

ESD association standard practice

ESD SP9.2-2003

*for the Protection of Electrostatic
Discharge Susceptible Items-*

*Footwear –
Foot Grounders Resistive Characterization
(not to include static control shoes)*



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7900 Turin Road, Bldg. 3
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Approved September 21, 2003
ESD Association



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Published by:

Electrostatic Discharge Association
7900 Turin Road, Building 3
Rome, NY 13440

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Printed in the United States of America

ISBN: 1-58537-083-5

(This foreword is not part of ESD Association Standard Practice SP9.2-2003)

Foreword

This standard practice was developed to provide test methods for evaluating foot grounders and foot grounder systems used to electrically bond or ground personnel as part of an ESD Control Program. Static Control Shoes are tested using ANSI/ESD STM9.1.

This standard practice was processed and approved for submittal to the ESD Association Standards Committee by the 9.2 Foot Grounders Work Group. At the time it was approved, the Working Group had the following members:

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1.0 PURPOSE AND SCOPE

1.1 Purpose

This standard practice describes the electrical test methods for evaluation and compliance verification (periodic testing) of foot grounders.

1.2 Scope

This standard practice is intended for testing foot grounders and foot grounder systems used for grounding personnel engaged in working with ESD sensitive assemblies and devices. It does not address static control shoes.

2.0 DEFINITIONS

Foot Grounders

Personnel grounding device worn on the shoe. The device makes electrical contact with the surface on which the wearer is standing. The device also makes contact with 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).

Flooring / Foot Grounder System Resistance

(foot grounder, person and floor): The Flooring / Foot grounder system resistance is the total resistance of the foot grounders when worn by the person standing on a static control floor.

Floor Contacting Surface (FCS)

That part of the foot grounder that makes electrical contact to the grounding surface.

Body Contacting Mechanism (BCM)

That part of the foot grounder that makes electrical contact with the body.

Foot Grounder System

A foot grounder properly worn by a person where the electrical path includes the person and the foot grounder.

Foot Grounder System Resistance

(foot grounder and person): The foot grounder system resistance is the measure of the total resistance of the foot grounder when worn by the person standing on a stainless steel plate.

Current Limiting Resistance

A resistance incorporated in the electrical path to ground of foot grounder system. This resistance is intended to limit the electrical current that could pass through the foot grounder in the event of inadvertent user contact with electrical potential.

3.0 REFERENCED PUBLICATIONS

ANSI/ESD S20.20 Standard for the Development of an Electrostatic Discharge Control Program for – Protection of Electrical and Electronic Parts, Assemblies and Equipment.

ASTM D257 Standard Test Method for DC Resistance or Conductance of Insulating Materials.

ESD STM 97.1 Floor Materials and Footwear – Resistance Measurements in Combination with a Person

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 external and internal policy. Users are cautioned that this document cannot replace or supersede any requirements for personnel safety. The ultimate responsibility for personnel safety resides with the end user of this document.

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 the equipment must be followed when performing these tests.

5.0 LIMITS AND MARKING

“Laboratory Evaluation Tests” provide methods for incoming goods inspection. “Compliance Verification” is a simple check of electrical continuity. Compliance Verification should be used on a regular, user-defined basis, to ensure that the foot grounder system is electrically functional. See Appendix A for additional guidance.

5.1 Limits for Laboratory Evaluation Testing

See ANSI/ESD S20.20 for recommended performance criteria and Appendix E for recommended classifications.

5.2 Limits for Compliance Verification

See ANSI/ESD S20.20 for recommended performance criteria and Appendix E for recommended classifications.

5.3 Marking (labeling)

It is recommended that each foot grounder be marked with the manufacturer's name or logo and the current limiting resistance.

6.0 TEST METHODS

6.1 Laboratory Evaluation Testing of Foot Grounders

This test measures the value of the resistance of foot grounders and assures continuity between the discrete parts of the foot grounder.

6.1.1 Equipment

The measurement apparatus called the meter, whether it is a single meter or a collection of instruments that are capable of reading from 5.0×10^4 ohms to at least 1.0×10^{10} ohms with a test voltage between 7 to 30 volts DC open circuit.

Insulative Support Surface: A flat insulative plate sufficiently large to support the foot grounder under test. The resistance of the insulative surface shall be greater than 1.0×10^{13} ohms per square when measured per ASTM D-257.

Electrodes: Two cylindrical $2.27 \text{ kg} \pm .06 \text{ kg}$ (5 pound $\pm 2 \text{ oz.}$) electrodes with a diameter of $63.5 \text{ mm} \pm .25 \text{ mm}$ (2.5 inches $\pm .1$ inches) each having contacts 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 metal surface.

Conductive rubber electrodes are used for material evaluation and qualification.

Note: If aluminum foil covered electrodes are used, a correlation between the conductive rubber electrode and the aluminum foil covered electrode should be established for each material to be measured.

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.

6.1.2 Test and Preconditioning Environment

Specimens shall be preconditioned and tested at two environmental conditions:

- 1) $12\% \pm 3\%$ relative humidity, $23^\circ \pm 3^\circ$ C. ($73^\circ \pm 5^\circ$ F) for a minimum of 48 hours but not greater than 72 hours.
- 2) $50\% \pm 2\%$ relative humidity, $23^\circ \pm 3^\circ$ C. ($73^\circ \pm 5^\circ$ F) for a minimum of 48 hours but not greater than 72 hours.

6.1.3 Procedure

A minimum of six (6) specimens from each sample type shall be preconditioned and tested at 12% RH per 6.1.2.

See Figures 1 and 2 for examples of test setups.

- a) Place the foot grounder on the insulative surface so that the Floor Contacting Surface (FCS) is exposed and parallel to the insulative surface. Place an electrode on the FCS.
- b) Place the Body Contacting Mechanism (BCM) on the insulative surface so that it contacts the FCS only at the one intended point. The BCM should not make inadvertent contact with straps or other parts of the foot grounder. Place the second electrode on the BCM at the point farthest away from the FCS.
- c) Measure and record the resistance of the foot grounder.
- d) Repeat the test for the remaining specimens.
- e) Repeat steps a through d with a minimum of six (6) specimens from each sample type, preconditioned and tested at 50% RH per 6.1.2.

6.2 Compliance Verification Testing of the Foot Grounder System

This test verifies the resistance of the foot grounder system. This can be accomplished by using either an Integrated Tester (6.2.2) or Instrumentation (6.2.3).

NOTE: Parallel ground paths can cause false indications. See Appendix C

6.2.1 Equipment

Measuring Instrument(s): An integrated foot grounder tester or a measurement apparatus called the meter, whether it is a single meter or a collection of instruments that are capable of reading from 5×10^4 ohms to at least 1×10^{10} ohms with an open circuit test voltage between 7 to 30 volts DC. See Appendix A.

Electrode: A stainless steel cylinder 150 mm (6 inches) in length and 25mm (1 inch) in diameter. Foot Electrode: A conductive metal plate, 305mm square (12 inches). All dimensions are nominal.

Insulative Support Surface: A base plate larger than the conductive metal plate. The

resistance of the insulative surface shall be greater than 1.0×10^{13} ohms per square when measured per ASTM D-257.

Note: Users should be aware that the test voltage used here is different from ESD STM 97.1. This difference may produce different results.

6.2.2 Procedure (Integrated Tester)

- a) Place the foot grounders on the user's shoes per the manufacturer's instructions.
- b) Place the left foot on the floor plate and touch the body contact area on the tester with one hand. Activate the tester per the manufacturer's instructions.
- c) Remove the left foot from the floor plate. Record the "Accept" or "Reject" indication. Accept and reject criteria are user defined in accordance with Paragraph 5.2.
- d) Repeat steps b and c above with the right foot.

6.2.3 Procedure (Instrumentation)

See figure 3 for an example of a test setup.

- a) Place the foot grounders on the user's shoes per the manufacturer's instructions.
- b) Place the foot electrode on top of the insulative support surface. Attach the conductive plate to the common terminal (-) of the instrument. Connect the stainless steel cylinder to the positive terminal (+) of the instrument.
- c) Place the right foot on the metal plate and grasp the electrode with one hand. Measure the resistance of the foot grounder system. Remove the right foot from the foot electrode. Record the "Accept" or "Reject" indication. Accept and reject criteria are user defined in accordance with Paragraph 5.2.
- d) Repeat steps b and c above with the left foot.

6.3 Reporting

6.3.1 Laboratory Evaluation Testing

Report the following:

Test date, equipment used, foot grounder identification, test voltage, resistance and

markings (labeling). See appendix D for test report form.

6.3.2 Compliance Verification Testing

Report the following:

Test date, foot grounder identification, pass or fail indication.

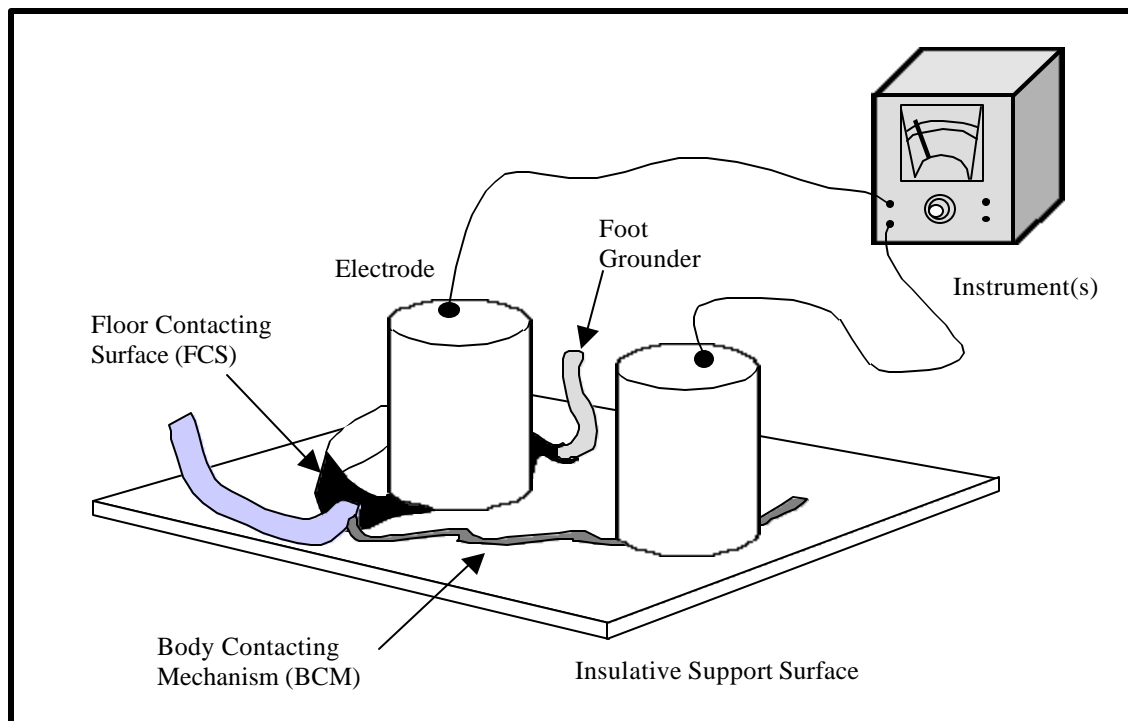


Figure 1: Foot Grounder Resistance Test

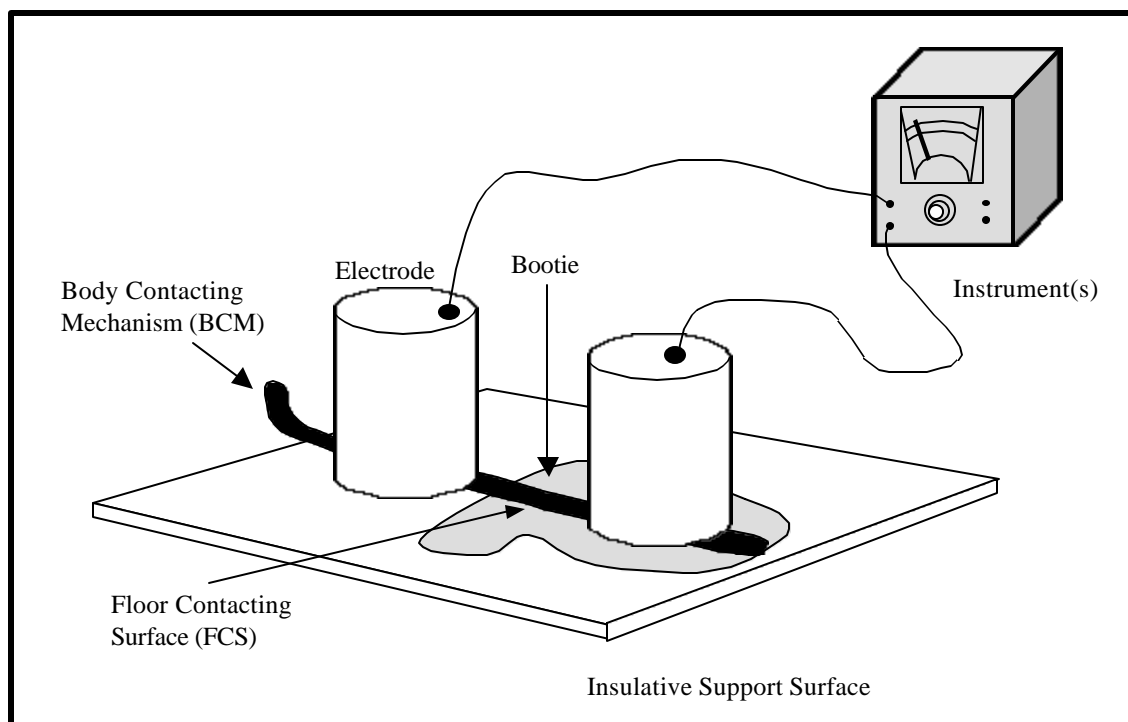


Figure 2: Bootie Resistance Test

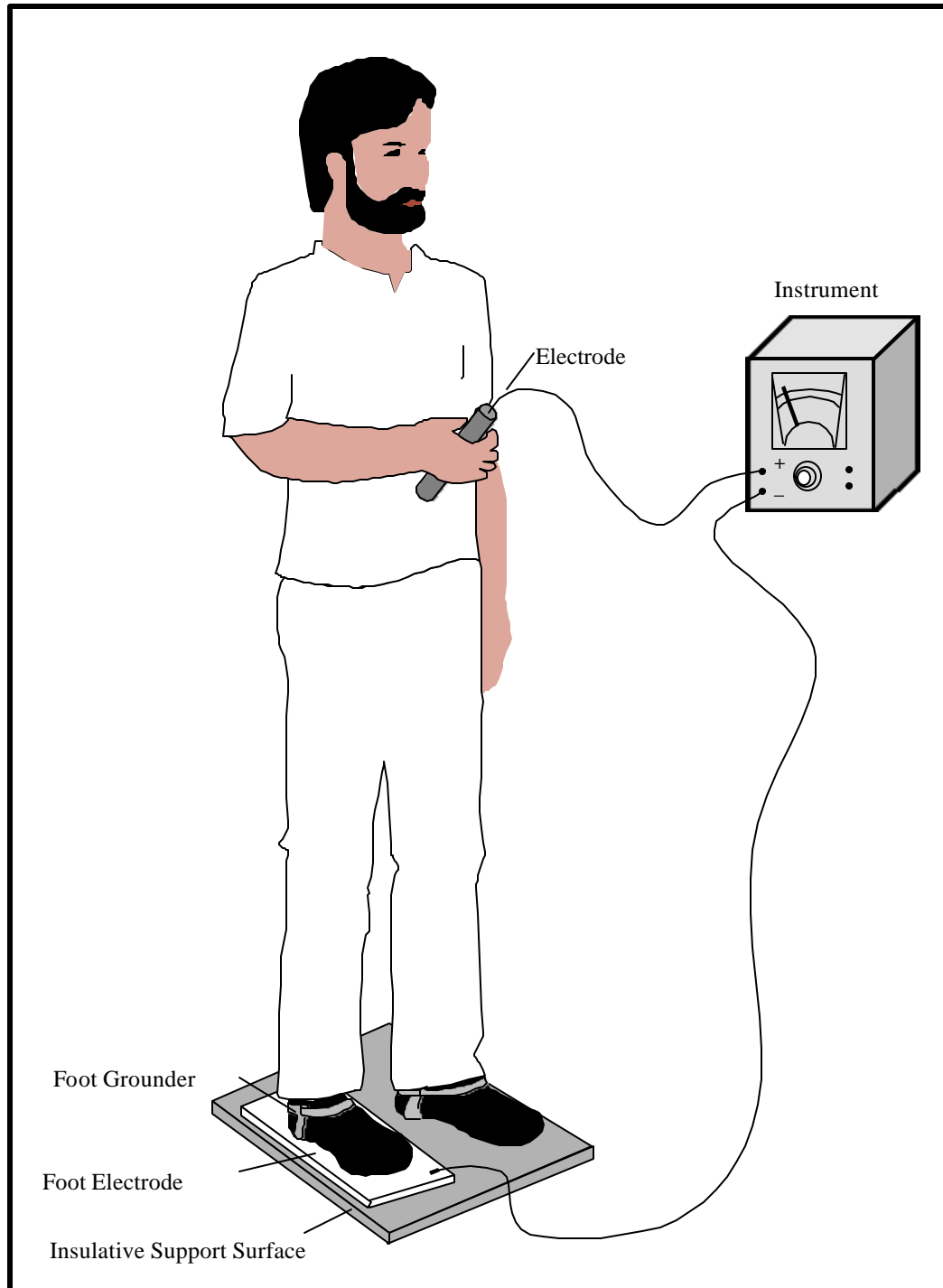


Figure 3: Foot Grounder System Resistance Test

APPENDIX A - Tester Voltage Influence on High/Accept/Low Indications

Results of a foot grounder continuity test may vary due to skin contact resistance. The variations of the skin resistance are mainly caused by the contact area, and the moisture on the skin. The higher the voltage applied to the skin, the less the skin contact resistance affects the total resistance of the system test.

The skin contact resistance during a system test may be high enough that the current limiting resistance of a foot grounder is not correctly indicated.

The system tester's open circuit voltage and the test voltage under load can cause the skin contact resistance measurement to vary by tens of millions of ohms. For example, an applied voltage of 1 volt may result in a resistance of 3.0×10^7 ohms. However, an applied voltage of 30 volts under the same conditions may result in a measured resistance as low as 1.0×10^6 ohms.

Typically, the variation of the skin contact resistance becomes negligible when the applied voltage exceeds 30 volts. Since exact measurements are not needed for a system test, applied voltages between 7 - 30 volts DC are usually appropriate.

APPENDIX B - Foot Grounder Usage Guidance

Compliance verification should be performed prior to each use (daily, shift change, etc.). The accumulation of insulative materials on the FCS may increase the foot grounder system resistance. If foot grounders are worn outside the ESD protected area testing for functionality before reentry to the ESD protected area should be considered.

APPENDIX C - Parallel Ground Paths

A parallel ground path allows a flow of electrical current through a path that is not intended for the test. Parallel ground paths may be caused by several different situations.

For example:

- a. The path represented by the person standing with one shoe on the floor and the other shoe on the test apparatus. A parallel path may be created by the shoe on the floor. Current from the test instrument is then directed down two paths when it was intended to be directed down one. The correct path for the test is with one shoe in the air or on an insulating surface and the other shoe on the test plate.
- b. The path presented by a person inadvertently supporting themselves by means of one hand on another object such as a wall, table or supporting member in order to measure the resistance in one foot contact. The hand has created a parallel path to ground.
- c. The path represented by a person leaning against another object with other parts of the body in order to provide physical support during a testing sequence. This can then lead to other grounding paths and erroneous results.

APPENDIX D - Foot Grounder Laboratory Evaluation Test Report

| | | |
|--------------------------------------|--|--|
| Test Date | | |
| | | |
| Foot Grounder Identification | | |
| | | |
| Markings: Manufacturer ID | | |
| | | |
| Manufacturer Resistance Value | | |
| | | |
| Equipment Used | | |
| | | |
| | | |
| | | |
| Test Voltage Applied | | |
| | | |
| Resistance Measured | | |
| | | |
| | | |
| | | |

APPENDIX E - Foot Grounder Classification

| Electrical | Resistance Value* |
|---------------------------------------|--|
| Foot Grounder Standard Use Type A | 8.0×10^5 to 3.5×10^7 |
| Foot Grounder Special Use High Type B | 3.5×10^7 to 1.0×10^9 |
| Foot Grounder Special Use Low Type C | $<8.0 \times 10^5$ |

* Resistance values are obtained from evaluation or compliance verification testing.

Foot Grounder Classification

Standard use:

Type A (standard) foot grounder has a lower resistance limit of 8.0×10^5 ohms to limit current flow to <0.5 milliamp at 240 VAC. The upper resistance limit of less than 3.5×10^7 ohms is defined by ANSI/ESD S20.20 as the recommended person to ground resistance value.

Special use:

Special electrical performance characteristics of materials used to make foot grounders may be required to achieve product attributes such as non-marking and high durability or very low resistance for handling some components. These special characteristics may necessitate foot grounder resistance values outside of the recommend level defined in ANSI/ESD S20.20.