are considered:

- Daily wrist strap checks are sufficient in some applications while in other operations constant wrist strap monitoring may be used for added operator grounding reliability.
- Packaging checks may depend on the composition of the packaging and its use. Some packaging may have static control properties that deteriorate more quickly with time and use, and some packaging may be humidity dependent and may have limited shelf life.
- Some materials, such as ESD floor finishes, may require more frequent monitoring because of their lack of permanency. Other materials, such as ESD vinyl floor covering, may require less monitoring. The testing of a floor should also be considered after maintenance on the floor has been performed.

(This annex is not part of ESD Association Technical Report ESD TR53-01-18)

ANNEX C (INFORMATIVE) – ESD TR53-01 REVISION HISTORY

C.1 2015 Version Changes

1. Added the garments – hanging clamp method section.
2. Added the gloves and finger cots section.
3. Added the handtools section.
4. Added the process required insulators section.
5. Moved some of the required test equipment to the test equipment section at the beginning of the document
6. Repeated some information into other sections.

C.2 2018 Version Changes

1. Consolidated the garments sections (Section 15.0).
2. Moved gloves and finger cots to Annex A.
3. Added isolated conductors.