

ESD Association Standard

ANSI/ESD S1.1-2006
Reaffirmation of ANSI/ESD S1.1-1998

*For the Protection of Electrostatic
Discharge Susceptible Items*

Wrist Straps

*Electrostatic Discharge Association
7900 Turin Road, Bldg. 3
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*ESD Association Standard
for the Protection of Electrostatic Discharge Susceptible Items -
Wrist Straps*

Approved February 26, 2006
ESD Association



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Foreword

This standard has been developed to establish test methods for evaluating the electrical and mechanical attributes of wrist straps used in an electrostatic control program. Wrist straps are intended to connect the user to electrical ground, thus preventing electrostatic charge on a user's body from attaining a level that may damage ESD susceptible devices or assemblies.

Test methods and performance limits for Evaluation, Acceptance, and Functional testing are provided. Application and construction guidance is included in the Appendices. This document is reformatted from EOS/ESD S1-1987 using improved test methods.

This standard was originally designated ESD S1.1-1998 and approved on October 4, 1998. This standard is a reaffirmation of ANSI/ESD S1.1-1998 and was approved on February 26, 2006. This standard was prepared by the 1.0 Wrist Straps Subcommittee. The 1998 version was prepared by the 1.0 Wrist Straps Subcommittee. At that time the 1.0 Wrist Straps Subcommittee had the following members:

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TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE.....	1
1.1 PURPOSE	1
1.2 SCOPE	1
2.0 REFERENCED DOCUMENTS.....	1
3.0 DEFINITION OF TERMS.....	1
4.0 TESTING LEVELS AND PERFORMANCE LIMITS.....	2
5.0 TEST METHODS.....	4
5.1 WRIST STRAP CONTINUITY AND RESISTANCE TEST	4
5.1.1 Equipment.....	4
5.1.2 Procedure	4
5.1.3 Reporting	4
5.2 CUFF RESISTANCE TEST	4
5.2.1 Equipment.....	4
5.2.2 Procedure (Interior Resistance)	4
5.2.3 Procedure (Exterior Resistance).....	4
5.2.4 Reporting	5
5.3 CUFF SIZE REQUIREMENTS	5
5.3.1 Equipment.....	5
5.3.2 Self-Adjusting Cuffs.....	5
5.3.3 "One-Size-Fits-All" Cuffs	5
5.4 BREAKAWAY FORCE	5
5.5 CONNECTION INTEGRITY	5
5.5.1 Equipment.....	5
5.5.2 Procedure	5
5.5.3 Reporting	5
5.6 GROUND CORD EXTENDIBILITY	6
5.7 BENDING LIFE TEST	6
5.7.1 Equipment.....	6
5.7.2 Procedure	6
5.7.3 Reporting	6
5.8 MANUFACTURER'S IDENTIFICATION.....	6
5.9 IDENTIFICATION OF NON-STANDARD RESISTANCE VALUE	6
5.10 WRIST STRAP RESISTANCE	6
5.10.1 Equipment.....	7
5.10.2 Procedure	7
5.10.3 Reporting	7
5.11 WRIST STRAP SYSTEM CONTINUITY TEST	7
5.11.1 Equipment.....	7
5.11.2 Procedure (Integrated Checker).....	7

5.11.3 Procedure (Ohmmeter)	7
5.11.4 Reporting	7

FIGURES

Figure 1: Wrist Strap Resistance Test Apparatus	8
Figure 2: Flex Test Setup	9
Figure 3: Wrist Strap System Resistance Test	10

TABLES

Table 1: Evaluation Testing	3
Table 2: Acceptance Testing	3
Table 3: Functional Testing	3

ANNEX A	11
----------------------	-----------

ANNEX B	12
----------------------	-----------

ESD Association Standard for the Protection of ESD Susceptible Items – Wrist Straps

1.0 PURPOSE AND SCOPE

1.1 Purpose

This standard provides electrical and mechanical test methods and performance limits for evaluation, acceptance and functional testing of wrist straps.

1.2 Scope

This standard is intended for testing wrist straps and wrist strap systems used for the grounding of personnel engaged in working with ESD sensitive assemblies and devices. It does not address constant monitoring systems.

2.0 REFERENCED DOCUMENTS

ESD ADV1.0, Glossary of Terms¹

3.0 DEFINITION OF TERMS

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

Wrist Strap

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

Wrist Strap System

A wrist strap when properly worn by a person, where the electrical path includes the person, the cuff and the ground cord.

Cuff

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

Ground Cord

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

Evaluation Testing

Stringent testing of a wrist strap to determine its electrical and mechanical performance abilities. Data are in the form of values from laboratory testing.

Acceptance Testing

Incoming tests to confirm proper marking and electrical functionality. Data are in the form of visual inspection records, and values or pass/fail notation.

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Functional Testing

End-use testing to confirm electrical functionality. Data are in the form of pass/fail notation or values.

Current-Limiting Resistance

A resistance value incorporated in series with the wrist strap's electrical path to ground. This resistance limits electrical current that could pass through the ground cord in the event of inadvertent user contact with electrical potential.

Resistance Range

User-specified upper and lower resistance values which define the user-acceptable resistance values of a wrist strap or wrist strap system.

Strain Relief

A construction feature designed to protect the connections and cord from premature failure.

Breakaway Force

That force required to disconnect the ground cord from the cuff.

4.0 TESTING LEVELS AND PERFORMANCE LIMITS

This standard specifies different types of testing for wrist straps. Tables 1, 2 and 3 detail the three types of testing with the associated limits and paragraph references to test methods. The methods provide appropriate tests for the different levels of wrist strap examination. The "Evaluation Tests" are laboratory tests for measuring the performance of a wrist strap or for the comparison of wrist straps. "Acceptance Tests" provide methods for incoming goods inspection. Finally, the "Functional Test" is a simple check of electrical continuity. This test shall be used on a regular, user-defined basis, to ensure that the wrist strap is electrically functional.

Table 1. Evaluation Testing

Electrical	Limit	Test Ref.
Wrist Strap Continuity and Resistance	1 megohm $\pm$ 20%, or user defined value	5.1
Cuff Resistance Interior: Exterior:	$\leq$ 100 kilohms or user defined value. $\geq$ 10 megohms	5.2
Mechanical	Limit	Test Ref.
Cuff Size	Defined	5.3
Breakaway Force	> .45 kg (1 lb), < 2.3 kg (5 lb)	5.4
Connector and Cord Integrity	> 2.3 kg (5 lb) and > 66% of cord strength	5.5
Ground Cord Extendibility	Extension to manufacturer's specified length with no continuity loss.	5.6
Bending Life	$\geq$ 16,000 cycles	5.7
Marking	Limit	Test Ref.
Manufacturer's Identification	Logo and/or name	5.8
Identification of Non-Standard Resistance Value	Red feature. Value Marked.	5.9

Table 2. Acceptance Testing

Electrical	Limit	Test Ref.
Wrist Strap Resistance	1 megohm $\pm$ 20%, or user defined value.	5.10
Marking	Limit	Test Ref.
Manufacturer's Identification	Logo and/or name	5.8
Identification of Non-Standard Resistance Value	Red feature. Value Marked.	5.9

Table 3. Functional Testing

Electrical	Limit	Test Ref.
Wrist Strap System Continuity	"pass" or $\leq$ 10 megohms, or user defined value	5.11

5.0 TEST METHODS

Refer to Tables 1, 2 and 3 for test method applications.

5.1 Wrist Strap Continuity and Resistance Test

This test measures the value of the current-limiting resistance and assures continuity between the discrete parts of the wrist strap.

5.1.1 Equipment

- A Test Fixture (see Figure 1) comprising an insulative stand and two 2.54 cm (1 inch) diameter stainless steel cylinders, with one cylinder fixed to the stand directly above the second. The second cylinder will weigh .11 kg (0.25 lb) and is mounted in a slot in the stand that allows free vertical movement.
- An ohmmeter or other instrument(s) capable of reading from at least 50 kilohms to at least 100 megohms with a test voltage of 7 to 30 volts DC open circuit.
- Six samples of wrist straps

5.1.2 Procedure

Using the fixture shown in Figure 1, place the cuff around the cylinders with the cuff interior toward the cylinders and the ground cord connector on the right side and parallel to the cylinders, evenly spaced between the cylinders. Allow the .11 kg (0.25 lb) cylinder to move freely and stress the cuff.

Connect the ground cord to the cuff.

Connect the ohmmeter to the top cylinder and to the ground connector of the ground cord. Measure and record the resistance.

Repeat the test for a total of six wrist straps.

5.1.3 Reporting

Report the resistance for each wrist strap.

5.2 Cuff Resistance Test

Resistance of the cuff interior and exterior is determined.

5.2.1 Equipment

See 5.1.1.

5.2.2 Procedure (Interior Resistance)

Using the test fixture from 5.1.1, Figure 1, place a cuff around the cylinders with the cuff interior toward the cylinders and the ground cord connector on the right side and parallel to the cylinders, evenly spaced between the cylinders. Allow the .11 kg (0.25 lb) cylinder to move freely and stress the cuff.

Connect the ohmmeter to the top cylinder and the ground cord connector on the cuff. Measure and record the resistance value.

Repeat procedure for a total of six cuffs.

5.2.3 Procedure (Exterior Resistance)

Place a cuff around the cylinders (Figure 1) with the cuff exterior toward the cylinders and the ground cord connector on the right side and parallel to the cylinders, evenly spaced between the cylinders. Allow the .11 kg (0.25 lb) cylinder to move freely and stress the cuff.

Connect the ohmmeter to the top cylinder and the ground cord connector on the cuff. Measure and record the resistance value.

Repeat procedure for a total of six cuffs.

5.2.4 Reporting

Report the interior resistance and exterior resistance of each cuff.

5.3 Cuff Size Requirements

Cuff sizes are determined by the cuff's ability to fit over a specifically sized cylinder. A cuff's ability to expand to fit over a hand, yet contract to fit snugly around a wrist is determined by fitting the cuff over specifically sized large and small cylinders.

5.3.1 Equipment

- 1 cylinder having an outside diameter of 4.3 cm (1.70 inches)
- 1 cylinder having an outside diameter of 5.3 cm (2.10 inches)
- 1 cylinder having an outside diameter of 8.25 cm (3.25 inches)
- 1 cylinder having an outside diameter of 8.9 cm (3.50 inches)

5.3.2 Self-Adjusting Cuffs

"Large"-sized self-adjustable expanding metal or fabric cuffs shall fit snugly onto a 5.3 cm (2.10 inch) diameter cylinder, and be capable of easily fitting over a 8.9 cm (3.50 inch) diameter cylinder.

"Small"-sized self-adjustable expanding metal or fabric cuffs shall fit snugly onto a 4.3 cm (1.70 inch) diameter cylinder, and be capable of easily fitting over a 8.25 cm (3.25 inch) diameter cylinder.

5.3.3 "One-Size-Fits-All" Cuffs

"One-Size-Fits-All" Cuffs shall fit snugly on a 4.3 cm (1.70 inch) diameter cylinder and be capable of sufficient expansion to fit over a 8.9 cm (3.5 inch) cylinder.

5.4 Breakaway Force

With the ground cord connected to the cuff in a normal manner, a force of $\geq .45$ kg (1 lb) but ≤ 2.3 kg (5 lb) applied to the ground cord, in the normal disconnect direction, shall be required to separate the ground cord from the cuff.

5.5 Connection Integrity

The strengths of the ground cord, the ground cord's attachment to the ground, and cuff connectors are determined.

5.5.1 Equipment

- Tensile Tester capable of 6.35 cm (2.5 inches) per minute travel.
- Grippers for Tensile tester.
- Chart Recorder

5.5.2 Procedure

Using the Tensile Tester and chart recorder, test and record the tensile strength (breaking point) of the ground cord, the ground connector to the ground cord, and the cuff connector to the cord. Repeat the test for a total of six ground cords.

5.5.3 Reporting

Report the tensile strength of each connector.

5.6 Ground Cord Extendibility

Retractable-type ground cords shall be capable of being extended to the manufacturer's specified length without pulling the cuff away from the user's wrist to the extent that electrical continuity, as measured in 5.11, is interrupted.

5.7 Bending Life Test

Ground cord flex life is determined.

5.7.1 Equipment

- Mechanical Ground Cord Flex Tester: A machine that drives a rocker plate through an arc of 120 degrees at a rate of approximately 2,000 cycles per hour (see Figure 2).
- A Flex Tester with a larger number of rocker plates is acceptable.
- Ground cords are attached to the rocker plates by means of a mounting that simulates alternately the cuff connector and the ground connector.
- .45 kg (1 lb) weights
- Resistance Meter with a test voltage ≤ 30 volts.

5.7.2 Procedure

Attach one end of a ground cord to a rocker plate. Connect the opposite end to a .45 kg (1 lb) weight and allow the ground cord to hang freely. Connect the resistance monitoring cable to the ground cord conductor at the weighted end.

Start the flex tester.

Six cords shall be tested with the cuff connection attached to rocker plate and six cords shall be tested with the ground connection attached to rocker plate.

5.7.3 Reporting

Ground cord failure is defined as the total resistance of the circuit exceeding 1.25 megohms (or user defined value), or when there is visible evidence of mechanical failure in the cord jacket or strain relief. Each ground cord shall have a minimum life of at least 8,000 cycles and the average of all samples tested shall have a minimum life of 16,000 cycles.

5.8 Manufacturer's Identification

Wrist straps shall have the manufacturer's name or logo embossed, molded or otherwise permanently marked in a prominent location.

5.9 Identification of Non-Standard Resistance Value

Wrist straps incorporating a resistance of non-standard value (other than 1.0 megohm $\pm 20\%$) shall be identified by having a prominent feature, red in color, on the wrist strap. Additionally, the value of the non-standard resistance shall be marked on the portion of the wrist strap that contains the resistance. Only wrist straps incorporating a non-standard value shall use the color red on any portion of the wrist strap.

5.10 Wrist Strap Resistance

This test determines the resistance of the wrist strap.

5.10.1 Equipment

An ohmmeter or other instrument(s) capable of reading from 50 kilohms to at least 100 megohms with a test voltage of 7 to 30 volts DC open circuit.

5.10.2 Procedure

Connect the cuff to the ground cord. Attach the ground cord to an ohmmeter lead. Connect the skin contact area of the cuff to the other ohmmeter lead. Measure the resistance of the wrist strap. Repeat the test for a total of six wrist straps.

5.10.3 Reporting

Report the resistance value of each wrist strap.

5.11 Wrist Strap System Continuity Test

This verifies the acceptability of the resistance path of the wrist strap system using an integrated wrist strap checker or an ohmmeter. This test shall be performed with the wrist strap on the intended user(s) wrist. This test includes the wrist strap user's resistance as part of the total system resistance.

5.11.1 Equipment

An integrated wrist strap system checker

– OR –

an ohmmeter or other instrument(s) capable of reading from 50 kilohms to at least 100 megohms with a test voltage of 7 to 30 volts DC open circuit.

A stainless steel cylinder 15.24 cm (6 inches) in length and 2.54 cm (1 inch) in diameter (Figure 3).

5.11.2 Procedure (Integrated Checker)

Place the cuff on the user's wrist, attach the ground cord to the cuff, and attach the ground cord to the integrated checker. Touch the body contact area on the checker with the hand closest to the cuff, and activate the checker per the manufacturer's instructions. Record the "Pass" or "Fail" indication.

5.11.3 Procedure (Ohmmeter)

Place the cuff on the user's wrist, attach the ground cord to the cuff, and attach the ground cord to the common terminal (-) of the ohmmeter. Connect the stainless steel cylinder to the positive terminal (+) of the ohmmeter. Grasp the cylinder with the hand closest to the cuff. Measure and record the resistance of the wrist strap system (see Figure 3).

5.11.4 Reporting

A "Pass" indication from the integrated checker indicates that the resistance of the wrist strap system is acceptable for use. A value of ≤ 10 megohms or a reading falling within the user-specified resistance range indicates that the wrist strap system is acceptable for use.

NOTE: See Annex A for troubleshooting guidance about correcting "failing" wrist straps.

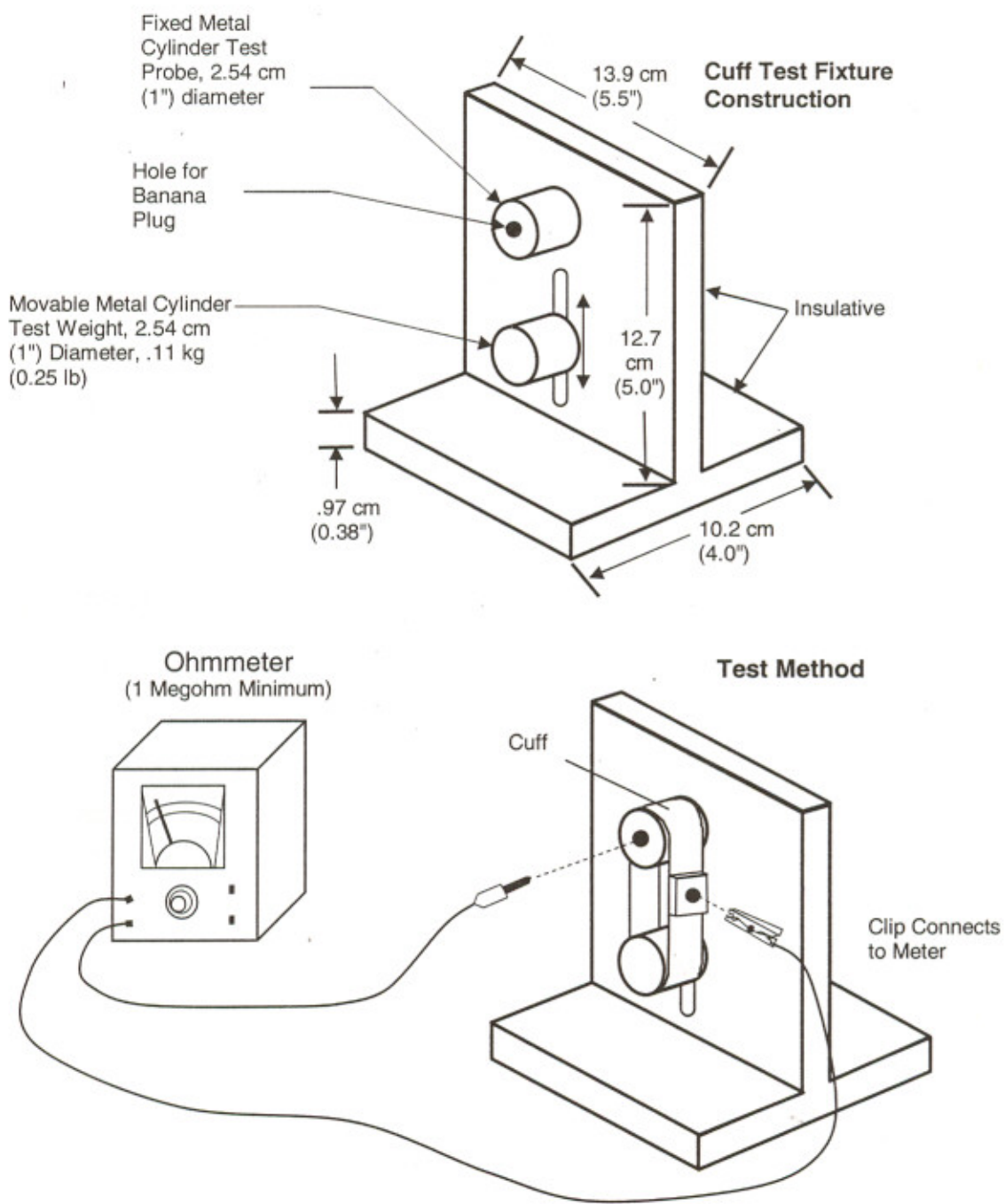


Figure 1: Wrist Strap Resistance Test Apparatus

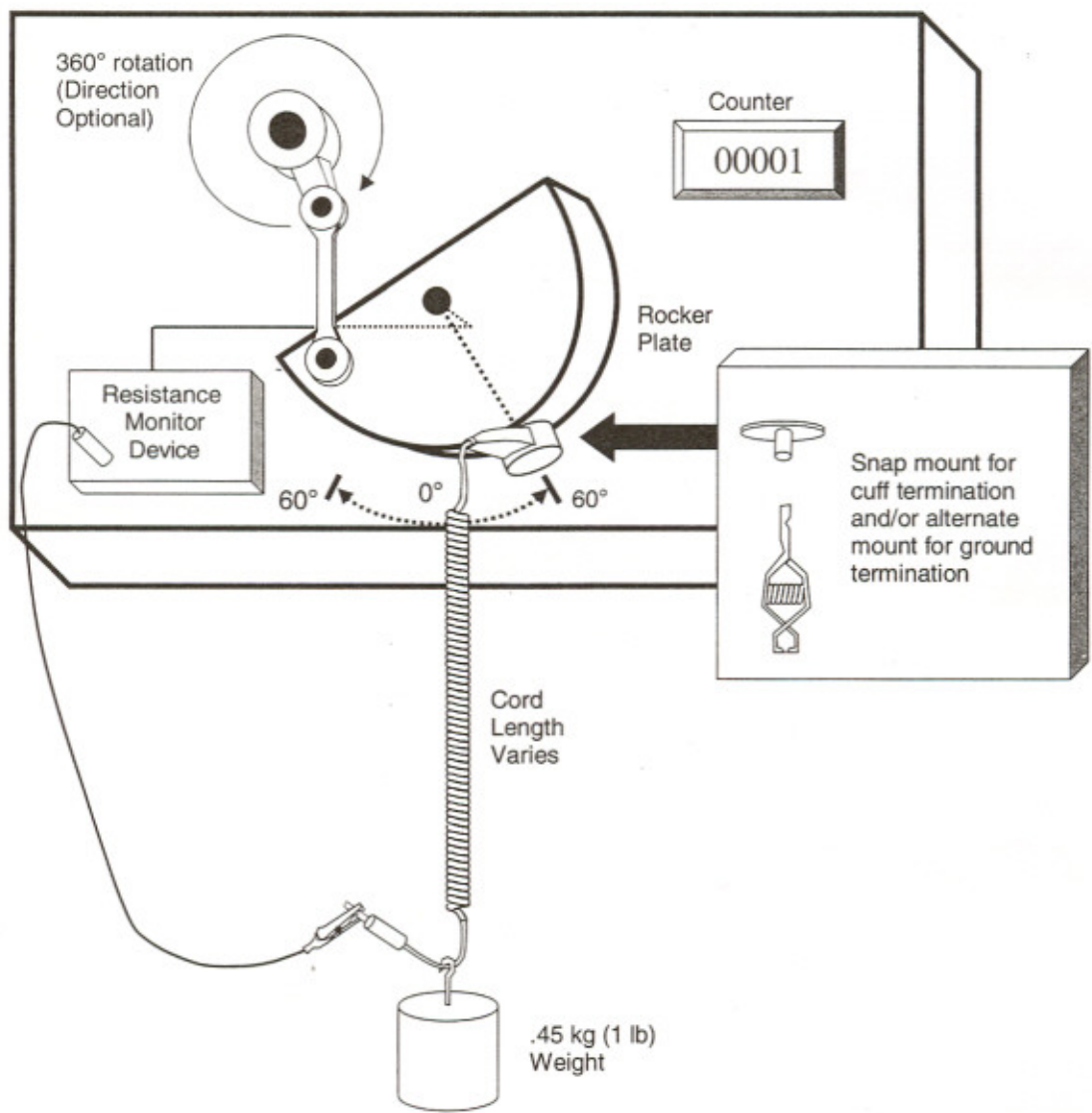


Figure 2: Flex Test Apparatus

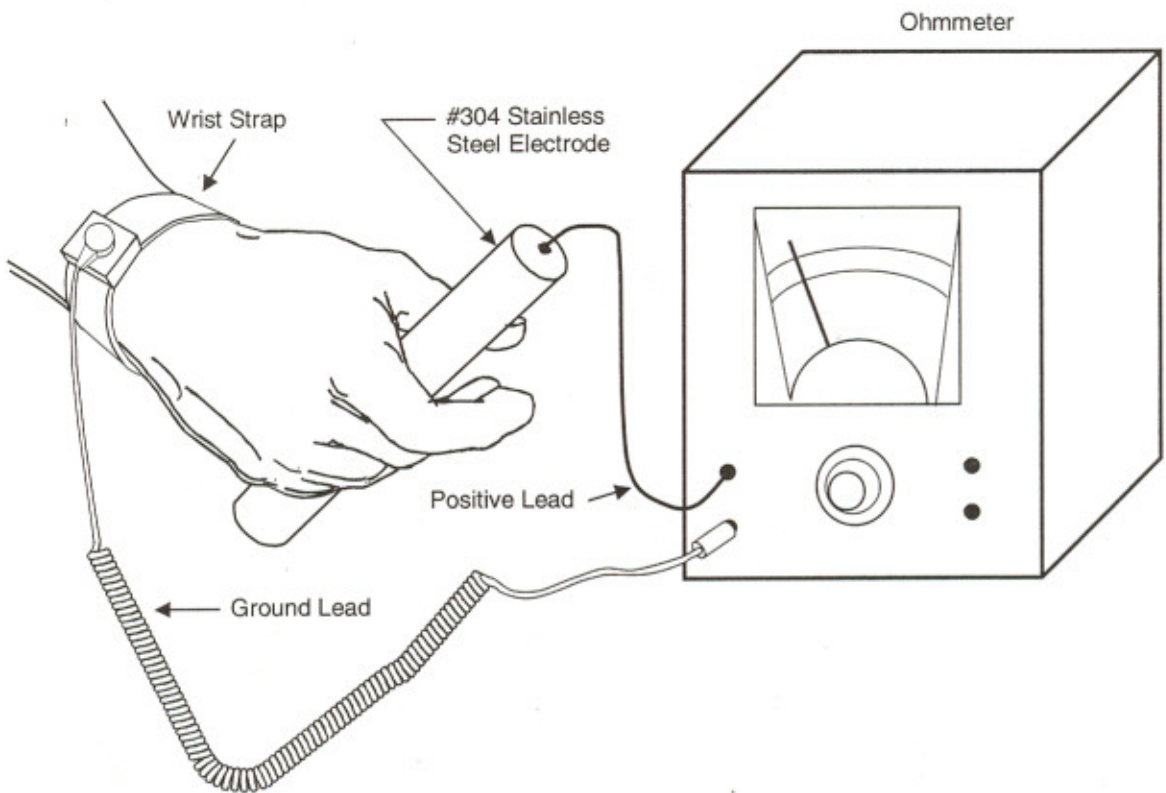


Figure 3: Wrist Strap System Resistance Test

ANNEX A (INFORMATIONAL)

This annex is intended to provide guidance for the application and construction of wrist straps. This annex is not part of the requirements of ANSI/ESD S1.1.

Application Guidelines

1. Ground Fault Protection

The use of Ground Fault Current Interrupters (GFCI) should be considered whenever personnel may come into contact with electrical power sources.

2. Breakaway Force

The connection(s) should not prevent a person's easy and rapid departure from the work area.

3. Frequency of Functional Testing

The wrist strap system should be tested daily to ensure proper electrical value. Nominally, the upper resistance reading should be ≤ 10 megohms or a user-defined value. Daily testing may be omitted if constant monitoring is used.

NOTE: Integrated Wrist Strap Checker's operation should be verified per the manufacturer's instructions.

4. Grounding Considerations

Connections to ground beneath the front edge of a work bench or to a common ground point connection on a work mat are convenient means of wrist strap grounding. Static dissipative mats should not be placed in series with the electrical path of a wrist strap.

When handling ESD sensitive devices or assemblies in installed equipment, the wrist strap should be connected to a proper or identified ground point.

5. Fabric Cuff Washing / Cleaning

Occasional washing of expandable fabric cuffs will remove skin oils and other contaminants that may increase contact resistance. Excessive washings or severe washings may shorten the life of the cuff. Washing should be performed per the manufacturer's instructions. Functional testing should be performed after washing and drying the fabric cuff.

6. Troubleshooting

The following steps may indicate the cause of a "fail" condition, or an unacceptable resistance reading as determined in 5.11.4:

A) Cuff Fit

Visually examine the wrist strap cuff to ensure that it is adjusted snugly to the skin and fitted per the manufacturer's instructions.

B) Wrist Strap Components

Replace the cuff with a new cuff and repeat the test in 5.11.

Replace the ground cord with a new ground cord and repeat the test in 5.11.

C) Skin Contact Resistance

If steps A and B are not effective, and the wrist strap in question functions on a different person, the "failing" person's skin may have a high electrical resistance. The use of an expandable metal cuff and/or dissipative lotion or gel may reduce the person's skin contact resistance.

ANNEX B (INFORMATIONAL)

This annex is intended to provide guidance for the application and construction of wrist straps. This annex is not part of the requirements of ANSI/ESD S1.1.

Construction Guidelines

1. Current-Limiting Resistance

A resistance of sufficient resistance to limit current to less than 0.0005 amps (0.5 mA), at the highest voltage that may be encountered, should be incorporated into the wrist strap.

Nominally, 800,000 ohms (800 kilohms) are sufficient for voltages of up to 240 volts alternating current (AC). The value of 1 megohm is specified because it is a standard value discrete resistor. Special situations may dictate the use of values above or below the 1 megohm value. Wrist straps with nominal resistances other than 1 megohm should be marked in accordance with paragraph 5.9.

Discrete current-limiting resistors should be located near the connection between the ground cord and the cuff.

2. Cuff Outside Surface

To reduce the possibility of a wrist strap wearer inadvertently conducting an electrical current through the cuff exterior to the skin, the resistance of the cuff exterior should be > 10 megohms.