

ESD TR53-01-22

ESD Association Technical Report

ESD TR53-01-22
Revision of ESD TR53-01-18



***For the Protection of Electrostatic
Discharge Susceptible Items***

***Compliance Verification of ESD
Control Items***

EOS/ESD Association, Inc.
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(This foreword is not part of ESD Association Technical Report ESD TR53-01-22)

FOREWORD

This technical report¹ describes the compliance verification procedures and test equipment that can be used to verify the performance of electrostatic discharge (ESD) control items (previously, protective equipment and materials) after procedures are established and implemented. These compliance verification procedures should be applied to provide a baseline for comparison with future compliance verification results. The objective of these compliance verification procedures is to identify if significant performance changes in ESD control items have occurred over time and to verify compliance with the Organization's ESD control program.

The wide variety of ESD control items and the environments in which they are used may require compliance verification procedures different from those described in this technical report. Users of this technical report may need to adapt the compliance verification procedures and test equipment (as required) to produce meaningful data for their applications. Organizations that perform these compliance verification procedures must determine sample size requirements and time intervals between compliance verification. These should be based on how critical the ESD control items are to their ESD control program.

Compliance verification procedures in this technical report are based on standards, standard test methods, and standard practices currently published by the EOS/ESD Association Inc.

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 on May 31, 2018. ESD TR53-01-22 is a revision of ESD TR53-01-18 and was approved on March 25, 2022.

¹ **Technical Report (TR).** A collection of technical data or test results published as an informational reference on a specific material, system, or process.

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ESD Association Technical Report for the Protection of Electrostatic Discharge Susceptible Items – Compliance Verification of ESD Control Items

1.0 PURPOSE, SCOPE, AND APPLICATION**1.1 Purpose**

The purpose of this document is to provide compliance verification procedures and troubleshooting guidance of test equipment and test setup when used for ESD control items (previously, protective equipment and materials) that have been implemented in ESD control programs, such as those specified in ANSI/ESD S20.20.

The procedures are based on standards, standard test methods, and standard practices currently published by the EOS/ESD Association Inc. and are simplified where necessary.

Organizations may, by reference to this document in their compliance verification plan, adopt the necessary compliance verification procedures described herein without change or addition. Alternatively, compliance verification procedures described in this document may be adapted to match the Organization's ESD control program requirements, provided deviations in test equipment and compliance verification procedures are documented in their compliance verification plan.

1.2 Scope

This document describes compliance verification procedures for the following ESD control items as defined per ANSI/ESD S20.20:

- Grounding/Equipotential Bonding Systems
 - Equipment Grounding Conductor
 - Auxiliary Ground
 - Equipotential Bonding
- Personnel Grounding
 - Wrist Strap System
 - Footwear/Flooring System
 - Groundable Static Control Garment System
- ESD Protected Areas (EPAs)
 - Insulators
 - Isolated Conductors
 - Worksurface
 - Wrist Strap
 - Wristband
 - Personnel Ground Wrist Strap Connection (non-monitored)
 - Continuous Monitors
 - Footwear
 - Foot Grounders
 - Flooring
 - Seating
 - Ionization
 - Shelving (When used to store unprotected ESDS items)
 - Mobile Equipment (Working Surfaces)
 - Electrical Soldering/Desoldering Hand Tools

- Static Control Garment
- Groundable Static Control Garment
- Groundable Static Control Garment System
- Packaging

NOTE: Product qualification of ESD control items is excluded from the scope of this document.

1.3 Application

Compliance verification procedures in this technical report are to be performed by competent personnel familiar with test equipment operation and knowledgeable of the ESD control items being verified.

NOTE: For additional information regarding common failure modes of ESD control items, see ESD TR20.20.

2.0 REFERENCED PUBLICATIONS

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

ESD ADV1.0, ESD Association's Glossary of Terms²

ESD TR20.20, Handbook for the Development of an Electrostatic Discharge Control Program for the Protection of Electronic Parts, Assemblies, and Equipment²

ANSI/ESD S1.1, Wrist Straps²

ANSI/ESD S13.1, Electrical Soldering/Desoldering Hand Tools²

ANSI/ESD S541, Packaging Materials²

ANSI/ESD S6.1, Grounding²

ANSI/ESD S20.20, Protection of Electrical and Electronic Parts, Assemblies and Equipment²

ANSI/ESD SP3.3, Periodic Verification of Air Ionizers²

ANSI/ESD SP3.4, Periodic Verification of Air Ionizer Performance Using a Small Test Fixture²

ANSI/ESD SP3.5, Test Methods for Air Assist Bar Ionizers, Soft X-Ray (Photon) Ionizers, Room Ionization Alternatives, and Non-Airflow Alpha Ionizers²

ANSI/ESD SP9.2, Footwear – Foot Grounders Resistive Characterization²

ANSI/ESD STM2.1, Garments – Resistive Characterization²

ANSI/ESD STM3.1, Ionization²

ANSI/ESD STM4.1, Worksurfaces – Resistance Measurements²

ANSI/ESD STM7.1, Flooring Systems - Resistive Characterization²

ANSI/ESD STM9.1, Footwear – Resistive Characterization²

ANSI/ESD STM11.11, Surface Resistance Measurement of Static Dissipative Planar Materials²

ANSI/ESD STM11.12, Volume Resistance Measurements of Static Dissipative Planar Materials²

ANSI/ESD STM11.13, Two-Point Resistance Measurement²

ANSI/ESD STM12.1, Seating – Resistive Measurement²

ANSI/NFPA 70, National Electric Code³

ASTM D2240, Standard Test Method for Rubber Property—Durometer Hardness⁴

ASTM D257, Standard Test Methods for DC Resistance or Conductance of Insulating Materials

² EOS/ESD Association, Inc., 218 West Court Street, Rome, NY, 13440; +1 315-339-6937; www.esda.org

³ National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471

⁴ ASTM International, PO Box C700, West Conshohocken, PA, 19428 USA, 215-299-5400

ASTM D991, Standard Test Method for Rubber Property – Volume Resistivity of Electrically Conductive and Antistatic Products

3.0 DEFINITIONS

The terms used in the body of this document are in accordance with the definitions found in ESD ADV1.0, ESD Association's Glossary of Terms, available for complimentary download at www.esda.org.

AC equipment ground. Within an EPA, the AC equipment ground is the preferred ground system when it is available. The equipment grounding conductor electrically bonds the AC equipment ground to the ground bus at the main service equipment panel of the facility. AC equipment within the EPA and all the ESD control items are at the same electrical potential when this system is used.

- The ground point at which the equipment grounding conductor is bonded to any piece of equipment, at the equipment end of the conductor in a single-phase electrical service.
- The 3rd wire (green/green with a yellow stripe) terminal of a receptacle.
- The entire low impedance path (electrically equivalent to the equipment grounding conductor) from a piece of electrical equipment to the neutral bus at the main service equipment).

NOTE: Wiring colors may vary in National Electric Codes.

auxiliary ground. A separate supplemental grounding conductor for use other than general equipment grounding.

common connection point. A device or location (less than 1 ohm within itself) where the conductors of two or more ESD control items are connected to bring the ungrounded ESD control items to the same electrical potential through equipotential bonding.

common point ground. A grounded device or location where the conductors of one or more ESD control items are bonded.

electrostatic discharge sensitive (ESDS) item. Electrical or electronic piece part, device, component, assembly, or equipment item that has some level of electrostatic discharge susceptibility. Also referred to as electrostatic discharge susceptible (ESDS) item.

equipotential bonding. Electrical interconnect between two or more elements to achieve the same electrical potential within a system.

ESD control items. All the items, materials, devices, tools, and equipment used to control static electricity within an EPA.

ESD grounding/bonding reference system. The ESD grounding system selected for use in a facility or situation best suited for the application: a) AC equipment ground; b) auxiliary ground; c) equipotential bonding.

foot grounders. A personnel grounding device worn on the shoe. The device makes electrical contact with the surface on which the wearer is standing. The device also contacts the wearer through either direct skin contact or by contacting moisture inside the shoe. This definition includes heel/toe grounders and booties or similar devices (excluding static control shoes).

footwear system. A system consisting of static control footwear (shoes) or foot grounders, properly worn by a person, where the electrical path includes the person, the footwear, and a foot electrode.

ground cord. The portion of the wrist strap that provides the flexibility of movement while completing the electrical circuit between the wristband and ground.

Level 2 technical element. An ESD technical element connected in series to a common point ground or a common connection point (equipotential bonding) through another technical element.

NOTE: A Level 2 technical element can be used as an ESD grounding/bonding reference point, provided it has been previously verified.

resistance point-to-point (Rpp). The resistance in ohms measured from one cylindrical electrode to the other cylindrical electrode on the surface of an ESD control item.

resistance point-to-groundable point (RpGP). The resistance in ohms measured between a single electrode placed on a surface and a groundable point.

resistance to ground (Rtg). The resistance in ohms measured between a single electrode placed on a surface and ground.

static control footwear (shoes). A covering for the human foot that has properties to control the net accumulation of static charge when used in conjunction with a static control floor, floor finish, or floor mat.

wristband. The portion of the wrist strap worn on the wrist. The wristband maintains electrical contact with a person's skin.

wrist strap. An assembled device consisting of a wristband and ground cord that provides an electrical connection of a person's skin to ground.

wrist strap system. A wrist strap that a person properly wears, where the electrical path includes the person, the wristband, and the ground cord.

4.0 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.

5.0 GENERAL USE OF THIS TECHNICAL REPORT

This document is organized by compliance verification sections based on the order that the ESD control items are referenced in ANSI/ESD S20.20. It is separated into general compliance verification objectives; a listing of EOS/ESD Association Inc., standards, standard test methods, or standard practices that this compliance verification procedure is based upon; and test equipment needed to perform the compliance verification, followed by compliance verification procedures using different test equipment, as applicable. Figures that follow the compliance verification test methods are intended as examples only and should be modified as necessary. The troubleshooting section is provided to aid the user in general issues regarding the test equipment used by the compliance verification procedure.

- Test equipment should be verified to be working properly before performing compliance verification procedures following the manufacturer's recommendation.
- Initial compliance verification procedures should be applied when the ESD control item is first brought into service. Subsequent compliance verification of the ESD control item should follow the same compliance verification techniques using the same or similar test equipment.

NOTE: Changes in the compliance verification procedure or test equipment may provide different results.

- Compliance verification of the ESD control item should be performed where the electrostatic discharge sensitive (ESDS) item is likely to reside or to be handled in the process. The intent is to assess the as-found condition of the ESD control item being verified. There should be no modification (for example, cleaning, rubbing, moving, etc.) of the ESD control item prior to verification.

NOTE: For information in determining the risk associated with the ESD control item in an as-used condition, refer to ANSI/ESD SP17.1 – Process Assessment Techniques.

5.1 General Troubleshooting

Troubleshooting procedures are provided within this technical report to assist the end-user in determining common potential failure modes within the compliance verification procedure and/or test equipment.

For troubleshooting common ESD control item failure modes, see ESD TR20.20 - Handbook for the Development of an Electrostatic Discharge Control Program for the Protection of Electronic Parts, Assemblies, and Equipment.

6.0 TEST EQUIPMENT

If the Organization's ESD control program required limits are outside the operating range for the test equipment listed in this section, the user is responsible for defining and documenting the test equipment used to meet their specific requirements.

Test equipment should be calibrated and operated according to the manufacturer's recommendations.

Before use, verify that the test equipment is operating properly, following the manufacturer's operating instructions. Procedures for verifying commonly used equipment can be found in Annexes B through G.

6.1 Charged Plate Monitor (CPM)

A charged plate monitor (CPM) consists of an ion collecting plate, a means to charge the ion collecting plate, a means to measure the ion collecting plate voltage, and a timer to measure discharge time. These four components may be separate instruments or integrated into a single instrument.

The CPM should be capable of measuring the ion collecting plate voltage so that when in the absence of ionization, the ion collecting plate voltage should not decay more than 10% of the initial test voltage within one minute.

The CPM response for measuring discharge time shall be less than 10% of the shortest discharge time expected to be measured.

NOTE: The CPM described in ANSI/ESD STM3.1, ANSI/ESD SP3.3, or ANSI/ESD SP3.4 meet these specifications.

NOTE: CPMs utilizing different isolated ion collection plate sizes, different ion collecting plate voltage measurement techniques, and those with different system capacitances may provide varying results. Isolated ion collection plate correlation should be conducted when switching between instrumentation.

6.2 Circuit Tester

A device that plugs into an electrical receptacle and indicates, typically using lights, that the electrical receptacle is wired correctly or if a fault condition exists.

NOTE: Some circuit testers may not differentiate ground (earth) and neutral wire reversals or determine the impedance to ground of the equipment grounding conductor.

6.3 Clamp/Electrodes

The clamp/electrodes shall consist of two flat electrically conductive plates (such as stainless steel) with a dimension of approximately 50 mm x 25 mm and enough compression force to retain and suspend the ESD control item under test.

6.4 Concentric Ring Electrode Assembly

The electrode assembly consists of two concentric rings made of conductive elastomer, which contact the material under test. The contact surface material of the electrode assembly shall be a conductive elastomer having a hardness of 50 to 70 on the Shore-A Durometer scale. The conductive elastomer shall have a volume resistivity of less than 10 ohm-cm per ASTM D991. The

inner electrode shall be a solid disk, 30.5 mm $\pm$ 1.0 mm in diameter. The outer electrode shall be a ring having an inner diameter of 57.0 mm $\pm$ 1.0 mm. The width of the outer ring shall be 3.0 mm $\pm$ 0.5 mm. The total weight of the complete concentric ring electrode assembly shall be 2.27 kg $\pm$ 0.06 kg.

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

6.5 Contact Voltmeter

A contact sensing instrument that is used to measure the surface potential that results from the electrostatic charge on a material. The meter shall be capable of measuring from 0 volts to $\pm$ 35 volts or greater with an accuracy of $\pm$ 10%. The instrument shall have an input capacitance of less than 1.0×10^{-13} Farads and an input impedance of greater than 1.0×10^{14} ohms.

6.6 DC Ohmmeter

The meter shall be capable of measuring a DC resistance of 1 ohm through 1 megohm (or other added resistance value) with an accuracy of $\pm$ 10%.

6.7 Electrostatic Field Meter

A non-contacting sensing instrument that is used to measure the electrostatic field that results from the electrostatic charge on a material. The meter shall be capable of measuring from 0 volts to $\pm$ 2000 volts/inch (78,740 volts/meter) or greater with an accuracy of $\pm$ 10%.

6.8 Foot Electrode

A conductive metal plate, supported by an insulative support surface, with an area large enough to accommodate a person's foot, without extending beyond any edge of the plate, nominally 300 mm x 300 mm.

6.9 Hand-Held Electrode

Stainless steel, brass, or copper round or tubular stock electrode, approximately 25 mm in diameter and 75 mm or greater in length, with a connection point at one end of the cylinder for connecting a lead from a test instrument. All dimensions are nominal.

6.10 Insulative Support Surface

When used for specimen support, a planar (flat) surface 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, 63.5 mm electrodes (see Section 6.14), an alternate method to verify the properties of the specimen support surface may be used by measuring the resistance point-to-point of the material with the electrodes spaced at least 150 mm apart (edge-to-edge). A resistance point-to-point of at least one order of magnitude greater than the upper limit of the measured item is required.

For test methods using concentric ring electrodes (see Section 6.4), an alternate method to verify the properties of the specimen support surface may be used by measuring the surface resistance of the material. Surface resistance of at least one order of magnitude greater than the upper limit of the measured item is required.

6.11 Integrated Checker

Integrated checker or meter, whether it is a single meter or a collection of instruments, capable of measuring resistance values greater than the user's specified requirements. Some integrated checkers require manual selection to appropriate test ranges.

6.12 Non-Contact Voltmeter

A non-contacting sensing instrument that is used to measure the voltage that results from the electrostatic charge on a material. The meter shall be capable of measuring from 0 volts to ± 2000 volts or greater with an accuracy of $\pm 10\%$.

6.13 Resistance Measurement Apparatus

The measurement apparatus, called the meter, whether it is an instrument or a collection of instruments, that are capable of the following:

The meter shall apply a voltage of 10 volts ($\pm 5\%$), while open circuit or under load, for measurements, or pass/fail indications, less than 1.0×10^6 ohms and apply a voltage of 100 volts ($\pm 5\%$), while open circuit or under load, for measurements of 1.0×10^6 ohms and greater.

Open circuit is defined as the difference in electrical potential between two terminals of the meter when no external resistance is connected.

Under load is defined as the difference in electrical potential between two terminals of the meter when an external resistance is connected.

NOTE: The resistance measurement apparatus should be capable of measuring at least one order of magnitude below the lowest value and one order of magnitude above the highest value required.

6.14 Resistance Measurement Electrode(s)

Cylindrical electrode, $2.27 \text{ kg} \pm 2.5\%$ with a diameter of $63.5 \text{ mm} \pm 5\%$ having a contact of electrically conductive material with a Shore-A durometer hardness between 50 and 70 as per ASTM D2240. When measured on a metallic surface, the resistance between two electrodes shall be less than 1.0×10^3 ohms.

6.15 Test Lead(s)

Test leads shall be suitable for the measurement being performed. Considerations should include safety and category ratings, cable lengths, and other important features based on the measurement type.

NOTE: It is common practice to connect the positive (+) terminal test lead to the applied voltage source and use the negative (-) terminal test lead to sense the return current. For compliance verification purposes, the lead polarity difference in measured resistance results should be considered negligible.

NOTE: The use of shielded and/or insulated cabling is recommended for high resistance measurements.

6.16 Two-Point Probe Assembly

The 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 $4.7 \text{ Newton} + 10\%$ at a travel of 4.3 mm. The pin tips are machined to accept friction fitted 3.2 mm diameter electrically conductive rubber electrodes or conductive rubber boots. The rubber has a Shore-A durometer hardness of 50-70 (ASTM Method D2240). Electrode volume resistivity is $< 500 \text{ ohm-cm}$. The electrodes are spaced 6.4 mm center to center.

NOTE: Before use, the resistance between two resistance measurement electrodes should be verified to be less than 1.0×10^3 ohms when measured at 10 volts on a metallic surface.

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

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7.0 COMPLIANCE VERIFICATION OF ESD CONTROL ITEMS

7.1 Grounding/Equipotential Bonding Systems

The objective of this compliance verification procedure is to establish the ESD grounding/bonding system, where the ESD grounding/bonding reference point is unknown or has not been identified by qualified personnel. The ESD grounding/bonding reference point may be based on either an equipment grounding conductor (see Figure 1) or an auxiliary ground (see Figure 2). Generically, a combined figure consisting of both selectable ESD grounding/bonding systems is created, as shown in Figure 3.

NOTE: In many countries, national electrical codes or regulations require verification of grounding/ bonding systems that include mains wiring systems to be carried out by qualified personnel.

The methods described in this section are derived from ANSI/ESD S6.1 - Grounding and ANSI/NFPA 70 – National Electric Code. The methods are based on United States standards and should be modified and/or adapted for use outside of the United States.

The Organization's application and the physical environment in which the ESD control item is implemented dictates the selection of the ESD grounding/bonding reference system used to establish the ESD grounding/bonding reference point. The following sections provide compliance verification procedures used to establish an ESD grounding/bonding reference point.

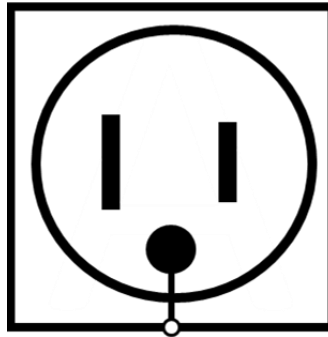


Figure 1: Equipment Grounding Conductor Symbol

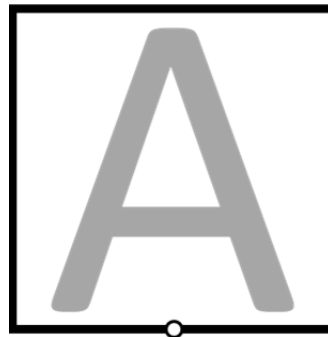


Figure 2: Auxiliary Ground Symbol

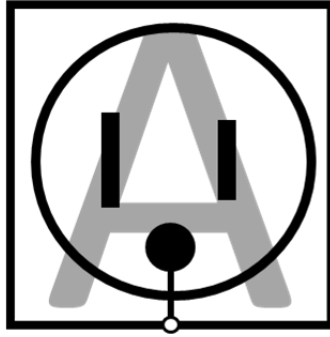


Figure 3: ESD Grounding/Bonding Reference Point Symbol

7.1.1 Equipment Grounding Conductor

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

- ANSI/ESD S6.1, Grounding
- ANSI/NFPA 70, National Electric Code

Test Equipment

- Circuit tester

7.1.1.1 Wiring Orientation

- Connect the circuit tester to the electrical receptacle containing the equipment grounding conductor being used as the ESD grounding/bonding reference point. See Figure 4.
- Verify the following:
 - ✓ Hot and equipment grounding conductor wires are not reversed.
 - ✓ Hot and neutral wires are not reversed.

Upon successful verification, the equipment grounding conductor can be used as an ESD grounding/bonding reference point. See Figure 3.

CAUTION: EQUIPMENT GROUNDING CONDUCTOR FAILURES SHOULD BE REVIEWED BY QUALIFIED PERSONNEL.

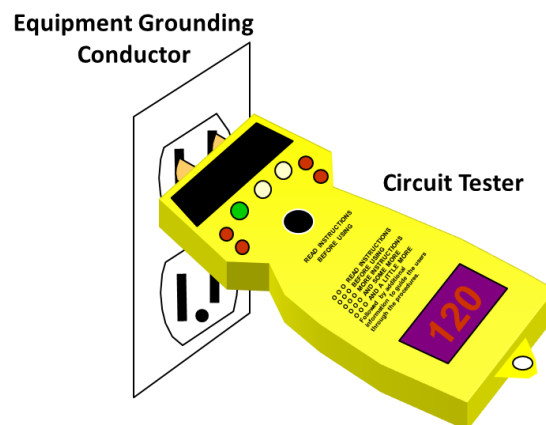


Figure 4: Equipment Grounding Conductor Wiring Orientation using a Circuit Tester

7.1.1.2 Troubleshooting

1. Verify that the circuit tester can indicate a pass or fail condition and that all lights are functioning properly.

7.1.2 Auxiliary Ground

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

- ANSI/ESD S6.1, Grounding
- ANSI/NFPA 70, National Electric Code

Test Equipment

- DC ohmmeter
- Test lead(s)

7.1.2.1 Equipment Grounding Conductor to Auxiliary Ground

- a. Set the DC ohmmeter to measure in ohms.
- b. Connect one end of the first test lead to the negative terminal (-) of the DC ohmmeter, and the other end of the test lead to a previously verified equipment grounding conductor. See Section 7.1.1.
- c. Connect one end of the second test lead to the positive terminal (+) of the DC ohmmeter, and the other end of the test lead to the auxiliary ground to be verified. See Figure 5.
- d. Verify the following:
 - ✓ Resistance from the equipment grounding conductor to auxiliary ground meets requirements.

Upon successful verification, the auxiliary ground can be used as an ESD grounding/bonding reference point. See Figure 3.

CAUTION: AUXILIARY GROUND FAILURES SHOULD BE REVIEWED BY QUALIFIED PERSONNEL.

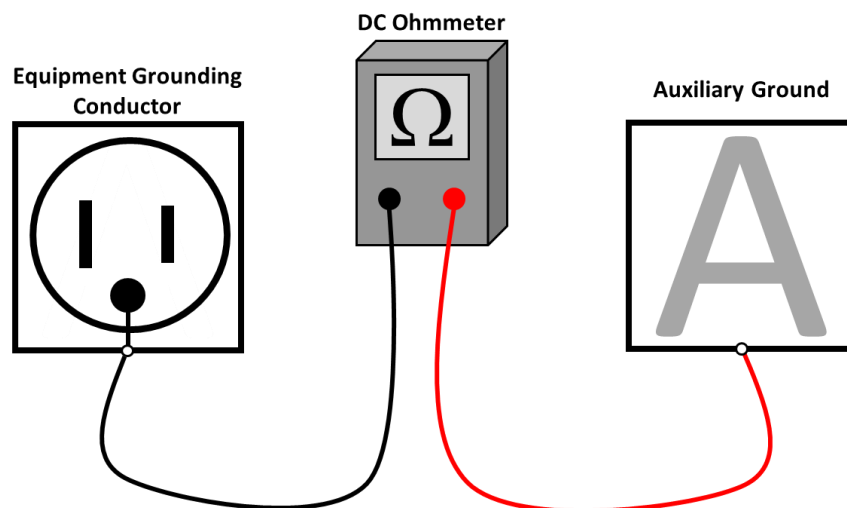


Figure 5: Equipment Grounding Conductor to Auxiliary Ground using a DC Ohmmeter

7.1.2.2 Troubleshooting

1. Examine and confirm that test lead(s) are not loose, broken, or disconnected.
2. Verify that the DC ohmmeter and appropriate test leads can measure resistance values greater than and less than the expected measurement range.

7.1.3 Equipotential Bonding

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

- ANSI/ESD S6.1, Grounding
- ANSI/NFPA 70, National Electric Code

Test Equipment

- DC ohmmeter
- Resistance measurement apparatus
- Resistance measurement electrode(s)
- Test lead(s)

7.1.3.1 Resistance Between Common Connection Point and ESD Control Item

Equipotential bonding may be used by interconnecting ESD control items, such as a worksurface and wrist strap, to the same common connection point. This method is recommended for use only when access to an ESD grounding/bonding reference point (equipment grounding conductor or auxiliary ground) is unavailable.

- a. Connect one end of the first test lead to the negative (-) terminal of the resistance measurement apparatus, and the other end of the test lead to the common connection point.
- b. Connect one end of the second test lead to the positive (+) terminal of the resistance measurement apparatus, and the other end of the test lead to the resistance measurement electrode.
- c. Place the resistance measurement electrode on the ESD control item used for equipotentially bonding. See Figure 6.
- d. Verify the following:
 - ✓ The resistance between the common connection point and the ESD control item meets requirements.
- e. Repeat compliance verification procedure for any additional ESD control items that share the same common connection point. See Figure 6.

NOTE: Measurement connections to an ESD control item may be achieved in several ways. Typical methods utilize both direct connections and connections using resistance measurement electrodes.

NOTE: Compliance verification measurements directly from one ESD control item to another can be used as an alternative method. For example, it is acceptable to measure the resistance directly between the worksurface and the personnel ground connection.

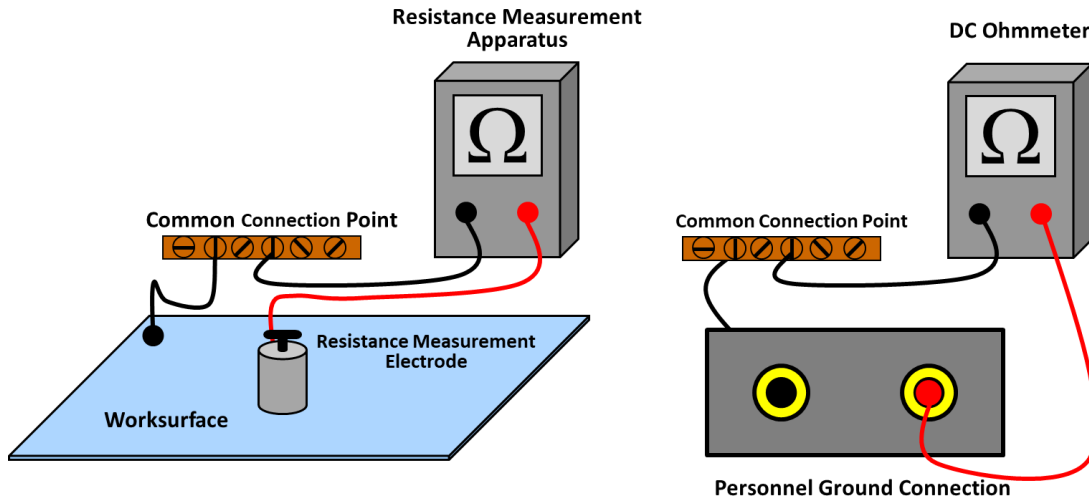


Figure 6: Resistance Between Common Connection Point and ESD Control Item (Examples)

7.1.4 Troubleshooting

1. Examine and confirm that test lead(s) are not loose, broken, or disconnected.
2. When used with the appropriate test leads, verify that the resistance measurement apparatus can measure resistance values greater than and less than the expected measurement range.
3. Examine the resistance measurement electrode(s) for contamination buildup, removing surface contamination following the manufacturer's recommendations, and allow adequate drying time before retesting.
4. When used with the resistance measuring apparatus and appropriate test leads, verify that the resistance measurement electrodes can measure resistance values greater than and less than the expected measurement range.

7.2 Personnel Grounding

7.2.1 Wrist Strap System Resistance

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

- ANSI/ESD S1.1, Wrist Straps

Test Equipment

- Hand-held electrode
- Integrated checker
- Resistance measurement apparatus
- Test lead(s)

7.2.1.1 Integrated Checker

- a. If applicable, set the integrated checker to the wrist strap setting.
- b. Put the wristband on the user's wrist and attach the ground cord to the wristband.
- c. Adjust the wristband, if necessary, to ensure a proper fit.
- d. Insert the ground cord into the integrated checker test receptacle.
- e. Press and hold the contact/test plate with either hand activating the integrated checker following the manufacturer's instructions until the measurement is completed. See Figure 7.