IEC 61340-4-9

Edition 3.0 2024-10

INTERNATIONAL STANDARD

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Electrostatics –
Part 4-9: Standard test methods for specific applications – Garments – Resistive characterization

Électrostatique –
Partie 4-9: Méthodes d'essai normalisées pour des applications spécifiques – Vêtements – Caractéristiques résistives

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CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms and definitions 8
4 Atmosphere for conditioning and testing 8
5 Equipment and materials 9
5.1 Resistance measurement apparatus 9
5.1.1 General 9
5.1.2 Product qualification 9
5.1.3 Acceptance testing 9
5.1.4 Ohmmeter for testing personnel ground path 9
5.2 Resistance measurement electrodes 9
5.2.1 Cylindrical electrodes 9
5.2.2 Clamps or electrodes 10
5.2.3 Cuff test fixture 10
5.2.4 Hand-held electrode 10
5.3 Support surface 10
5.3.1 Insulative support surface 10
5.3.2 Insulative sleeve inserts 10
5.3.3 Insulative hangers 10
6 Test procedure 10
6.1 Sample preparation 10
6.1.1 General 10
6.1.2 Number of samples 11
6.2 Humidity requirements 11
6.3 Test procedures 11
6.3.1 General 11
6.3.2 Resistance point-to-point 11
6.3.3 Resistance point-to-groundable point 12
6.3.4 Cuff measurements 12
6.3.5 Groundable static control garment system 12
7 Product qualification 13
8 Reporting 13
Annex A (informative) Garment types and resistance values 20
Annex B (informative) Data collection sheet (example) 21
Bibliography 23

Figure 1 – Test set-up – Resistance point-to-point (sleeve-to-sleeve procedure with insulative sleeve inserts) 14
Figure 2 – Test set-up – Resistance point-to-point (insulative sleeve insert inserted into sleeve detail) 14
Figure 3 – Test set-up – Resistance point-to-point (panel-to-panel procedure with insulative support surface) 14
Figure 4 – Test set-up – Resistance point-to-point (cuff-to-cuff procedure) 15

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Figure 5 – Test set-up – Resistance point-to-point (electrode inserted into cuff detail) 15
Figure 6 – Test set-up – Resistance point-to-point (hanging clamp sleeve-to-sleeve procedure) 16
Figure 7 – Clamps or electrodes for hanging garment test 16
Figure 8 – Test set-up – Resistance point-to-groundable point (cuff-to-groundable-point procedure with insulative sleeve inserts) 17
Figure 9 – Test set-up – Resistance point-to-groundable point (sleeve-to-groundable-point procedure with insulative sleeve inserts) 17
Figure 10 – Groundable garment cuff test 18
Figure 11 – Test set-up – Groundable static control garment system resistance (groundable garment in combination with a person using a meter and hand-held electrode) 18
Figure 12 – Test set-up – Groundable static control garment system resistance (groundable garment in combination with a person using an integrated tester) 19

Table 1 – Product qualification 13
Table A.1 – Garment types and resistance values 20

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ELECTROSTATICS –

Part 4-9: Standard test methods for specific applications – Garments – Resistive characterization

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IEC 61340-4-9 has been prepared by IEC technical committee 101: Electrostatics. It is an International Standard.

This third edition cancels and replaces the second edition published in 2016. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) IEC 61010-1 and IEC 61010-2-030 added as requirements for measurement equipment;

b) testing voltage range for personnel ground path changed from "7 V DC to 30 V DC" to "7 V DC to 100 V DC";

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c) cleaning requirements changed from a minimum of five cycles of cleaning to a minimum of three cycles of cleaning;

d) moderate humidity requirements deleted;

e) figures replaced with generic drawings.

The text of this International Standard is based on the following documents:

Draft	Report on voting
101/718/FDIS	101/721/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 61340 series, published under the general title *Electrostatics*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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INTRODUCTION

This part of IEC 61340 provides test methods for evaluating the electrical resistance of garments that contain surface conductive or dissipative components or materials used in the electronics industry for the control of electrostatic discharge. This document defines procedures for measuring electrical resistance, including a system resistance test for garments that provide a ground path for personnel.

Clothing made from synthetic fibres is a common source of electrostatic charge. Wearing an appropriate static control garment over personnel clothing can minimize the effect of this charge. To effectively control electrostatic charges of the static control garments and effectively shield the electrostatic field of personnel clothing, the static control garment should be grounded.

Three categories of garments are considered in this document.

a) A static control garment can suppress or otherwise affect an electric field from clothing worn underneath the garment without being attached to ground. However, without grounding, a charge can accumulate on conductive or dissipative elements of a garment, if present, resulting in a charged source.

b) A groundable static control garment can provide a higher level of suppression when the lower resistance fabric is connected to ground.

c) 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 wearer to an identified ground path. Groundable static control garment systems can 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).

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Resistive characterization is only one aspect to consider in evaluating garments for any specific application. To fully characterize a garment, it can be necessary to take into consideration electrical field attenuation, static decay, peak voltage, residual voltage and triboelectric charging. Other attributes related to applications and environments, such as cleanroom compatibility, chemical and fire resistance, should be evaluated in the garment selection process but are beyond the scope of this document.

Garments constructed from fabrics made with fibres that are not surface conductive but can have other related properties that impart some level of electrostatic charge dissipation or suppression when connected to ground, are not specifically measured by the methods provided in this document. This being the case, some garment fabrics and construction can allow for surface voltage accumulation and charge transfer to occur which can be detrimental to electronic items.

Alternate methods for evaluating the electrostatic properties of garments are described in IEC TS 61340-4-2 [1][1].

[1] Numbers in square brackets refer to the Bibliography.

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ELECTROSTATICS –

Part 4-9: Standard test methods for specific applications – Garments – Resistive characterization

1 Scope

This part of IEC 61340 provides test methods for measuring the electrical resistance of garments used for static control applications. These test methods can be used for evaluating outer garments that are homogenously conductive or homogeneously dissipative, or that utilize surface conductive or surface dissipative components or elements.

NOTE It is possible that the test methods defined in this document will not be able to measure materials with buried conductive layers.

The resistance point-to-point test method tests the electrical resistance between the two sleeves, any two panels or any two electrically interconnected components of the static control garment, including the electrical resistance across the seams and cuffs of the garment as applicable.

An alternate sleeve-to-sleeve test method is described, using clamps to hang a garment.

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Static control garments that electrically bond to the wearer and provide a path to ground from the wearer are evaluated using the resistance point-to-point test method, the resistance point-to-groundable point test method, as well as a system test to determine the resistance from the person through the garment to the groundable point of the garment system.

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A band resistance measurement test is provided in IEC 61340-4-6 which can be used for garments so equipped with cuffs that are intended to perform the same function as a wrist strap band.

The system test with a person wearing a groundable static control garment system includes the ground cord that connects to the groundable point of the garment.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61010-1, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61010-2-030, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for equipment having testing or measuring circuits*

IEC 61340-2-3, *Electrostatics – Part 2-3: Methods of test for determining the resistance and resistivity of solid materials used to avoid electrostatic charge accumulation*

IEC 61340-4-6, *Electrostatics – Part 4-6: Standard test methods for specific applications – Wrist straps*

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3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
acceptance testing
testing used to confirm to users that products delivered are substantially the same as the samples used to qualify products

3.2
garment system
any electrically interconnected components of a static control apparel

3.3
point-to-point resistance
resistance measured from one point to another on the surface of the same panel or two different panels of a garment

Note 1 to entry: Point-to-point resistance is expressed in Ω.

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3.4
static control garment
personnel garment that is designed for electrostatic charge control

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3.5
product qualification
testing used to confirm that products comply with the requirements of an ESD control program or other specification

3.6
groundable static control garment
garment that exhibits an electrical resistance from point-to-point and from any point or panel on the garment to the groundable point on the garment

Note 1 to entry: The groundable point can be a cuff contact to the wearer's skin or a separate dedicated grounding point connector.

3.7
groundable static control garment system
system whereby a garment that is used to establish the primary ground path for a person to the groundable point of the garment and the connection of the garment to ground, typically through a grounding cord

Note 1 to entry: The garment is a groundable static control garment as defined in 3.6, with additional features to enable grounding of the wearer.

4 Atmosphere for conditioning and testing

The following requirements supersede any other specification relating to the atmosphere for conditioning and testing that can be given in one or more of the documents referred to in this document.

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Unless otherwise agreed, the atmosphere for conditioning and testing for laboratory evaluations shall be at a temperature of 23 °C ± 2 °C and 12 % ± 3 % relative humidity. The conditioning time prior to testing shall be at least 48 h.

5 Equipment and materials

5.1 Resistance measurement apparatus

5.1.1 General

Electrical equipment for measurement shall comply with the safety requirements of IEC 61010-1 and IEC 61010-2-030. The measurement apparatus, called the meter, whether it is a single meter or collection of instruments, shall be capable of the following.

5.1.2 Product qualification

The meter shall have a circuit voltage while under load of (100 ± 5) V for measurements of $1{,}0 \times 10^6$ Ω and above, and (10 ± 0,5) V for measurements from $1{,}0 \times 10^4$ Ω to $1{,}0 \times 10^6$ Ω. The meter shall have an open circuit or under load voltage of (10 ± 0,5) V) for measurement from $1{,}0 \times 10^3$ Ω to $1{,}0 \times 10^4$ Ω.

The meter shall be capable of making measurements from $1{,}0 \times 10^3$ Ω to $1{,}0 \times 10^{12}$ Ω.

5.1.3 Acceptance testing

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The product qualification meter can be used for acceptance testing or the following:

The meter shall have an open circuit voltage of (100 ± 5) V for measurements of $1{,}0 \times 10^6$ Ω and above, and (10 ± 0,5) V for measurements less than $1{,}0 \times 10^6$ Ω.

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The meter shall be capable of making measurements from $1{,}0 \times 10^3$ Ω to $1{,}0 \times 10^{12}$ Ω.

In case of disagreement, the meter used for product qualification shall be used to resolve any disputes.

5.1.4 Ohmmeter for testing personnel ground path

Integrated tester or meter, whether it is a single meter (ohmmeter) or a collection of instruments that are capable of measuring from $5{,}0 \times 10^4$ Ω to at least $1{,}0 \times 10^8$ Ω with a test voltage from 7 V DC to 100 V DC open circuit. If the test voltage exceeds 60 V DC, or 35 V DC in wet locations, the additional safety limits for current and capacitive charge specified in IEC 61010-1 shall be applied.

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

5.2 Resistance measurement electrodes

5.2.1 Cylindrical electrodes

A cylindrical 2,5 kg ± 0,25 kg electrode with a diameter of 63,5 mm ± 1 mm, having a contact of electrically conductive material with a Shore-A durometer hardness between 50 and 70. The resistance between two electrodes should be less than $1{,}0 \times 10^3$ Ω when measured at 10 V on a metallic surface.

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5.2.2 Clamps or electrodes

The clamps or electrodes shall consist of two flat electrically conductive plates (e.g. stainless steel) with a dimension of approximately 50 mm × 25 mm each. The clamps or electrodes shall be electrically conductive with sufficient compression force to retain and suspend the garment. See Figure 7.

5.2.3 Cuff test fixture

A test fixture comprising an insulative stand and two stainless steel cylinders (25,0 ± 0,5) mm in diameter, with one cylinder fixed to the stand directly above the second. The second cylinder shall have a mass of (0,11 ± 0,01) kg and is mounted in a slot in the stand that allows free vertical movement. See Figure 10.

5.2.4 Hand-held electrode

A hand-held electrode, for example stainless steel, brass, copper or other suitable metal round or tubular stock, approximately 25 mm in diameter and 75 mm or greater in length, with provision for connection to the meter (such as a banana plug receptacle or screw connector) attached to one end of the cylinder. See Figure 11.

5.3 Support surface

5.3.1 Insulative support surface

An insulative surface when used for specimen support shall have a surface resistance of greater than $1{,}0 \times 10^{12}$ Ω when measured in accordance with IEC 61340-2-3. The insulative surface shall be large enough to accommodate the entire garment when it is laid out flat.

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5.3.2 Insulative sleeve inserts

Two pieces of insulative material meeting the requirements of 5.3.1 cut into approximately 75 mm by 152 mm strips to slide into the sleeves (and cuffs if so equipped) of garments under test to isolate one side of the sleeve from the other.

5.3.3 Insulative hangers

The points to which the clamps described in 5.2.2 holding a garment under test shall be isolated from ground by a resistance greater than $1{,}0 \times 10^{12}$ Ω when measured with an instrument meeting the requirements of 5.1.3. Insulating thread can be used for this purpose.

6 Test procedure

6.1 Sample preparation

6.1.1 General

Garments can have a temporary finish on them, either a residue from processing treatments or deliberately applied by garment manufacturers, that can reduce electrical resistance. Such finishes shall be removed before proper evaluation of the long-term properties of garments can be made. This can be achieved by processing garments through a minimum of three cycles of the garment manufacturer's specified or user defined cleaning process, prior to performing laboratory tests.

The person performing the tests should examine the garment's construction and make a general sketch showing separate front and back panels used to fabricate the garment. Number the panels for measurement identification purposes from No. 1 to No. n. Identify the sleeves and cuffs as left and right. The groundable points, if they exist, should be shown on the sketch. The sketch should accompany the test results to become part of the test report.

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6.1.2 Number of samples

Test a minimum of three samples for each style and manufacturer when using this test method for qualification.

6.2 Humidity requirements

For product qualification, resistance point-to-point, resistance point-to-groundable point and cuff measurements shall be conducted at humidity conditions according to Clause 4. Humidity conditioning for product qualification of the groundable static control garment system is optional and can require a walk-in environmental chamber.

6.3 Test procedures

6.3.1 General

Subclause 6.3 defines the test methods for measuring the electrical resistance of garments. It includes a resistance point-to-point test and a resistance point-to-groundable point test. The described test procedures can be used for product qualification and acceptance testing. A system test for a garment that provides a path to ground from a person while being worn is also described.

6.3.2 Resistance point-to-point

6.3.2.1 Panel-to-panel

Precondition the test samples according to 6.2 as required. Place the garment on an insulative support surface as described in 5.3.1. Place the garment with the front panels opened and laid out as flat as possible (it is possible that larger garments such as overalls will not allow this completely). Place the insulative sleeve inserts from 5.3.2 into each sleeve (including the cuff, if so equipped, or leg cuffs of an overall) of the garment under test. Attach test leads from the resistance measuring apparatus (meter) to the electrodes defined in 5.2.1. Place one electrode on a panel of the sample. Place the second electrode on another panel of the same sample. Ensure the panels are on the insulative support surface and do not touch any other part of the garment. Apply 10 V and observe the reading after 5 s. If the reading is less than $1{,}0 \times 10^6$ Ω, record the value. If the reading is greater than or equal to $1{,}0 \times 10^6$ Ω, apply 100 V for a minimum of 15 s (or until reading stabilizes) and record the results. Switching the test voltage to 100 V can result in a resistance reading of less than $1{,}0 \times 10^6$ Ω. When this occurs the reading made with the 100 V test voltage shall be recorded. Repeat for all electrically interconnected components and panels as well as exterior cuff-to-cuff and sleeve-to-sleeve, making sure that the electrodes are directly above the insulative inserts (see Figure 1, Figure 2 and Figure 3). Resistance point-to-point measurements can give variable results depending on the arrangement of the garment under test and location of electrodes on it. For qualification testing, at least three measurements shall be made with the garment arrangement and electrode location re-arranged between each measurement. The result is the highest of the three measured values. Repeat for all test samples.

6.3.2.2 Interior cuff-to-cuff

Some garments can have an insulative exterior and conductive interior of the cuff or incorporate a wrist strap band or another wrist bonding mechanism or device. Precondition the test samples according to 6.2 as required. Insert the measurement electrodes inside the cuffs or wrist bonding devices (see Figure 4 and Figure 5). Apply 10 V and observe the reading after 5 s. If the reading is less than $1{,}0 \times 10^6$ Ω, record the value. If the reading is greater than or equal to $1{,}0 \times 10^6$ Ω, apply 100 V for a minimum of 15 s (or until reading stabilizes) and record the results. Switching the test voltage to 100 V can result in a resistance reading of less than $1{,}0 \times 10^6$ Ω. When this occurs, the reading made with the 100 V test voltage shall be recorded. Repeat for all test samples.

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6.3.2.3 Hanging clamp sleeve-to-sleeve

Precondition the test samples according to 6.2 as required. Hang the garment from each sleeve with electrically isolated clamps (see Figure 6). Place the clamps so that they connect the exterior and the interior of the cuff. The resistance measurement shall be made by attaching a test lead to one clamp and attaching the other test lead to the other clamp. Apply 10 V and observe the reading after 5 s. If the reading is less than $1{,}0 \times 10^6$ Ω, record the value. If the reading is greater than or equal to $1{,}0 \times 10^6$ Ω, apply 100 V for a minimum of 15 s (or until reading stabilizes) and record the results. Switching the test voltage to 100 V can result in a resistance reading of less than $1{,}0 \times 10^6$ Ω. When this occurs, the reading made with the 100 V test voltage shall be recorded. Repeat for all test samples.

6.3.3 Resistance point-to-groundable point

Precondition the test samples according to 6.2 as required. Place the garment with the front panels opened and laid out as flat as possible (it is possible that larger garments such as overalls will not allow this completely) on an insulative support surface as described in 5.3.1. Use one electrode as described in 5.2.1 connected to one test lead of the meter. Place the insulative sleeve insert from 5.3.2 into each sleeve of the garment under test. Place the electrode on a cuff (see 6.3.2.2 for interior cuff-to-cuff measurements), sleeve (directly above the insulative insert) or panel. Connect the other test lead of the meter to the garment groundable point. Apply 10 V and observe the reading after 5 s. If the reading is less than $1{,}0 \times 10^6$ Ω, record the value. If the reading is greater than or equal to $1{,}0 \times 10^6$ Ω, apply 100 V for a minimum of 15 s (or until reading stabilizes) and record the results. Switching the test voltage to 100 V can result in a resistance reading of less than $1{,}0 \times 10^6$ Ω. When this occurs, the reading made with the 100 V test voltage shall be recorded. If cuffs are designated as groundable points, measurements shall be made between sleeves and cuffs or between panels and cuffs; see 6.3.2.2 for cuff-to-cuff measurements. Repeat for all panels, sleeves and cuffs and groundable points (see Figure 8 and Figure 9). Repeat for all test samples.

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6.3.4 Cuff measurements

IEC 61340-4-6 provides test methods for the evaluation of wrist strap bands and cuffs. These methods can be adapted for use in testing garment cuffs or any wrist strap cuff type grounding mechanism that can be part of a garment and used to bond to the skin of the wearer. The band resistance test procedure described in IEC 61340-4-6 shall be used to measure the interior resistance of the garment cuff or wrist strap grounding mechanism (see Figure 10).

NOTE Some garments can be used in conjunction with resistance continuous monitoring systems. Garments of this type can have one cuff that provides the skin contact for personnel grounding, and the other cuff is used for monitoring the electrical continuity between the garment and the wearer. The two cuffs are isolated electrically from each other in this type of garment. The manufacturer can be contacted for assistance in measuring this type of garment.

6.3.5 Groundable static control garment system

Users of this document should ensure that garments tested in this procedure meet the grounding requirements at the lowest humidity levels experienced in their facility.

This procedure verifies the resistance path from a person wearing the garment, through the body-garment cuff contacts or wrist strap cuff type grounding mechanism to the ground termination point of the garment grounding wire. Testing in a controlled environment is not a requirement of this subclause. Personnel shall wear the garment under test for a minimum of 10 min prior to testing.

This test is conducted with the meter described in 5.1.4. This test includes the ground cord and wearer's resistance as part of the total system resistance (see Figure 11 and Figure 12). The test can be performed using a proprietary integrated tester (Figure 12) or resistance meter of similar specification (Figure 11). Connect the grounding point of the garment to the tester using the ground cord. Contact is made to the tester via a push button, contact plate (on the integrated tester, Figure 12) or a hand-held electrode (Figure 11). Apply the test voltage and record the result.

IEC 61340-4-9:2024 • https://standards.iteh.ai/catalog/standards/iec/76e003d3-53ca-493b-80a2-89f12b3788ba/iec-61340-4-9-2024

7 Product qualification

Table 1 describes the test required, based on the garment that is being qualified. For more information on garments, see Annex A.

Table 1 – Product qualification

Garment type	Qualification testing required	Options to comply with testing requirements
Static control garment	Resistance point-to-point (see 6.3.2)	Interior cuff-to-cuff (see 6.3.2.2) – only required if exterior of cuff is insulative and interior is conductive
	Panel-to-panel (see 6.3.2.1) – all garments	Hanging clamp sleeve-to-sleeve (see 6.3.2.3) – can be used as an alternative to panel-to-panel or interior cuff-to-cuff testing
Groundable static control garment	Resistance point-to-point (see 6.3.2)	Interior cuff-to-cuff (see 6.3.2.2) – only required if exterior of cuff is insulative and interior is conductive
	Panel-to-panel (see 6.3.2.1) – all garments	Hanging clamp sleeve-to-sleeve (see 6.3.2.3) – can be used as an alternative to panel-to-panel or interior cuff-to-cuff testing
	Resistance point-to-groundable point (see 6.3.3)	Cuff measurements (see 6.3.4) – can be used as an alternative to the method described in 6.3.2.2 when measuring resistance point-to-groundable point
Groundable static control garment system	Resistance point-to-point (see 6.3.2)	Interior cuff-to-cuff (see 6.3.2.2) – only required if exterior of cuff is insulative and interior is conductive
	Panel-to-panel (see 6.3.2.1) – all garments	Hanging clamp sleeve-to-sleeve (see 6.3.2.3) – can be used as an alternative to panel-to-panel or interior cuff-to-cuff testing
	Resistance point-to-groundable point (see 6.3.3)	Cuff measurements (see 6.3.4) – can be used as an alternative to the method described in 6.3.2.2 when measuring resistance point-to-groundable point
	Total system resistance (see 6.3.5)	

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8 Reporting

Record all resistance values. Record the voltage levels, relative humidity and temperature for each test sample. Record the type of test equipment used and test date. See Annex B for an example of a data collection sheet with sketches.

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