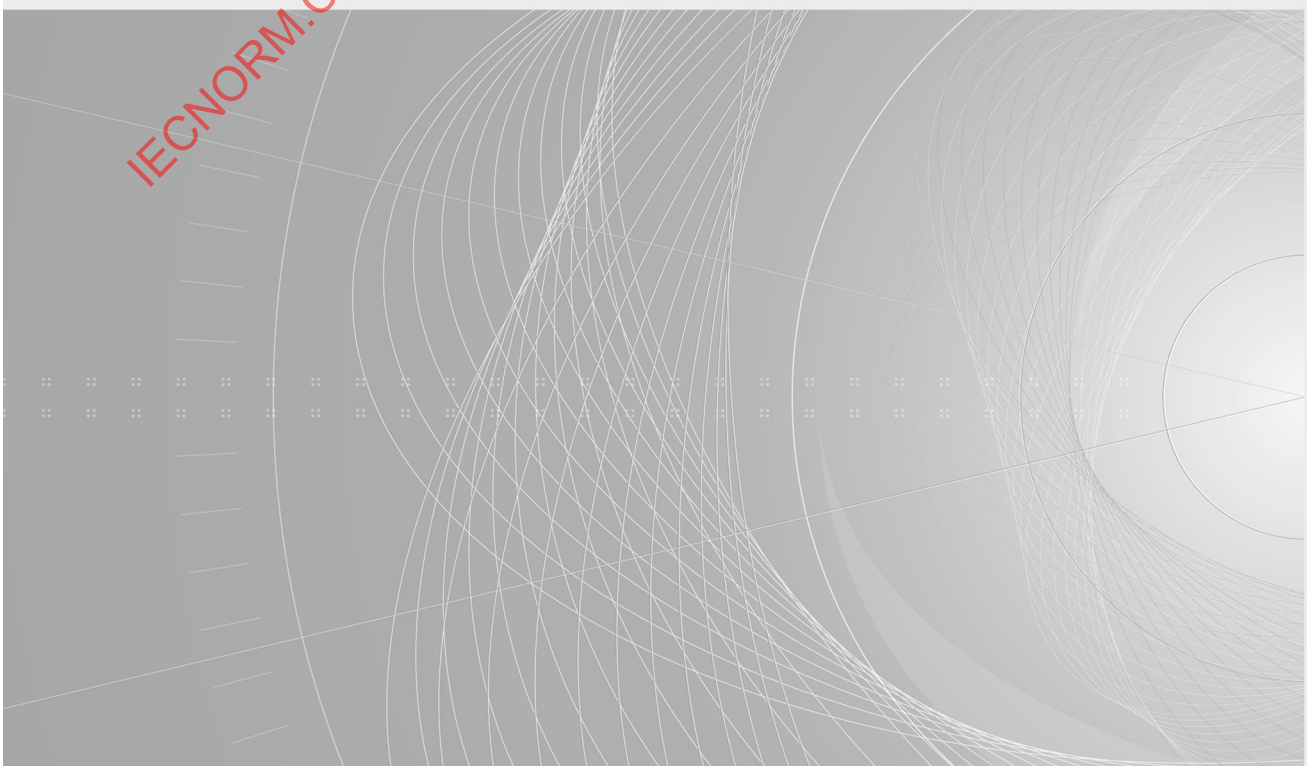
IEC TR 61340-5-4

Edition 1.0 2019-08

TECHNICAL REPORT

colour inside

Electrostatics –
Part 5-4: Protection of electronic devices from electrostatic phenomena – Compliance verification



IEC TR 61340-5-4:2019-08(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC TR 61340-5-4

Edition 1.0 2019-08

TECHNICAL REPORT

colour inside

Electrostatics –
Part 5-4: Protection of electronic devices from electrostatic phenomena – Compliance verification

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 17.220.99; 29.020

ISBN 978-2-8322-7272-5

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

ELECTROSTATICS –

Part 5-4: Protection of electronic devices from electrostatic phenomena – Compliance verification

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a Technical Report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 61340-5-4, which is a Technical Report, has been prepared by IEC technical committee 101: Electrostatics.

The text of this Technical Report is based on the following documents:

Draft TR	Report on voting
101/581/DTR	101/586/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 web site under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Compliance verification is the process of monitoring and measuring all elements of an ESD control program. Regular compliance checks and tests are an essential part of this process, ensure that area precautions and equipment remain effective, and that an ESD control program is correctly implemented in compliance with an ESD control program plan.

Qualification testing is typically carried out under controlled conditions, often in a laboratory environment, and using industry recognized standards. Verification testing is carried out under operational conditions using test methods that are appropriate to an organization's requirements. Although qualification test methods can be used, compliance verification testing often uses simple equipment and procedures. Accuracy is still important, but of equal importance is the ability to carry out non-destructive testing without interrupting the normal business of the organization.

This document describes equipment and test methods that can be used for verification testing of ESD control items and systems, and provides users with some guidance on how to carry out the tests and take appropriate action to ensure continuous compliance.

The compliance verification test frequency is not described in this document. See Annex A for test frequency considerations.

ELECTROSTATICS –

Part 5-4: Protection of electronic devices from electrostatic phenomena – Compliance verification

1 Scope

This part of IEC 61340 describes compliance verification testing for technical items that are included in ESD control programs, such as those specified in IEC 61340-5-1.

Test methods, in the main body of this document, are based on those specified in IEC 61340-5-1 and other parts of IEC 61340, and are simplified where necessary for the purposes of compliance verification, to be performed by competent personnel.

Additional compliance verification tests and procedures within the scope of this document are described in Annexes B to G.

Users can, by reference to this document in their compliance verification plan, adopt the necessary test methods described herein without change or addition. Alternatively, tests methods described in this document can be adapted to match the requirements of their own ESD control program, provided deviations in equipment or procedure are documented in their compliance verification plan.

Product qualification is excluded from the scope of this document.

2 Normative references

There are no normative references in this document

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the documents cited in the bibliography apply.

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

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

4 Personnel safety

The procedures and equipment described in this document can 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. This document cannot replace or supersede any requirements for personnel safety.

Electrical hazard reduction practices should be exercised and proper grounding instructions for equipment should be followed.

5 Test equipment

5.1 Selection of test equipment

If the specifications for test equipment described in Clause 5 do not match the range of measurements required to be made in the ESD control program, other test equipment that does match the range should be used and documented in the ESD control program plan.

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

5.2 AC outlet analyzer (or mains socket tester)

This is a device that plugs into an AC outlet and gives an indication, typically using lights, that the outlet is correctly wired, or if a fault condition exists. For compliance verification testing, an AC outlet analyzer can be used to indicate the correct wiring of the equipment grounding conductor.

Please note that some AC outlet analyzers might not be able to differentiate ground (or earth) and neutral wire reversals, line and neutral wire reversals, and line and ground wire reversals, or determine if the impedance to ground of the equipment grounding conductor is within the organization's specification.

5.3 AC circuit tester (impedance meter)

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

5.4 Charged plate monitor (CPM)

5.4.1 CPM requirements

A CPM has a plate that measures (150 ± 1) mm x (150 ± 1) mm with a minimum capacitance of 15 pF when it is mounted in the test fixture without electrical connections. The total capacitance of the test circuit, with plate, is (20 ± 2) pF. A CPM as described in IEC 61340-4-7 meets these requirements.

The electrostatic field meter or voltmeter should be capable of measuring voltage in such a way that, in the absence of ionization, the CPM plate voltage does not decay more than 10 % of the initial test voltage within five minutes. The response time should be less than 10 % of the shortest discharge time expected to be measured.

5.4.2 Portable verification kit

Portable verification kits for compliance verification of ionizers are commercially available and typically consist of four components: 1) electrostatic field meter or voltmeter, 2) CPM plate separated from a ground plate on insulating standoffs, 3) plate charger, and 4) ground plate. These four components may be integrated into a single instrument. A stopwatch or other timer is used to measure discharge times.

For convenient use in a portable kit, the CPM plate is typically smaller than that specified for a CPM.

A verification kit that has a capacitance or plate size that differs from the defined CPM plate may be used if the user develops a correlation factor for decay and offset voltage.

The plate charger should be capable of charging the CPM plate to a voltage of each polarity in excess of the initial test voltage.

5.5 Concentric ring electrode assembly

The electrode assembly contains a central disc surrounded by a concentric ring made of conductive materials that make contact with the material under test.

The electrode assembly described in IEC 61340-2-3 meets the requirements for compliance verification testing.

NOTE See also ANSI/ESD STM11.11.

5.6 DC ohmmeter

The instrumentation specified in IEC 61340-2-3 for laboratory evaluations and acceptance testing have output voltages of (10,0 ± 0,5) V or (100,0 ± 5) V depending on the range of resistance being measured. Instrumentation meeting the requirements for laboratory evaluations or acceptance testing as specified in IEC 61340-2-3, or instrumentation meeting the following requirements should be used for compliance verification testing.

Compliance verification instrumentation should be capable of making measurements one order of magnitude above and one order of magnitude below the intended measurement range. The output voltage of compliance verification instrumentation may vary from laboratory evaluation or acceptance testing instrumentation, and may be rated under load or open circuit. Compliance verification instrumentation should be checked against laboratory evaluation or acceptance testing instrumentation to ensure there is correlation between measurement results.

A DC ohmmeter may be a single, self-contained instrument, or a combination of instruments (e.g. DC power supply, voltmeter and ammeter). If the DC ohmmeter has a self-switching test voltage, it should be ensured that the changeover meets the requirements specified in IEC 61340-2-3 or specified by the user.

5.7 Electrostatic field meter

The electrostatic field meter is an instrument used to measure the electric field that results from electrostatic charge on a material.

There are different types of electrostatic field meter in common use including induction probes and field mills. The relative merits of these types are discussed in IEC TR 61340-1.

5.8 Electrostatic voltmeter

The electrostatic voltmeter is an instrument used to measure the voltage that results from the static charge on a material. Electrostatic voltmeters may be non-contacting, based on field meters or induction probes, or contacting. IEC TR 61340-1 gives guidance on the use of different types of electrostatic voltmeters.

5.9 Foot electrode

The foot electrode is a conductive metal plate that is at least large enough to accommodate a person's foot, without the foot extending beyond any edge of the plate (typically 305 mm x 305 mm).

5.10 Hand-held electrode

The hand-held electrode is a stainless steel, brass or copper round or tubular stock, approximately 2,5 cm in diameter and 7,5 cm or greater in length, with a connector at one end. All dimensions are nominal.

5.11 Resistance measurement electrode(s)

A resistance measurement electrode consists of a cylindrical electrode, (2,5 ± 0,25) kg with a diameter of (65 ± 5) mm having a contact of electrically conductive material with a Shore A hardness between 50 and 70. The resistance between two resistance measurement electrodes should be less than $1,0 \times 10^3$ Ω when measured at (10,0 ± 0,5) V on a metallic surface.

The electrode described in IEC 61340-2-3 meets these specifications.

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.

NOTE Other electrodes can be used providing the results have been shown to be comparable.

5.12 Insulative support surface

A planar (flat) surface, when used for specimen support, should have a surface resistivity greater than $1,0 \times 10^{13}$ Ω when measured as per IEC 62631-3-2 or a surface resistance or point-to-point resistance greater than $1,0 \times 10^{12}$ Ω when measured as per IEC 61340-2-3. The area of the insulative support surface should be large enough to completely isolate the largest specimen intended to be tested on it.

5.13 Integrated checker

An integrated checker is a purpose-built instrument that is used for measuring wrist strap or footwear resistance as worn.

An integrated checker for wrist straps should indicate fail for resistances above $3,5 \times 10^7$ Ω, or a user defined limit.

An integrated checker for footwear should indicate fail for resistance above $1,0 \times 10^8$ Ω, or a user defined limit.

5.14 Two-point probe

A two-point probe consists of an insulated metal body with a polytetrafluoroethylene (PTFE) insulator inserted into each end. One insulator holds test leads; the other holds receptacles that accept spring-loaded pins. The pins are gold plated and have a spring force of (4,6 ± 0,5) N. The pin tips are (3,2 ± 0,1) mm diameter electrically conductive rubber electrodes with Shore A hardness of 50 to 70. The resistance between the two resistance measurement electrodes should be less than $1,0 \times 10^3$ Ω when measured at (10,0 ± 0,5) V on a metallic surface.

The two-point probe described in IEC 61340-2-3 meets these specifications.

5.15 Surface resistance bar electrode

Concentric ring electrodes often cannot be applied because of the size and shape of materials. Insufficient contact area or contact material can also result in high resistance between the electrode and the specimen. If concentric ring electrodes result in errors, a user defined surface resistance bar electrode (SRB) may be used instead.

An SRB is an alternative electrode that is useful especially in measurements of hard, concave and convex surfaces. In addition, orientation of resistance can be evaluated with an SRB.

When a user defined SRB is used, the following parameters should be mentioned in a test report: dimensions of the bars, contact force or mass of the electrode, contact material and distance between the bars. In addition, test voltage and electrification time should be recorded. If the result is expressed as surface resistance (R_s), the dimensions of the electrode are not taken into account. If the result is expressed as surface resistivity (ρ_s), the following equation should be used: $\rho_s = R_s \cdot (w/l)$, where w is the width of the electrode and l is the distance between electrodes.

For inhomogeneous materials, the resistance value can vary a lot on the same sample. The calculation of the resistivity assumes a homogeneous sample.

6 Grounding/bonding systems

6.1 Responsibility for checking systems

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

If this is not the case in the facility then as a minimum the correct wiring should be checked as described below.

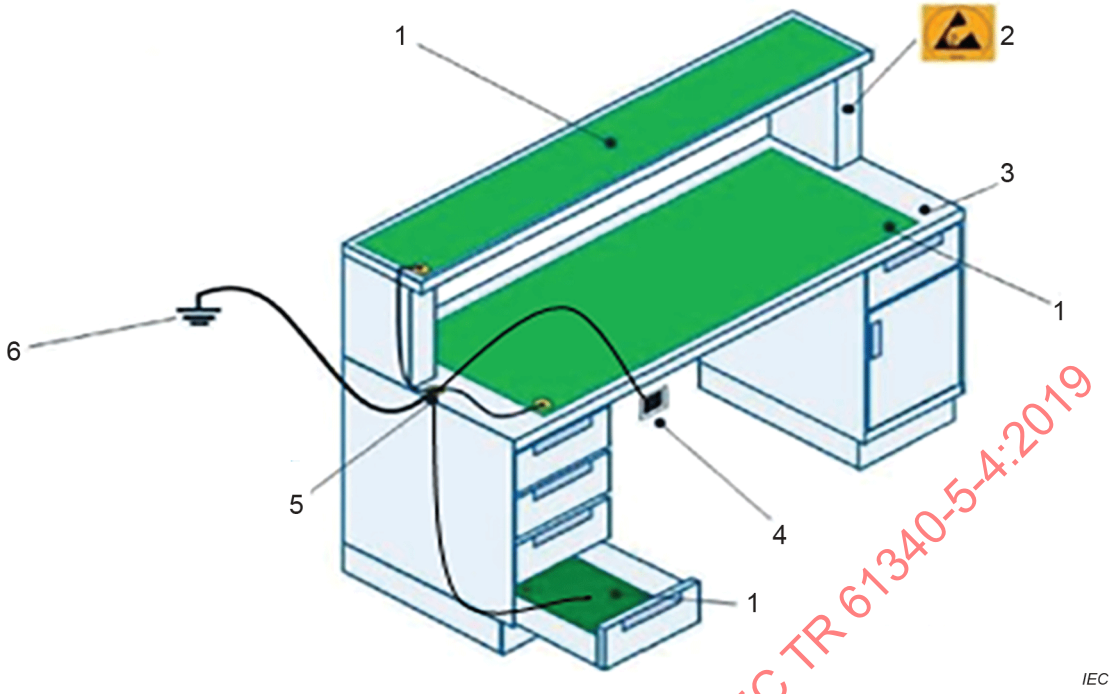
6.2 Objective

The objective of this compliance verification test procedure is to verify that the various grounding/bonding systems of an ESD protected area (e.g. ESD control workstation, see Figure 1) are within the resistance range allowed by the organization's specification. A properly configured ESD control workstation will have all ESD control work surfaces, fixtures, handling equipment and personnel grounding devices connected to a common ground point. The common ground point is connected to the ESD ground, which in most cases will be the equipment ground (protective earth). If a functional ground is used, it should be bonded to the electrical ground wherever possible (for information see IEC TR 61340-5-2).

6.3 Test equipment

See Clause 5 for general description of test equipment.

- DC ohmmeter.
- Two test leads of sufficient length.



Key

1 ESD control work surface (mat)
2 ESD control symbol
3 ESD control work surface
4 wrist strap bonding point
5 common ground point
6 equipment ground

Figure 1 – ESD control workstation

6.4 Test procedure for wrist strap bonding points

- Operate the DC ohmmeter according to the manufacturer's instructions.
- Connect two test leads to the DC ohmmeter.
- Connect or place one test lead to the wrist strap bonding point (personnel ground) and the other test lead to the ground reference.
- Measure the resistance according to the instruction of the DC ohmmeter and note the result.

6.5 Troubleshooting wrist strap bonding point failures

- Visually and mechanically confirm that all termination hardware and grounding wires are not inadvertently loose, broken, or disconnected.
- Verify the test equipment is operating properly and check/service the battery (if battery operated) following the manufacturer’s operating instructions for proper operation.
- Test the resistance of the wrist strap bonding point to the common ground point.
- Test the resistance of the common ground point to the ESD ground.

If the measured resistance is outside the specified range, connections between the wrist strap bonding point and common ground point, and/or the common ground point and ESD ground should be replaced and the resistance re-measured.

If the measured resistance is still outside the specified range, the workstation should be taken out of service and clearly marked as such.

7 Work surfaces

7.1 Basis of test procedure

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

- IEC 61340-2-3;
- ANSI/ESD S6.1.

7.2 Objective

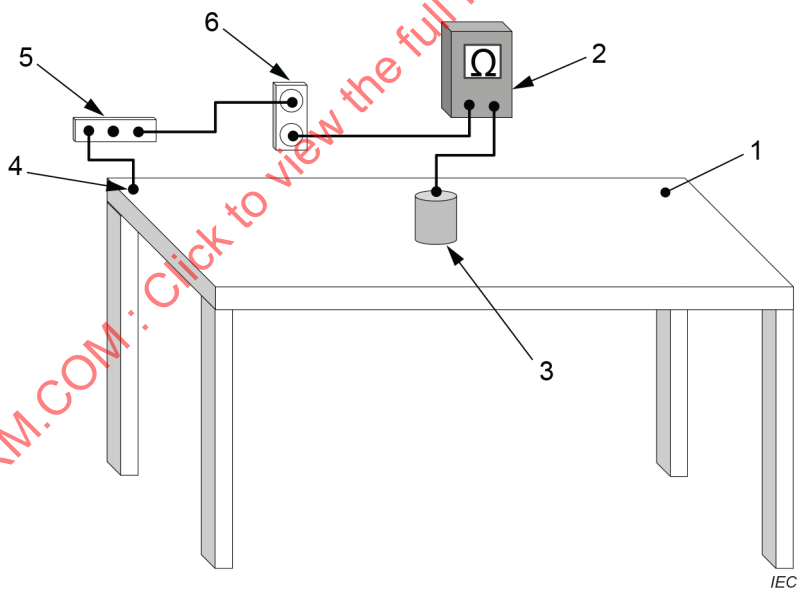
The objective of this test procedure is to verify that the ESD control work surface (a table mat or a bare table) is electrically bonded to the ground reference and is within the minimum and maximum resistance allowed by the user's specification.

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

7.3 Test equipment

See Clause 5 for general description of test equipment.

- one resistance measurement electrode;
- two test leads of sufficient length;
- DC ohmmeter.



Key

1 ESD control work surface
2 DC ohmmeter
3 resistance measurement electrode
4 groundable point
5 common ground point
6 equipment ground

Figure 2 – ESD control work surface test

NOTE Connection to the equipment ground is made using a connector or adaptor approved by national electrical codes and regulations.

7.4 Test procedure

- Do not clean the test surface before the verification.
- Remove all ESD sensitive items from the surface under test. All other items should be left in place on the surface. All ground connections (including equipment ground connections) should remain connected as the surface under test is being verified.
- Connect one end of a test lead to the resistance measurement electrode, and the other end to the test instrument. See Figure 2.
- Connect one end of the second test lead also to the test instrument, and the other end of the second test lead to the ground reference.
- Place the resistance measurement electrode on the surface under test.
- If a DC ohmmeter with a single test voltage or automatic switching test voltage is used, make a measurement and record the resistance.
- If a DC ohmmeter with 10 V and 100 V manually switched test voltages is used, apply 10 V and wait for the meter to stabilize or for 15 s. If the indicated resistance is less than $1{,}0 \times 10^6$ Ω, note the resistance. If the indicated resistance is equal to or greater than $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest. Note the resistance after the meter stabilizes or after 15 s.
- 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 is used.
- If the resistance is known to be equal to or greater than $1{,}0 \times 10^6$ Ω the measurement with 10 V may be omitted.

Tests should include those surface areas that are subject to wear or are visibly dirty.

If measurement results are outside the specified range, record this as a failure and continue to troubleshooting. Also if cleaning resolves the issue, this is still considered a failure and periodic cleaning need to be considered or changed.

7.5 Troubleshooting

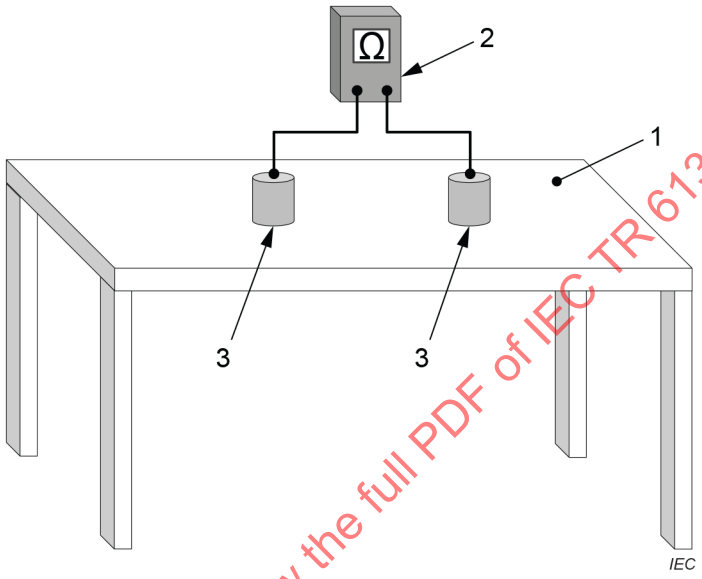
7.5.1 Visual/mechanical check

- Visually and mechanically confirm that all termination hardware and grounding wires are not loose, broken, or disconnected.
- Examine the surface to ensure it is not soiled or worn, which could cause increased surface resistance. If soiled, clean the surface with an approved cleaner. Ensure the surface is completely dry before retesting. If the measured resistance is within acceptable limits after cleaning, cleaning procedures should be reviewed and changed as appropriate. Periodic cleaning is recommended to maintain proper electrical function of all ESD control surfaces.
- When checking ESD control work surface mats:
  - Check the connection of the mat connector to the mat.
  - Check the connection of the ground cord to the mat connector.
  - Check the connection of the common ground point to the ground cord.
  - Check the connection of the equipment ground to the common ground point.

7.5.2 Electrical test

- Verify that the test equipment is operating properly and check/service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the resistance measurement electrode contact surface for dirt build-up. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean the electrode, allow the electrode to dry before retesting.

- With a DC ohmmeter, test the resistance of the surface to the groundable point. Over time the mechanical connection between the groundable point and the mat might become loose. Ensure that there is a good connection between the groundable point and the mat surface. With a DC ohmmeter, test the resistance of the groundable point to the common ground point.
- With a DC ohmmeter, test the resistance of the common ground point to the equipment ground.
- Ensure the surface material has not deteriorated. To determine this condition, the resistance between two locations on the top of the surface (point-to-point) can be performed using a DC ohmmeter and two resistance measurement electrodes with test leads. See Figure 3.



Key

1 ESD control work surface

2 DC ohmmeter

3 resistance measurement electrode

Figure 3 – Point-to-point measurement setup

Defective ESD control items that cannot be brought into compliance should be taken out of service.

8 Wrist strap system

8.1 Basis of test procedure

This compliance verification test procedure is based in part on IEC 61340-4-6.

8.2 Objective

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

8.3 Test equipment

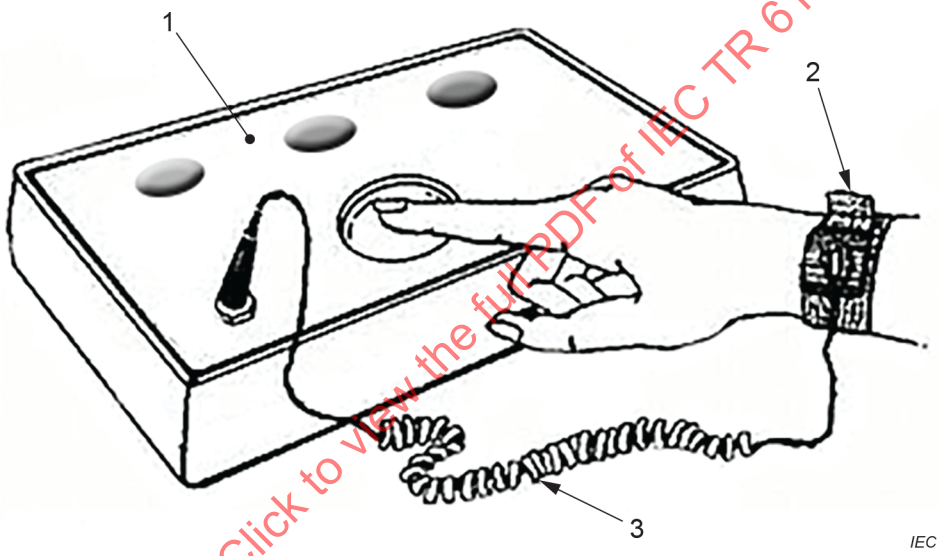
See Clause 5 for general description of test equipment.

- integrated checker for wrist straps, or DC ohmmeter;
- hand-held electrode;
- one test lead of sufficient length.

8.4 Test procedure

8.4.1 Testing with integrated checker

- Place the band on the user's wrist, attach the ground cord to the band and attach the other end of the ground cord to the integrated checker.
- Touch the contact area on the integrated checker with the fingers on the hand closest to the band and activate the integrated checker following the manufacturer's instructions.
- Record the resistance or the "pass" or "fail" indication (see Figure 4).



Key

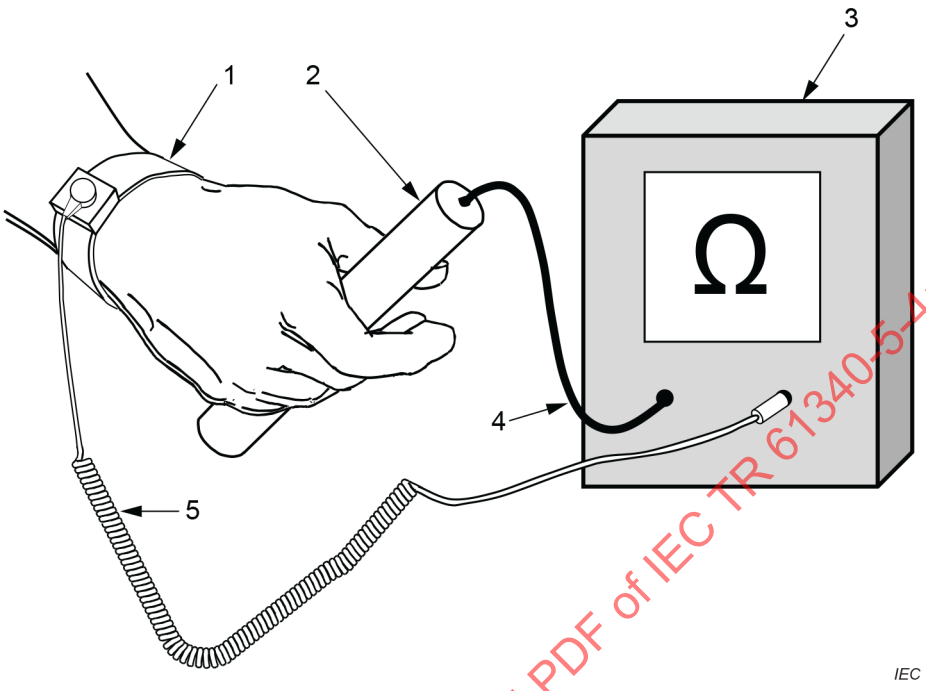
1 integrated checker
2 band
3 ground cord

Figure 4 – Wrist strap test using integrated checker

8.4.2 Testing with DC ohmmeter

- Place the wristband with personal ground cord attached on the user's wrist as per the organization's procedure. Adjust the wristband if necessary to ensure a snug fit.
- Attach the ground cord to the common terminal (-) of the meter.
- Connect one end of the test lead to the hand-held electrode and connect the other end of the test lead to the positive terminal (+) of the meter.
- Hold the hand-held electrode with the hand on which the wrist strap is being worn. See Figure 5.
- Apply 10 V and wait for the meter to stabilize or for 15 s. If the indicated resistance is less than $1{,}0 \times 10^6$ Ω, note the resistance. If the indicated resistance is equal to or greater than $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest.
- Measure and record the resistance of the wristband and ground cord system.

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



Key

1 band
2 hand-held electrode
3 DC ohmmeter
4 test lead
5 ground cord

Figure 5 – Wrist strap test using DC ohmmeter

8.5 Troubleshooting

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

Defective ESD control items that cannot be brought into compliance should be taken out of service.

9 Person-footwear system

9.1 Basis of test procedure

This compliance verification test procedure is based on the following publication:

- IEC 61340-5-1.

9.2 Objective

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

9.3 Test equipment

See Clause 5 for general description of test equipment.

- integrated checker for footwear, or DC ohmmeter;
- foot electrode;
- hand-held electrode;
- two test leads of sufficient length.

9.4 Test procedure

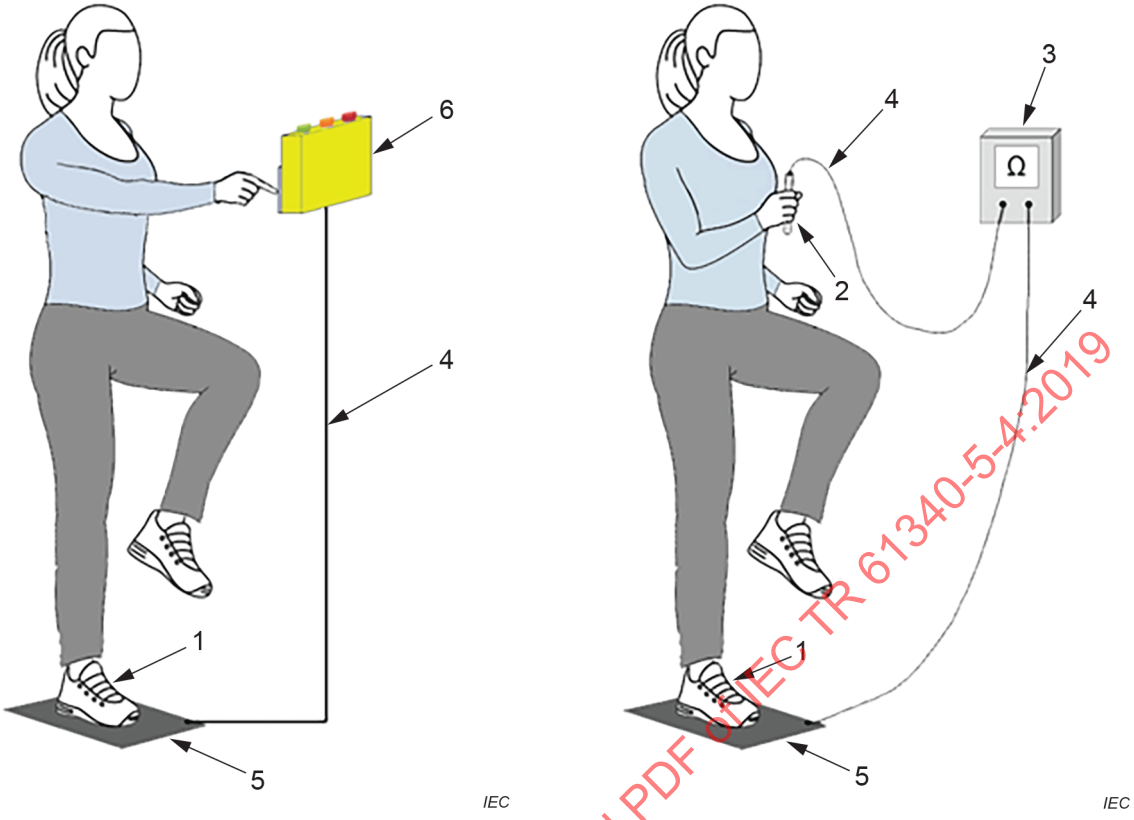
9.4.1 Testing with integrated checker

- Place the ESD footwear on feet as per the organization’s procedure.
- Place one foot on the integrated checker’s foot electrode ensuring the other foot is not in contact with the foot electrode or adjacent ESD control flooring.
- Touch the contact area on the integrated checker and activate the integrated checker following the manufacturer’s instructions. See Figure 6 a). Record the resistance or the “pass” or “fail” indication.
- Repeat for other foot.

NOTE Some integrated checkers that have dual-foot electrodes can do this measurement automatically.

9.4.2 Testing with DC ohmmeter

- Place the ESD control footwear on feet as per the organization’s procedure.
- Connect one end of the first test lead to the hand-held electrode, and the other end of the first test lead to the positive terminal (+) of the DC ohmmeter.
- Connect one end of the second test lead to the common terminal (-) of the DC ohmeter, and the other end of the second test lead to the foot electrode.
- Hold the hand-held electrode with either hand.
- Place one foot on the foot electrode ensuring the other foot is not in contact with the foot electrode or adjacent ESD control flooring. See Figure 6 b).
- Apply 10 V and wait for the meter to stabilize or for 15 s. If the indicated resistance is less than $1{,}0 \times 10^6$ Ω, note the resistance. If the indicated resistance is equal to or greater than $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest. Repeat for the other foot.
- Switching the test voltage to 100 V might 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 is used.



a) Test using integrated checker

b) Test using DC ohmmeter

Key

1 ESD control footwear
2 hand-held electrode
3 DC ohmmeter
4 test lead
5 foot electrode
6 integrated checker for footwear

Figure 6 – ESD control footwear test

9.5 Troubleshooting

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

Defective ESD control items that cannot be brought into compliance should be taken out of service.

10 Flooring

10.1 Basis of test procedure

This compliance verification test procedure is based on IEC 61340-4-1.

10.2 Objective

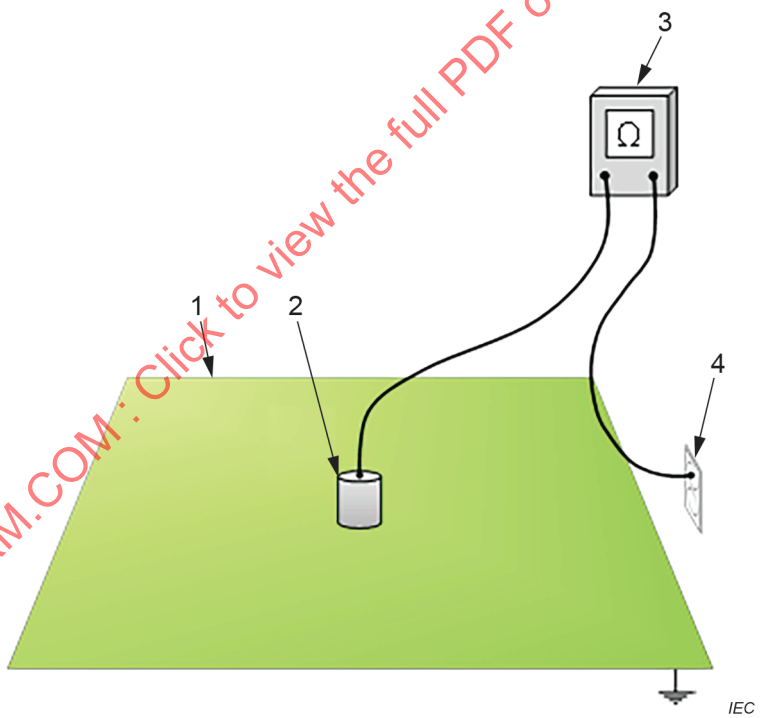
The objective of this compliance verification test procedure is to verify that the resistance of the ESD control flooring is within the minimum and maximum resistance allowed by the user's specification.

An ESD control floor might consist of a permanently installed floor, floor with ESD control floor finish, coatings, tile, paints or floor mat(s).

10.3 Test equipment

See Clause 5 for general description of test equipment.

- DC ohmmeter;
- one resistance measurement electrode;
- two test leads of sufficient length.



Key

1 ESD control flooring

2 resistance measurement electrode

3 DC ohmmeter

4 equipment ground

Figure 7 – ESD control flooring test

NOTE Connection to the equipment ground is made using a connector or adaptor approved by national electrical codes and regulations.

10.4 Test procedure

- Do not clean the ESD control floor before verification.
- Connect one end of a test lead to the electrode, and the other end of the test lead to the DC ohmmeter.
- Connect one end of the second test lead also to the DC ohmmeter, and the other end of the second test lead to the ground reference.
- Place the resistance measurement electrode on the floor surface. See Figure 7.
- Start with the voltage set to 10 V, wait for the meter to stabilize or for 15 s. If the value exceeds 1,0 x 10^6 Ω, select 100 V and repeat the measurement.
- Switching the test voltage to 100 V might result in a resistance reading of less than 1,0 × 10^6 Ω. When this occurs, the reading made with the 100 V test voltage is used.
- Tests should include those flooring areas that are subject to wear or are visibly dirty.
- The number of measurements should be chosen so as to be representative of the floor in question, but in any case should be at least one measurement per 100 m^2 with a minimum of six measurements.

10.5 Troubleshooting

- Verify that the test equipment is operating properly and check/service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the floor for excessive dirt/surface contamination. Remove surface contamination at the test site by following the manufacturer's recommendations. If using liquids to clean the floor, allow the flooring to dry before testing.
- Examine the resistance measurement electrode for dirt build-up. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean the electrode, allow the electrode to dry before retesting.
- Using a DC ohmmeter and two resistance measurement electrodes with test leads, perform a resistance point-to-point test to verify the floor material is the proper resistance.
- If measurement results are outside the specified range, record this as a failure and continue troubleshooting. Also if cleaning resolves the issue, this is still considered a failure and periodic cleaning should be considered or changed.
- When measuring ESD control floor mats:
  - Check the connection of the mat fastener to the mat.
  - Check the connection of the ground cord to the mat fastener.
  - Check the connection of the common ground point to the ground cord.
  - Check the connection of the equipment ground to the common ground point.
- Both test leads should be capable of being isolated from ground. AC line powered resistance measuring devices might give erroneous results due to undefined ground paths.

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

11 Person-footwear-flooring system

11.1 Measurement of electrical resistance

11.1.1 Basis of test procedure

This compliance verification test procedure is based on the following publications:

- IEC 61340-4-5;
- IEC 61340-5-1.

11.1.2 Objective

The objective of this compliance verification test procedure is to verify that the resistance of the footwear system (person, footwear and flooring) is within the minimum and maximum resistance allowed by the user's specification. The footwear might consist of shoes, foot grounders or booties. The ESD control floor might consist of a permanently installed floor, floor with ESD control floor-finish, coatings, tile, paints or floor mat(s).

11.1.3 Test equipment

See Clause 5 for general description of test equipment.

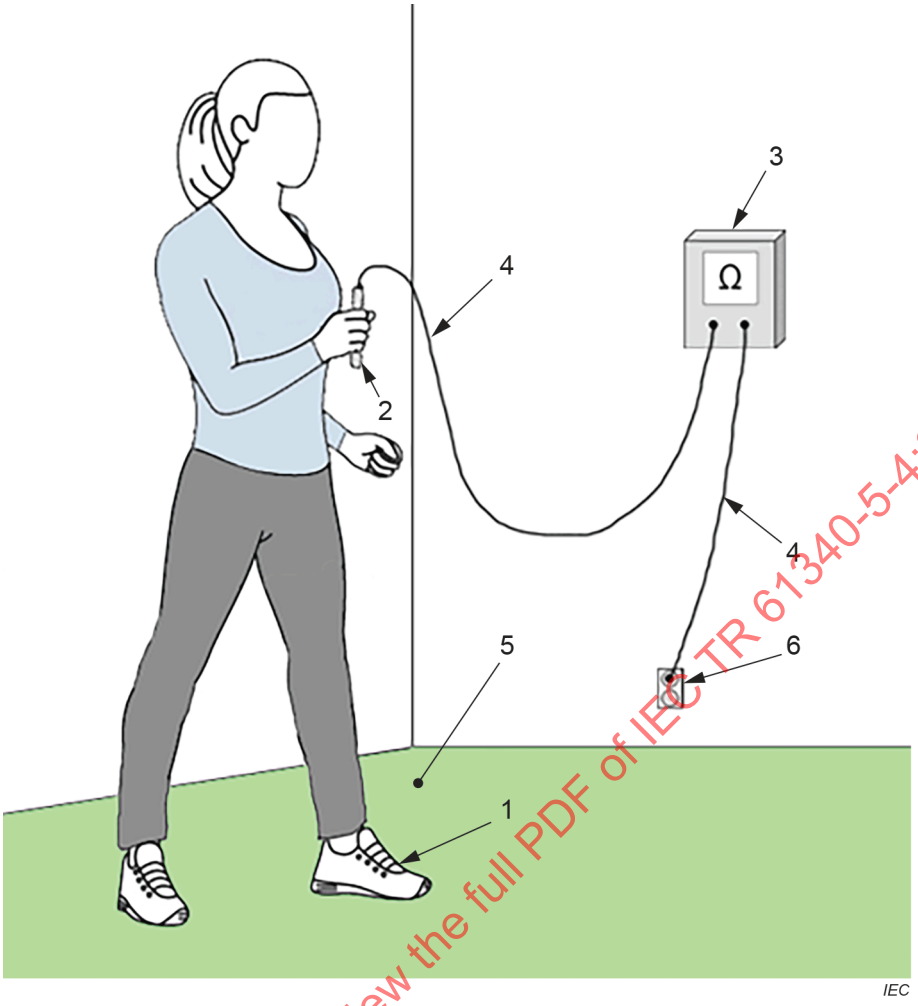
- hand-held electrode;
- DC ohmmeter;
- two test leads of sufficient length.

11.1.4 Test procedure

- Do not clean the ESD control floor before verification.
- Place the ESD control footwear on feet as per the organization's procedure.
- Connect the negative lead of the DC ohmmeter to the equipment ground.
- Connect the other lead to the hand-held electrode.
- Stand with both feet on the test floor covering and firmly grasp the hand-held electrode with either hand. See Figure 8.
- Apply 10 V and wait for the meter to stabilize or for 15 s. If the indicated resistance is less than $1{,}0 \times 10^6$ Ω, note the resistance. If the indicated resistance is equal to or greater than $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest. Record the reading.
- Switching the test voltage to 100 V might 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 is used.
- Repeat the measurements with only the left foot in contact with the floor covering and with the right foot held in the air about 150 mm above the floor covering.
- Repeat the measurements with only the right foot in contact with the floor covering and with the left foot held in the air about 150 mm above the floor covering.
- At least five measurements should be made for each floor covering material. For large floor areas at least five measurements per 500 m^2 of each floor covering material should be made.

11.1.5 Troubleshooting

- See 10.5.



Key

1 ESD control footwear
2 hand-held electrode
3 DC ohmmeter
4 test lead
5 ESD control floor
6 equipment ground

Figure 8 – Person-footwear-flooring system test

11.2 Measurement of body voltage

11.2.1 Basis of test procedure

This compliance verification test procedure is based on the following publications:

- IEC 61340-4-5;
- IEC 61340-5-1.

11.2.2 Objective

The objective of this compliance verification test procedure is to verify that the chargeability of a walking person with ESD control footwear on an ESD control floor remain within the specified limits. The footwear might consist of shoes, foot grounders or booties. The ESD control floor might consist of a permanently installed floor, floor with ESD control floor-finish, coatings, tile, paints or floor mat(s).

11.2.3 Test equipment

See Clause 5 for general description of test equipment.

- hand-held electrode;
- electrostatic voltmeter with autographic recorder/ or integrated instrument;
- one test lead of sufficient length.

11.2.4 Test procedure

- Do not clean the ESD control floor before verification.
- Place the ESD control footwear on feet as per the organization's procedure.
- Connect one lead of the electrostatic voltmeter/integrated instrument to the hand-held electrode.
- Connect, if required by the apparatus in use, the other lead of the test apparatus to the equipment ground.
- Stand with both feet on the test floor covering and firmly grasp the hand-held electrode with either hand.
- Users of this test method should choose a walking pattern typically of the majority of the workers within the area under investigation.
- Walk in the pattern chosen by the organization at a rate of two steps per second whilst maintaining the body facing in the same direction during the test.
- Continuously monitor body voltage measurements to check compliance with the organization's specified limits.
- At least five measurements should be made for each combination of footwear and floor covering material. For large floor areas at least five measurements per 500 m^2 should be carried out of each floor covering material.

It is important that the capacitance of the measurement equipment including the lead to the handheld electrode is kept low and relatively constant. The lead should also not be dragged across the floor since its surface can be tribo-charged and influence the results.

11.2.5 Troubleshooting

- Verify that the test equipment is operating properly and check/service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- To verify if the test system is functioning without the manufacturer's instructions, use a DC ohmmeter. Connect one test lead to ground and the other test lead to the electrostatic voltmeter. Switch the DC ohmmeter to 100 V test voltage and energize the meter. If the test system shows a corresponding value, the system is functioning.
- Examine the floor and footwear for excessive dirt/surface contamination. Remove surface contamination at the test site and/or from footwear by following the manufacturer's recommendations. If using liquids to clean the floor and/or footwear, allow the floor and/or footwear to dry before testing.
- If cleaning resolves the issue, this is still considered a failure and periodic cleaning should be considered or changed.

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

12 Seating

12.1 Basis of test procedure

This compliance verification test procedure is based on IEC 61340-2-3.

12.2 Objective

The objective of this compliance verification test procedure is to verify that the resistance of the chair under test grounding system is within the resistance range allowed by the user's specification.

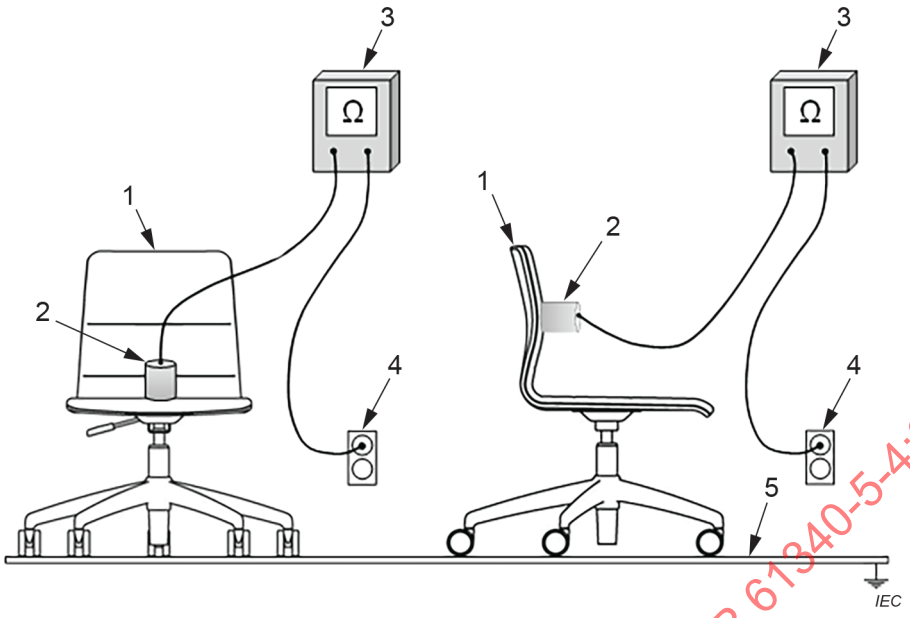
12.3 Test equipment

See Clause 5 for general description of test equipment.

- one resistance measurement electrode;
- DC ohmmeter;
- two test leads of sufficient length.

12.4 Test procedure

- Place the chair under test on the installed ESD control floor. Do not clean the ESD control floor or chair immediately prior to verification.
- Connect one end of a test lead to the resistance measurement electrode and connect the other end of the test lead to the test instrument.
- Connect one end of the second test lead also to the test instrument and connect the other end of the second test lead to the ground reference.
- Place/hold the resistance measurement electrode on the centre of the seat panel of the chair (place the electrode on any worn areas). See Figure 9.
- If holding the resistance measurement electrode, ensure you are not a parallel resistance path that can reduce the resistance measurement. The resistance measurement electrode should be insulated from the operator. This may be accomplished by using either an insulative sleeve over the resistance measurement electrode or body, or by the operator using an insulative glove or similar material.
- Apply 10 V and wait for the meter to stabilize or for 15 s. If the indicated resistance is less than $1{,}0 \times 10^6$ Ω, note the resistance. If the indicated resistance is equal to or greater than $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest. Note the resistance after the meter stabilizes or after 15 s.
- Switching the test voltage to 100 V might 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 is used.
- Optionally the following areas of the chair may be checked, using contact compatible electrodes appropriate to the design of the seat:
  - centre of the seat back;
  - foot ring (if so equipped);
  - arm rests (if so equipped).
- If the back of the chair backrest has a resistance above the dissipative range, the surface should be treated as a process required insulator (see 19.5).
- Tests should include those areas on the ESD control chair that are subject to wear or are visibly dirty.



Key

1 ESD control chair

2 resistance measurement electrode

3 DC ohmmeter

4 equipment ground

5 ESD control flooring

Figure 9 – ESD control chair test

12.5 Troubleshooting

- Verify that the test equipment is operating properly and check/service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the resistance measurement electrode for dirt build-up. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean the electrode, allow the electrode to dry before retesting.
- Verify the resistance of the ESD control floor surface to the reference ground. If the flooring surface resistance is high, clean the floor with an approved cleaner. Allow the floor to dry before retesting. If the floor passes after cleaning, retest the chair. If the floor fails, go to troubleshooting in the flooring section.
- Clean the groundable point (i.e., wheels, casters, drag chain) with an approved cleaner and allow drying before retesting.
- Verify that the point to point resistance, using two resistance measurement electrodes, or resistance to chassis of the chair's components, are appropriate.
- Check the electrical performance of the groundable point(s). Place one groundable point (i.e. wheels, casters, drag chain) on a conductive metal electrode and place the resistance measurement electrode on the centre of the seat panel of the chair.
- Measure the resistance from the resistance measurement electrode to the metal electrode.
- Repeat this test for all groundable points (i.e. wheels, casters, drag chain).
- Clean/vacuum the cloth seat, or clean the vinyl, leather or similar non-textile seat with an approved cleaner (allow non-textile materials to dry) and retest.

If cleaning any of the components of the test, the floor, groundable points or fabric result in bringing the chair into compliance, a failure should be noted and periodic cleaning should be considered or changed.

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

13 Air ionizers

13.1 Basis of test procedure

This compliance verification test procedure is based on IEC 61340-4-7.

13.2 Objective

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

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

13.3 Test equipment

See Clause 5 for general description of test equipment.

- charged plate monitor or a portable verification kit;
- a stopwatch or other suitable timer is typically used to measure discharge times with portable verification kits.

13.4 Test procedure

13.4.1 Initial test setup

- Measurements should be made at the location where ESD sensitive items are to be handled.
- In the absence of ionization, the CPM plate, when charged to the desired voltage, should not discharge more than 10 % of the test voltage within 5 min. Air ionizer heaters and air filters (if so equipped) should be left in their normal conditions during the test.

13.4.2 Discharge time test

- Turn the test equipment on and allow it to stabilize as per the manufacturer’s recommendations.
- Momentarily ground the CPM plate and set (or verify) zero voltage.
- After the CPM plate is disconnected from ground, do not zero the verification instrument in the presence of the ion field.
- Charge the CPM plate to a convenient voltage in excess of the initial test voltage for each polarity (e.g. +1 200 V or −1 200 V).
- Ensure the CPM plate is facing the air ionizer’s airflow.
- The discharge time measurement begins when the test plate voltage has decayed to the initial test voltage (typically ±1 000 V) and stops when the CPM plate voltage has decayed to the final test voltage (typically ±100 V).
- Repeat steps above for the opposite polarity. Note the discharge time in seconds for each polarity.

13.4.3 Offset voltage test (balance)

- Turn the test equipment on and allow it to stabilize as per the manufacturer's recommendations.
- Momentarily ground the CPM plate and set (or verify) zero voltage.
- After the CPM plate is disconnected from ground, do not zero the verification instrument in the presence of the ion field.
- Place the CPM plate facing the air ionizer's airflow. Wait for the reading to stabilize.
- Note the offset voltage (balance).

13.5 Troubleshooting

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

If cleaning or replacing any of the components of the test, the filters or emitter point, result in bringing the ionizer into compliance, a failure should be noted and periodic cleaning should be considered or changed.

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

14 Mobile equipment

14.1 Basis of test procedure

This compliance verification test procedure is based on the following publications:

- IEC TR 61340-5-2;
- ANSI/ESD S6.1;
- ESD ADV 53.1;
- IEC 61340-2-3.

14.2 Objective

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

Mobile equipment that is grounded with a ground cord should be tested according to Clause 7.

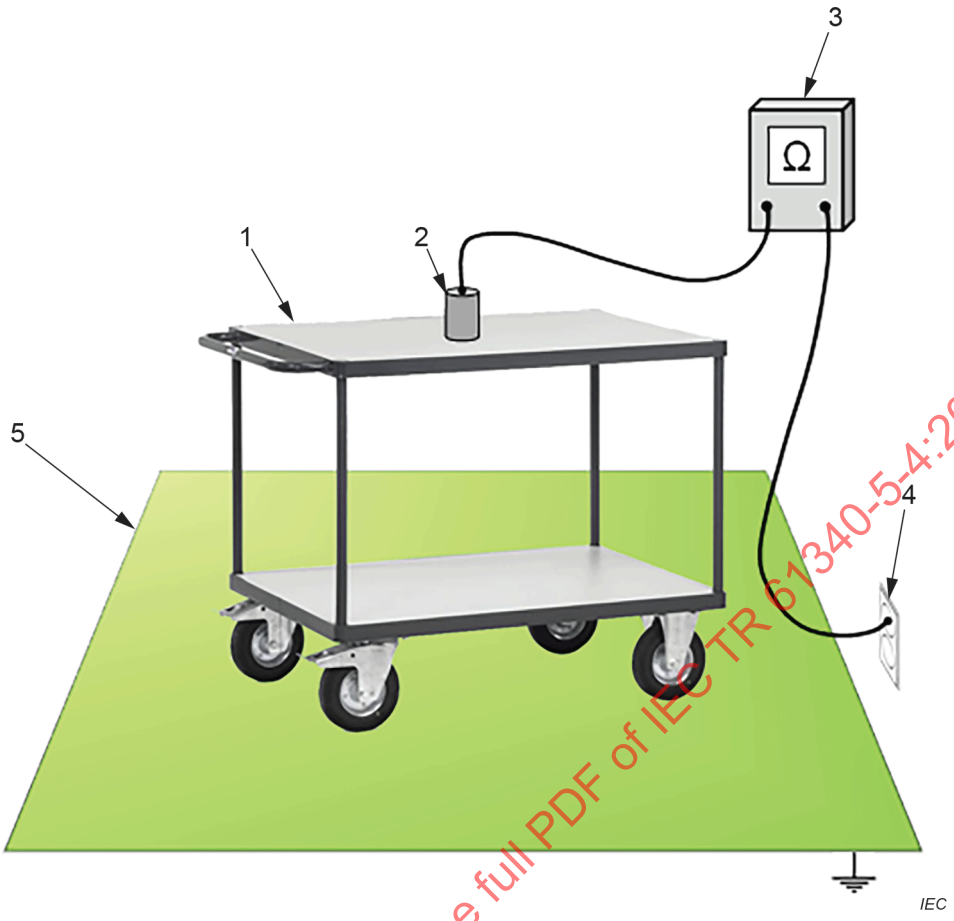
14.3 Test equipment

See Clause 5 for general description of test equipment.

- DC ohmmeter;
- resistance measurement electrode;
- two test leads of sufficient length.

14.4 Test procedure

- Place the mobile equipment on a grounded ESD control floor.
- Do not clean the ESD control floor immediately prior to verification.
- Remove all ESD sensitive items from the mobile equipment.
- Connect one end of the first test lead to the resistance measurement electrode, and the other end of the first test lead to the DC ohmmeter.
- Connect one end of the second test lead also to the DC ohmmeter, and the other end of the second test lead to the ground reference.
- Place the resistance measurement electrode on the centre of the top mobile equipment working surface. See Figure 10.
- Apply 10 V and wait for the meter to stabilize or for 15 s. If the indicated resistance is less than 1,0 x 10^6 Ω, note the resistance. If the indicated resistance is equal to or greater than 1,0 x 10^6 Ω, switch the meter to 100 V and retest. Note the resistance after the meter stabilizes or after 15 s.
- Switching the test voltage to 100 V might result in a resistance reading of less than 1,0 × 10^6 Ω. When this occurs, the reading made with the 100 V test voltage is used.
- Tests should include those areas on the mobile equipment that are subject to wear or are visibly dirty.



Key

1 ESD control mobile equipment
2 resistance measurement electrode
3 DC ohmmeter
4 equipment ground
5 ESD control flooring

Figure 10 – ESD control mobile equipment test

14.5 Troubleshooting

- Verify that the test equipment is operating properly and check/service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Verify that the floor resistance to ground meets defined requirements.
- Verify the components of the cart are not electrically isolated.
- Visually check to ensure that the groundable point(s) (for example drag chain, cables, casters, wheels) used to ground the mobile equipment to the floor are not soiled and are attached securely (clean accordingly, if necessary).
- Examine the grounding connections of the mobile equipment working surfaces.
- Examine the groundable point(s) on the mobile equipment to ensure that they are not soiled or worn, which could add resistance to the mobile equipment grounding system. If soiled, clean the groundable point(s) on the mobile equipment with an approved cleaner, and repeat the procedure.
- Check the electrical performance of the groundable point(s). Place one groundable point (i.e. wheels, casters, drag chain) on a conductive metal electrode and place the resistance measurement electrode on the centre of the top of the mobile equipment working surface.

- Measure the resistance from the resistance measurement electrode to the metal electrode.
- Examine the resistance measurement electrode for dirt build-up. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean the electrode, allow the electrode to dry before retesting.
- Drag chains/cables have been known to be unreliable for grounding mobile equipment (see IEC TR 61340-5-2). When making measurements on mobile equipment, a situation might occur where the initial result is outside the acceptable limits but a subsequent result after moving the equipment slightly is within the acceptable limits. In this case, it is recommended that further measurements be made to determine if the out-of-limits measurement can be treated as an outlier.

If cleaning any of the components of the test, the floor, groundable points, mobile equipment working surfaces, result in bringing the mobile equipment into compliance, a failure should be noted and periodic cleaning should be considered or changed.

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

15 Groundable static control garment system

15.1 Basis of test procedure

This compliance verification test procedure is based on the following publications:

- IEC 61340-4-6;
- IEC 61340-4-9.

15.2 Objective

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

A groundable static control garment system is a groundable static control garment that establishes an electrical bonding path for a person wearing the garment to the groundable point on the garment.

A groundable static control garment system provides a ground path for a person that not only suppresses the electrical field from clothing worn underneath the garment and dissipates triboelectrically generated surface charge, but also bonds the skin of the wearer to an identified ground path. Groundable static control garment systems might 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).

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

15.3 Test equipment

See Clause 5 for general description of test equipment.

- DC ohmmeter or integrated checker for wrist straps, which should give a pass/fail indication corresponding to the limits specified in the compliance verification plan;

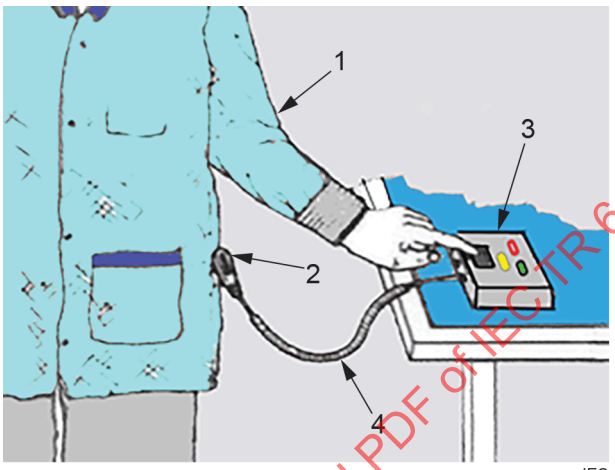
NOTE Some integrated checkers require manual selection to wrist strap resistance test ranges.

- hand-held electrode;
- two test leads of sufficient length.

15.4 Test procedure

15.4.1 Testing with integrated checker

- Put on a garment and properly fasten it as per the organization's procedure. Ensure the garment cuffs are snug to the skin. If adjustable cuffs are used, adjust to ensure a snug fit. Attach the ground cord to the garment's ground cord connection.
- If applicable, switch the wrist strap/footwear integrated checker to the wrist strap setting.
- Insert/attach the loose end of the ground cord into the integrated checker.
- Press and hold the metal contact/test plate with either hand until the pass/fail indication is shown. See Figure 11.



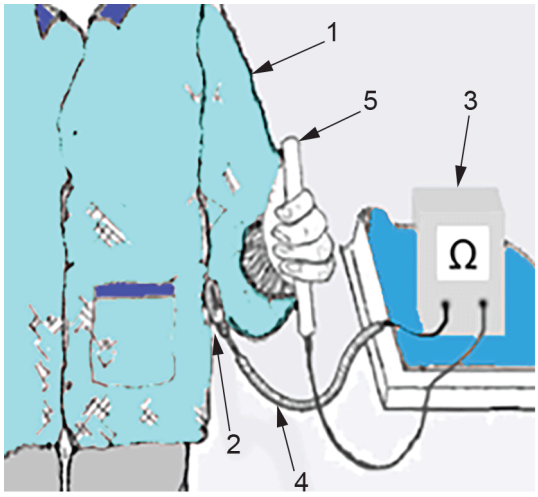
Key

1 groundable static control garment system
2 groundable point
3 integrated checker
4 ground cord

Figure 11 – Testing groundable static control garment system using integrated checker

15.4.2 Testing with DC ohmmeter

- Put on a garment and properly fasten it as per the organization's procedure. Ensure the garment cuffs are snug to the skin. If adjustable cuffs are used, adjust to ensure a snug fit.
- Attach the ground cord to the garment's groundable point.
- Connect the loose end of the ground cord to the common terminal (-) of the DC ohmmeter.
- Connect one end of the test lead to the hand-held electrode and connect the other end of the test lead to the positive terminal (+) of the DC ohmmeter.
- Hold the hand-held electrode with either hand. See Figure 12.
- Apply 10 V and wait for the meter to stabilize or for 15 s. If the indicated resistance is less than $1,0 \times 10^6$ Ω, note the resistance. If the indicated resistance is equal to or greater than $1,0 \times 10^6$ Ω, switch the meter to 100 V and retest. Note the resistance after the meter stabilizes or after 15 s.
- Switching the test voltage to 100 V might 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 is used.



Key

1 groundable static control garment system

2 groundable point

3 DC ohmmeter

4 ground cord

5 hand-held electrode

Figure 12 – Test setup – Groundable garment in combination with a person, hand-held probe and DC ohmmeter

15.5 Troubleshooting

- Verify that the test equipment is operating properly and check/service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Examine the garment cuff to ensure that it is correctly sized and adjusted to be snug to the skin with no intervening clothing or other items.
- Examine the garment and cuff area to ensure it is not soiled or torn.
- If the steps above are not effective, the person's skin might have a high electrical resistance. Changes in weather can affect the person's skin contact resistance. The use of a skin lotion or gel compatible with process requirements might reduce the person's skin contact resistance around the cuff area. If skin lotions and gels are used, more frequent testing during the work shift might be required to ensure their continued effectiveness.
- Examine the seams between panels to ensure they are not soiled or torn.
- Replace the ground cord with a new ground cord and repeat the procedure.
- Replace the garment with a new garment and repeat the procedure.

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

16 Static control garments and groundable static control garments point-to-point method

16.1 Basis of test procedure

This compliance verification test procedure is based on IEC 61340-4-9.

16.2 Objective

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

Other test methods for static control garments can be found in Annex B.

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

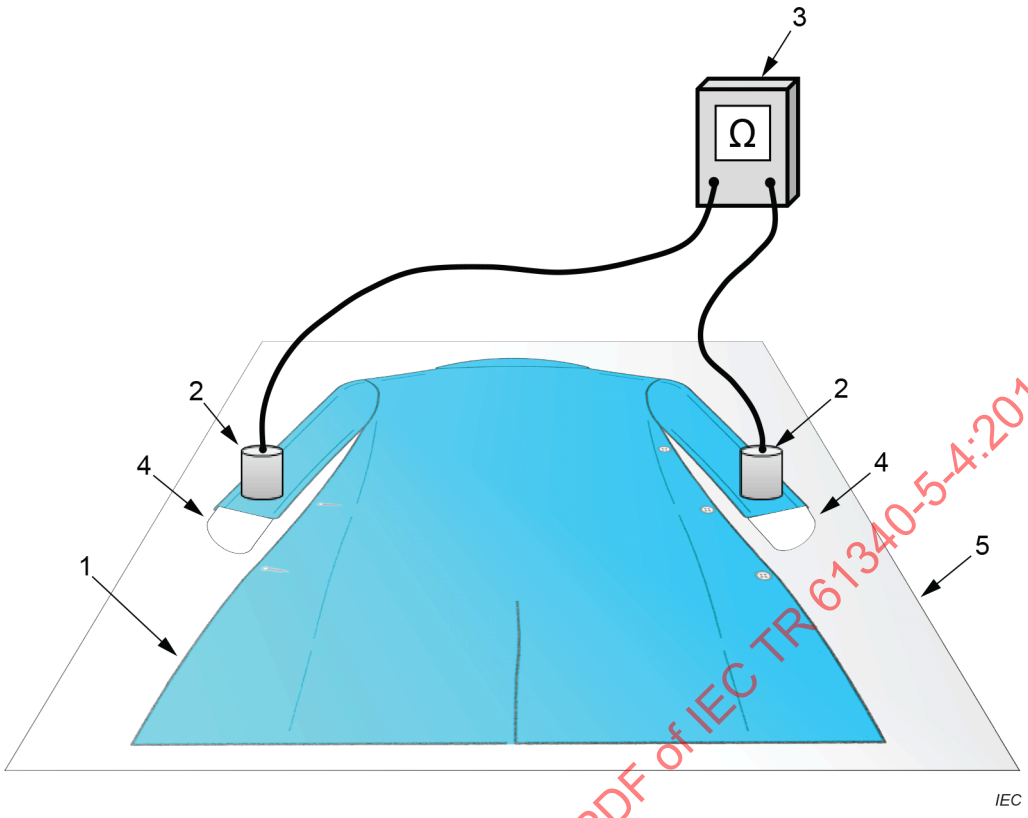
16.3 Test equipment

See Clause 5 for general description of test equipment.

- DC ohmmeter;
- two resistance measurement electrodes;
- two test leads of sufficient length;
- two insulative sleeve inserts (sufficiently large enough for garments).

16.4 Test procedure

- Connect the two resistance measurement electrodes to the test leads and connect the test leads to the integrated checker or meter.
- Place the garment opened as much as possible flat on the insulative support surface. It is important to open the garment to avoid any connections between panels that are not present when the garment is being worn.
- Insert the insulative sleeve inserts into the end of each sleeve. See Figure 13.
- Set the resistance measurement electrodes on each sleeve (or each cuff) of the garment. Ensure the sleeves are separated from the body of the garment. See Figure 13.
- Apply 10 V and wait for the meter to stabilize or for 15 s. If the indicated resistance is less than $1{,}0 \times 10^6$ Ω, note the resistance. If the indicated resistance is equal to or greater than $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest. Note the resistance after the meter stabilizes or after 15 s.
- Switching the test voltage to 100 V might 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 is used.



Key

1 static control garment or groundable static control garment

2 resistance measurement electrode

3 DC ohmmeter

4 insulative sleeve insert

5 insulative support

Figure 13 – Garment (point-to-point) test

16.5 Troubleshooting

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

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

17 Static control garments and groundable static control garments hanging clamp method

17.1 Basis of test procedure

This compliance verification test procedure is based on IEC 61340-4-9.

17.2 Objective

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

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

17.3 Test equipment

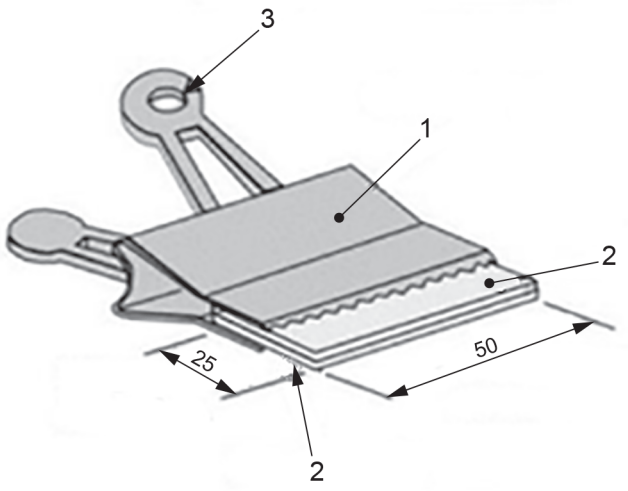
See Clause 5 for general description of test equipment.

- DC ohmmeter;
- insulative hanging apparatus (meeting the electrical requirements of the insulative support surface);
- two clamp electrodes (see Figure 14);
- two test leads of sufficient length.

17.4 Test procedure

- Using the insulative hanging apparatus hang garment from each sleeve with electrically isolated clamp electrodes.
- Clamp electrodes should be attached as follows:
  - for garments equipped with cuffs, attach to the cuffs;
  - for garment not equipped with cuffs, attach to the sleeves.
- The resistance measurement should be made by applying the voltage lead to one clamp and attaching the sensor lead to the other clamp. See Figure 15.
- Apply 10 V and wait for the meter to stabilize or for 15 s. If the reading is less than $1{,}0 \times 10^6$ Ω, note the resistance. If the reading is greater than or equal to $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest. Note the resistance after the meter stabilizes or after 15 s.
- Switching the test voltage to 100 V might 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 is used.

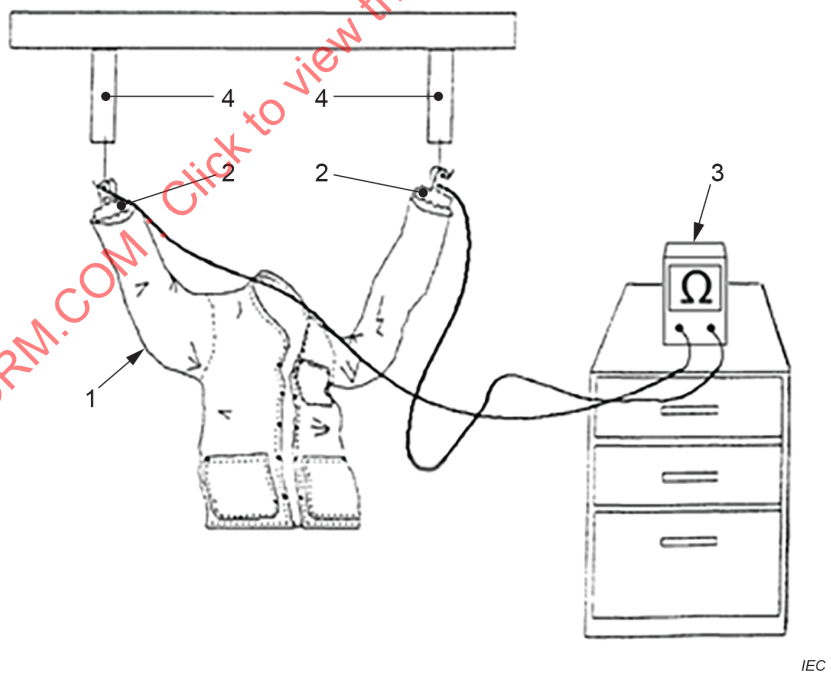
Dimensions in millimetres



Key

1 electrically conductive clamp
2 electrode, e.g. stainless steel
3 test lead connection

Figure 14 – Electrodes for hanging garment test



Key

1 static control garment or groundable static control garment
2 clamps
3 DC ohmmeter
4 insulator

Figure 15 – Alternate point-to-point resistance measurement

17.5 Troubleshooting

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

- Examine the electrodes for dirt build-up. Remove surface contamination by following the manufacturer's recommendations. If using liquids to clean the electrodes, allow the electrodes to dry before retesting.
- Examine the garment (e.g. seams between panels) to ensure it is not soiled or torn. Review laundry process:
  - High temperatures from washing, drying or ironing might damage the carbon fibres in the garment.
  - Fabric softeners used in the laundry process might coat the fibres.
  - Chlorine bleach might damage conductive fibres (especially silver based fibres).
  - Some garments, typically from rental suppliers, can require topical finishes or treatments to be re-applied after washing, either in the final rinse or as a separate process.

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

18 Packaging

18.1 Basis of test procedure

This compliance verification test procedure is based on the following publications:

- IEC TR 61340-1;
- IEC 61340-2-3;
- IEC 61340-5-3.

18.2 Objective

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

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

If packaging is used as a work surface, the requirements of work surfaces may be applied.

18.3 Test equipment

See Clause 5 for general description of test equipment.

- integrated checker or DC ohmmeter;
- insulative support surface;
- concentric ring electrode assembly;
- two surface resistance bar electrodes (SRB);
- two-point probe;

- conductive metal electrode, the area should be slightly greater than the packaging under test;
- two resistance measurement electrodes.

The electrodes and DC ohmmeter may be combined into a single integrated measuring instrument.

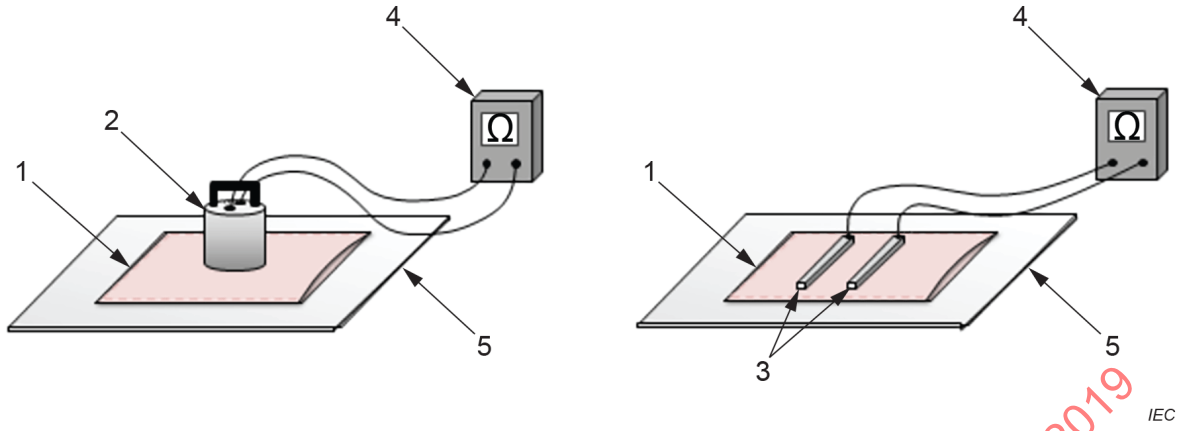
18.4 Test procedure

18.4.1 Surface resistance using an integrated measuring instrument

- Place the package on the insulative support surface to ensure making measurements that concur with product qualification or acceptance testing data. Measurement on dissipative or conductive surfaces will tend to bias the measurements and might provide erroneous results.
- Caution is needed when using the insulative specimen support surface for testing inside of an active EPA. All ESDS items should be moved a distance greater than 30 cm from the testing area.
- Place test electrodes of the integrated checker or meter near the centre of the package (or on worn areas).
- Apply the test voltage and observe the reading.
- If testing bag materials, the inside surface as well as the outside should be tested for surface resistance properties.

18.4.2 Surface resistance using a concentric ring electrode assembly or two SRBs

- Place the concentric ring electrode assembly or two SRBs near the centre of the package (or on worn areas). See Figure 16.
- Connect the DC ohmmeter to the electrodes.
- Apply 10 V and wait for the meter to stabilize or for 15 s. If the reading is greater than $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest. Note the resistance after the meter stabilizes or after 15 s.
- Switching the test voltage to 100 V might 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 is used.



a) Concentric ring electrode assembly **b) Surface resistance bar electrodes**

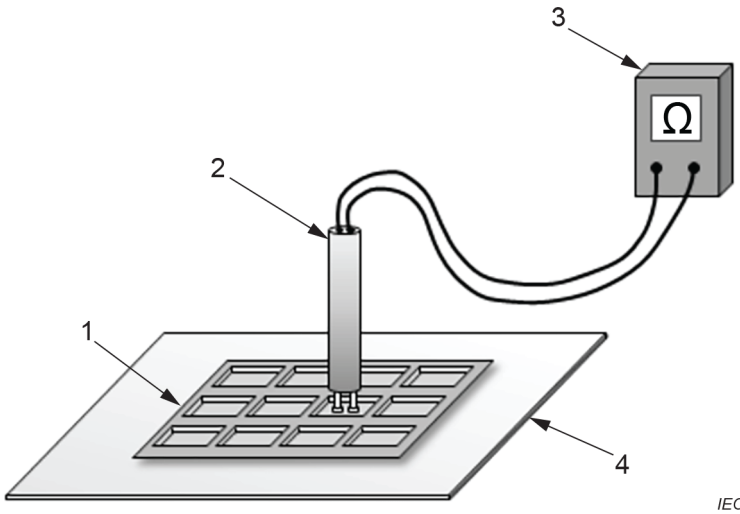
Key

1 ESD control packaging
2 concentric ring electrode assembly
3 surface resistance bar electrodes
4 DC ohmmeter
5 insulative support

Figure 16 – Setup for test method using concentric ring electrode assembly and surface resistance bar electrodes

18.4.3 Surface resistance using a DC ohmmeter and two-point probe

- Place the package on the insulative support surface. Measurement on dissipative or conductive surfaces will tend to bias the measurements and might provide erroneous results.
- Caution is needed when using the insulative specimen support surface for testing inside of an active EPA. All ESDS items should be moved a distance greater than 30 cm from the testing area.
- Place the test electrodes near the centre of the package (or on worn areas). It also is appropriate to place the probe into recessed areas as needed. See Figure 17.
- Connect the DC ohmmeter to the electrodes.
- Apply 10 V and wait for the meter to stabilize or 15 s. If the reading is greater than $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest. Note the resistance after the meter stabilizes or after 15 s.
- Switching the test voltage to 100 V might 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 is used.



Key

1 typical ESD control packaging: precision tray

2 two-point probe

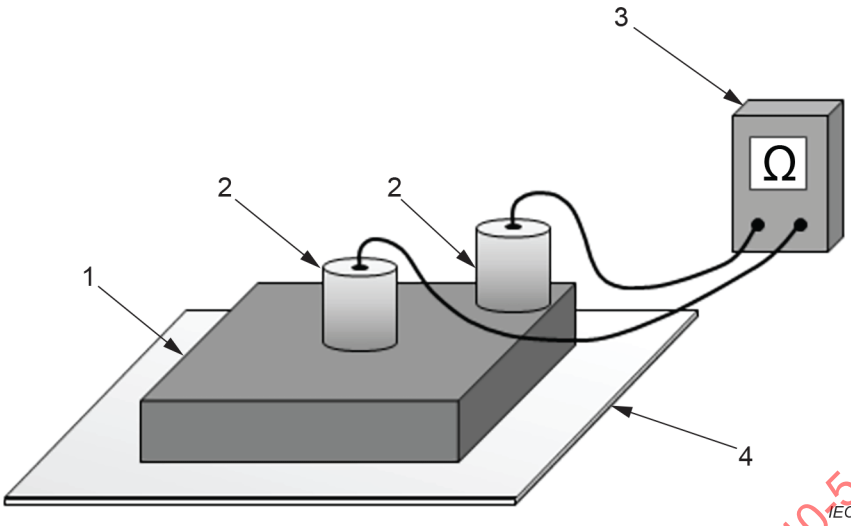
3 DC ohmmeter

4 insulative support

Figure 17 – Setup for test method using a DC ohmmeter and two-point probe

18.4.4 Point-to-point using resistance measurement electrode(s)

- Place one electrode near the centre of the package (or on worn areas) and the second electrode on one corner (or as near as possible to one corner). See Figure 18.
- Connect the DC ohmmeter to the resistance measurement electrodes.
- Apply 10 V and wait for the meter to stabilize or 15 s. If the reading is greater than $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest. Note the resistance after the meter stabilizes or after 15 s.
- Switching the test voltage to 100 V might 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 is used.



Key

1 ESD control packaging

2 resistance measurement electrode

3 DC ohmmeter

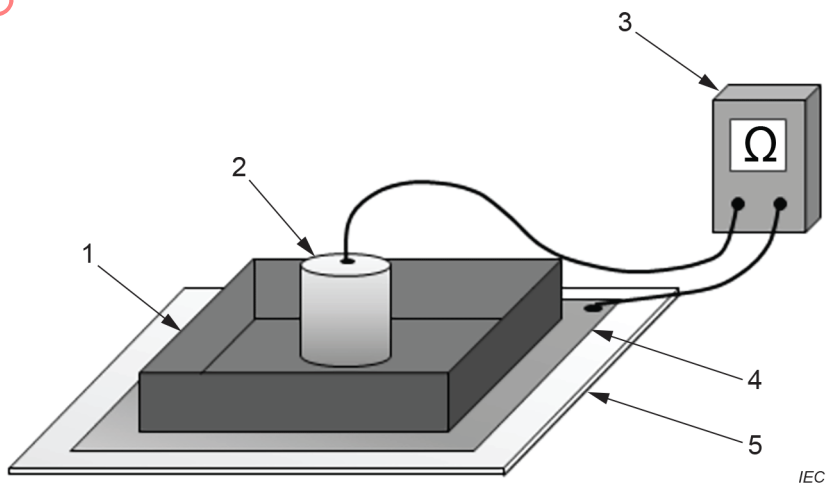
4 insulative support

Figure 18 – Setup for test method using two resistance measurement electrodes

18.4.5 Volume resistance using an integrated checker or DC ohmmeter

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

- Place the conductive electrode onto the insulative support surface and place the ESD control packaging on the conductive electrode. Place the resistance measurement electrode, integrated checker or concentric ring electrode in the centre of the ESD packaging. See Figure 19.
- Apply 10 V and wait for the meter to stabilize or for 15 s. If the reading is greater than $1{,}0 \times 10^6$ Ω, switch the meter to 100 V and retest. Note the resistance after the meter stabilizes or after 15 s.
- Switching the test voltage to 100 V might 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 is used.
- Repeat the test for the other samples.



Key

1 ESD control packaging

2 Resistance measurement electrode

3 DC ohmmeter

4 insulative support

5 conductive electrode

NOTE A concentric ring electrode can be used instead of the resistance measurement electrode with only the inner contact connected.

Figure 19 – Setup for test method using a resistance measurement electrode

18.5 Troubleshooting (surface and volume resistance)

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

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

19 Process required insulators

19.1 Basis of test procedure

The use of electrostatic field meters and electrostatic voltmeters are referenced in the following publications:

- IEC TR 61340-1;
- IEC TR 61340-5-2.

19.2 Objective

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

Non-essential insulators should be removed from the process environment.

19.3 Test equipment

See Clause 5 for general description of test equipment.

- electrostatic field meter or electrostatic voltmeter.

19.4 Test procedure for measuring electrostatic field strength at the site of the ESD sensitive device (ESDS) from electrostatic field source

The electrostatic field at the possible positions of the ESDS may be measured using an electrostatic field meter calibrated to read electrostatic field.

- Ground the field meter (some field meters may be grounded via a grounded person holding the case).
- Operate the electrostatic field meter in accordance with the manufacturer's instructions, including any procedures for zeroing.
- Position the field meter at a typical possible position of the ESDS closest to the electrostatic field source. Allow the reading to stabilize and then record the result. Check all possible orientations.
- Allow the meter to stabilize. The output of the meter may be in volts or V/m.
- Record the meter reading.

Some materials or objects in contact with or near a non-insulating surface might exhibit "field suppression" and show a lowered level of electrostatic field. If the item remains in that position, the field reading found can be considered realistic. If the item moves away from that position during normal operations, the field might increase considerably. In this case further measurements should be made with the item positioned away from the non-insulating surface.

19.5 Measurement of surface voltage of a process required insulator

When making measurements on process required insulators, it is important to take account of any charging mechanisms (contact and separation processes, rubbing, etc.) that might charge the insulators, and to replicate those processes as closely as possible before making measurements.

NOTE 1 When using electrostatic field meters calibrated as voltmeters, only sufficiently large flat surfaces will give correct surface voltage readings.

NOTE 2 Most electrostatic voltmeters only correctly indicate surface voltage when held at a specified distance from the surface being measured.

- Ground the electrostatic voltmeter (some meters may be grounded via a grounded person holding the case).
- Zero the meter according to the manufacturer's instructions if required.
- Position the field meter at the correct distance from the surface to be measured as per the manufacturer's instructions.
- Allow the reading to stabilize and then record the reading.

Some materials or objects in contact with or near a non-insulating surface might exhibit field suppression and show a lowered level of surface voltage. If the item remains in that position, the voltage reading found can be considered realistic. If the item moves away from that position during normal operations, the voltage might increase considerably. In this case, further measurements should be made with the item positioned away from the non-insulating surface.

19.6 Troubleshooting

- Verify that the test equipment is operating properly, check/service the battery (if battery operated), following the manufacturer's operating instructions for proper operation.
- If a process essential insulator is found with a field strength that exceeds the maximum requirement, then:
  - determine whether the highly charged insulator can be replaced with a static dissipative material of the same form and function – if so be sure to ground the static dissipative item upon installation;

  - reduce the charge on the insulator by use of an ionizer;
  - treat the surface with topical antistat.
- The process required insulator can be moved a minimum of 30 cm from the ESDS, if it can be used while maintaining this distance.

Caution should be taken to avoid contacting the sensing plate of the field meter. This includes fingers, gloves or any object. Any foreign residue or material on the meter's sensing plate might affect its ability to properly and accurately measure the electric field strength.

20 Process required isolated conductors

20.1 Basis of test procedure

The use of electrostatic voltmeters are referenced in the following publications:

- IEC TR 61340-1;
- IEC TR 61340-5-2.

20.2 Objective

A conductor that could make contact with the ESDS should be grounded if possible. If it is not possible to ground an isolated conductor, prevent contact with the ESDS, or remove it from the process, then the voltage on it should be measured. It can then be compared with the voltage on any ESDS which it might contact.

Non-essential isolated conductors should be removed from the process environment.

20.3 Test equipment

See Clause 5 for general description of test equipment.

- electrostatic field meter or electrostatic voltmeter (non-contacting or high-impedance contacting).

20.4 Test procedures

- Ground the electrostatic voltmeter (some meters may be grounded via a grounded person holding the case).
- Zero the meter according to the manufacturer's instructions if required.
- Position the field meter at the correct distance from the surface to be measured as per the manufacturer's instructions.
- Allow the reading to stabilize and then record the reading.

Some materials or objects in contact with or near a non-insulating surface might exhibit "field suppression" and show a lowered level of surface voltage. If the item remains in that position the voltage reading found can be considered realistic. If the item moves away from that position during normal operations, the voltage might increase considerably. In this case, further measurements should be made with the item positioned away from the non-insulating surface.

NOTE 1 When using electrostatic field meters calibrated as voltmeters, only sufficiently large flat surfaces will give correct surface voltage readings.

NOTE 2 Most electrostatic voltmeters only correctly indicate surface voltage when held at a specified distance from the surface being measured.

20.5 Troubleshooting

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

Annex A
(informative)

Test frequency

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

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

Examples of how test frequencies are considered:

Daily wrist strap checks are sufficient in some applications while in other operations constant wrist strap monitoring may be used for added operator grounding reliability.

Packaging checks might depend on the composition of the packaging and its use. Some packaging might have static control properties that deteriorate more quickly with time and use, and some packaging might be humidity dependent and might have limited shelf life.

Some materials, such as ESD floor finishes, might require more frequent monitoring because of their lack of permanency. Other materials, such as ESD vinyl floor covering, might require less monitoring. The testing of a floor should also be considered after maintenance on the floor has been performed.

Footwear check frequency should be based on the organization's experience.

Annex B
(informative)

Other test methods for static control garments

B.1 General considerations for other test methods

Some static control garments contain materials that are not accessible for resistance measurements by the methods described in Clause 16 or Clause 17. Examples of such fabrics include those containing core-conductive fibres and some coated or laminated fabrics. Such garments cannot be used as groundable static control garments or in groundable static control garment systems, but they may still be used as part of an ESD control program.

In some cases, an organization may decide to use the test methods described in Clause 16 and/or Clause 17, but specify a higher range of resistance than that specified in IEC 61340-5-1. The acceptable resistance range should be documented in the organization's ESD control program plan and compliance verification plan.

Compliance verification testing and acceptance limits for garments for which resistance measurements are not appropriate should be described in the organization's ESD control program plan and compliance verification plan.

IEC TS 61340-4-2 describes test methods for garments and garment materials, some of which are appropriate for compliance verification testing and are summarized in Clauses B.2 to B.6.

B.2 Precautions to be observed when conducting tests

The test procedures described in Clause B.3 involve the use of reference materials that might acquire and retain charge, test equipment that generates electrostatic fields, and other procedures that are not normally permitted in an EPA when unprotected ESDS are present. Therefore, testing should be done outside an EPA, or within an EPA in which all ESDS have been removed or placed in ESD control packaging prior to the start of testing.

B.3 Tribocharging tests for garments

B.3.1 Objective

The objective of these compliance verification test procedures is to determine if the net charge generated on garments after tribocharging is below the maximum value allowed by the user's specification.

Charge is measured directly, or is determined by measuring parameters that are proportional to charge: body voltage, electrostatic field or surface voltage.

B.3.2 Test equipment for body voltage measurements

See Clause 5 for general description of test equipment and IEC TS 61340-4-2:2013, Clause A.1, Clause B.1, C.2.2 and C.3.2.

- Electrostatic voltmeter capable of measuring body voltage of either polarity up to a voltage greater than the maximum voltage allowed by the user's specification.

- Reference rubbing materials: garments, seat covers or pieces of fabric as appropriate to the test procedure. These should be representative of the materials likely to contact the garments under test when in use, or that are known to generate high levels of charge on non-static control garments. In the latter case, at least two reference materials should be used: one electropositive and one electronegative. Examples of suitable materials include polyamide, wool, leather, polyester, polyvinylchloride and polytetrafluoroethylene.
- Metal base plate for person to stand on. Body voltage measurements can be made with the person grounded as they would be in normal operations, in which case a base plate is not required. However, in order to distinguish between good and poor garments, it might be better to measure body voltage on an isolated person or with a resistance to ground somewhat higher than is normally specified for normal operations. In this latter case the metal base plate is placed on an insulating support and can either be kept isolated during measurements or connected to ground via a resistor of specified value. The organization's compliance verification plan should specify if body voltage measurements are made on isolated persons or with a specific resistance to ground.
- Seat (optional), as used in normal operations, or one kept specifically for compliance verification testing of garments.
- Mannequin (optional). The organization's compliance verification plan should specify the design and electrical characteristics (surface resistance of covering, capacitance, etc.) of the mannequin.

B.3.3 Test procedures for body voltage measurements

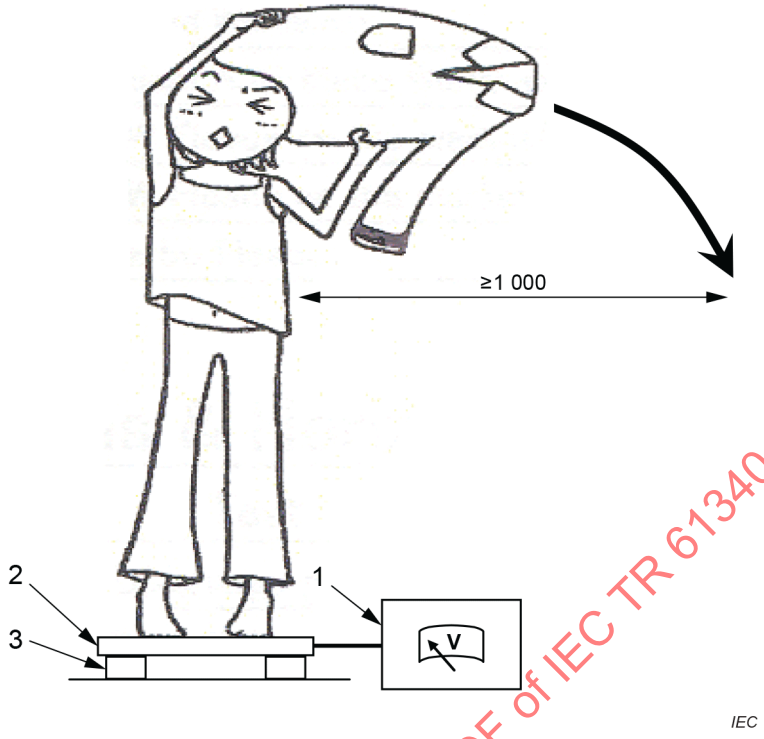
B.3.3.1 Testing by removal of garments

This test procedure is based on a similar procedure described in IEC TS 61340-4-2:2013, Clause A.2 and C.2.3.

- The test person puts on the garment under test, or it is placed on the mannequin.
- The reference garment is put on top of the garment under test.
- The test person stands on the metal base plate.
- Connect the test person or mannequin to the electrostatic voltmeter.
- Momentarily ground the test person or mannequin.
- Remove the reference garment and place it at least 1 m from the person under test or mannequin.
- Record the maximum body voltage.

An example of a suitable test setup is shown in Figure B.1.

Dimensions in millimetres



Key

1 electrostatic voltmeter

2 metal base plate

3 insulating support

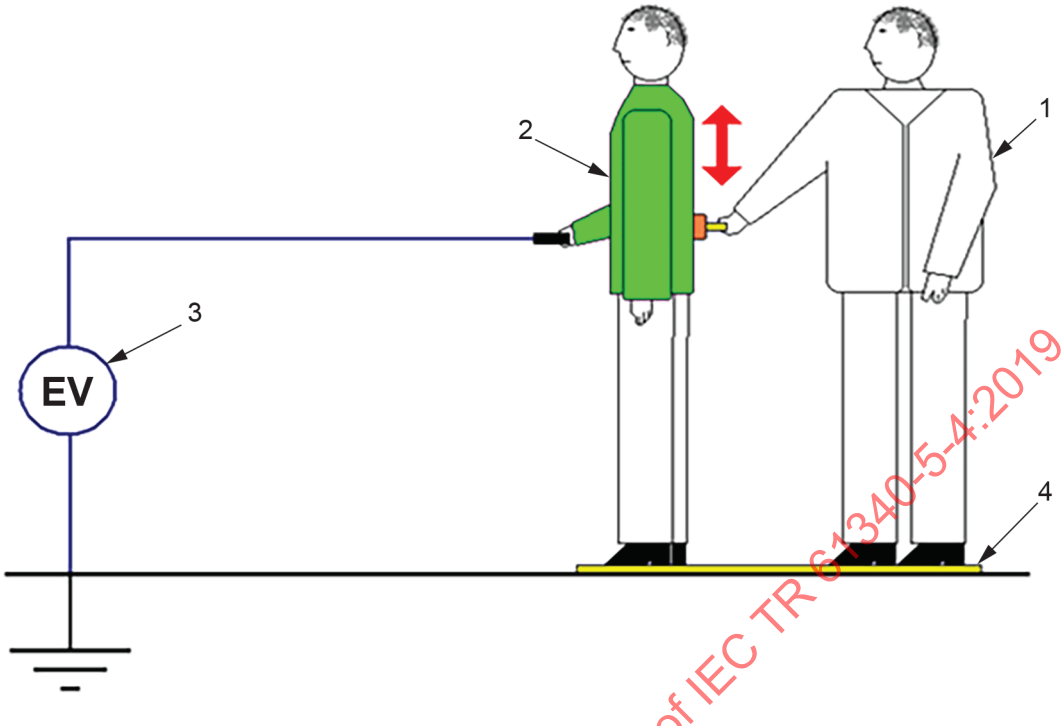
Figure B.1 – Example of a test setup for measuring body voltage whilst removing a garment

B.3.3.2 Testing by rubbing a garment

This test procedure is based on a similar procedure described in IEC TS 61340-4-2:2013, C.3.3.

- The test person puts on the garment under test, or it is placed on the mannequin.
- The test person stands on the isolated metal base plate.
- Connect the test person or mannequin to the electrostatic voltmeter.
- Momentarily ground the test person or mannequin.
- Rub the garment under test with the reference material.
- Record the maximum body voltage.

An example of a suitable test setup is shown in Figure B.2.



Key

1 operator

2 test person

3 electrostatic voltmeter

4 insulating support

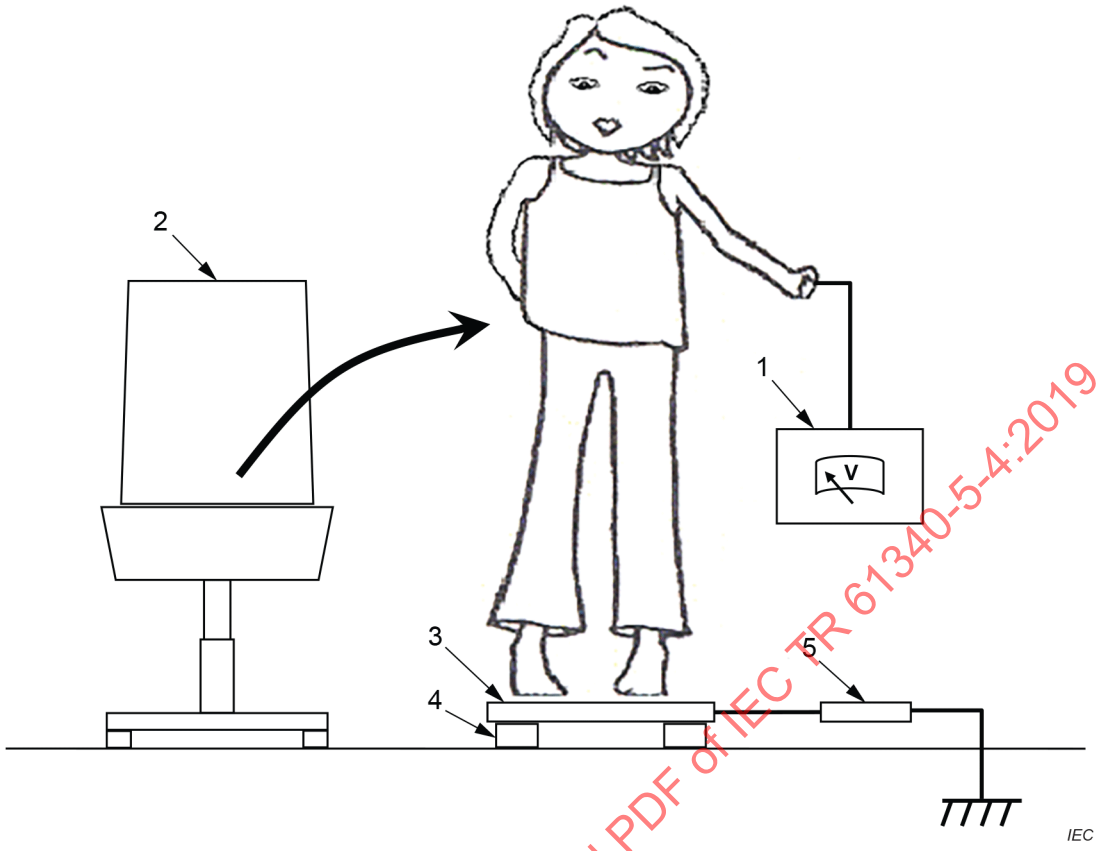
Figure B.2 – Example of a test setup for measuring body voltage whilst rubbing the garment under test

B.3.3.3 Testing using a seat

This test procedure is based on a similar procedure described in IEC TS 61340-4-2:2013, Clause B.2.

- The test person puts on the garment under test.
- The test person sits on the seat.
- Connect the test person to the electrostatic voltmeter.
- Momentarily ground the test person.
- The test person stands up on to the metal base plate.
- Record the maximum body voltage.

An example of a suitable test setup is shown in Figure B.3.



Key

1 electrostatic voltmeter
2 seat
3 metal base plate
4 insulating support
5 resistor (optional)

Figure B.3 – Example of a test setup for measuring body voltage on a person rising from a seat

B.3.4 Test equipment for measuring charge on garments

See Clause 5 for general description of test equipment, IEC TS 61340-4-2:2013, Clause A.1 and C.2.2, and IEC TR 61340-2-2:2000, 4.1.2.

- Faraday pail capable of holding the entire garment under test.
- Charge measuring instrument. Electrostatic voltmeter, charge amplifier or coulombmeter to determine the charge induced on the inner container of the Faraday pail.
- Reference garments that are known to generate high levels of charge on non-static control garments. At least two reference materials should be used: one electropositive and one electronegative. Examples of suitable materials include polyamide, wool and polyester.
- Metal base plate for person to stand on. The metal base plate is placed on an insulating support and can either be kept isolated during measurements or connected to ground via a resistor of specified value. Measurements can also be made with the person grounded as they would be in normal operations, in which case a base plate is not required. The organization's compliance verification plan should specify if measurements are made on isolated persons or with a specific resistance to ground.

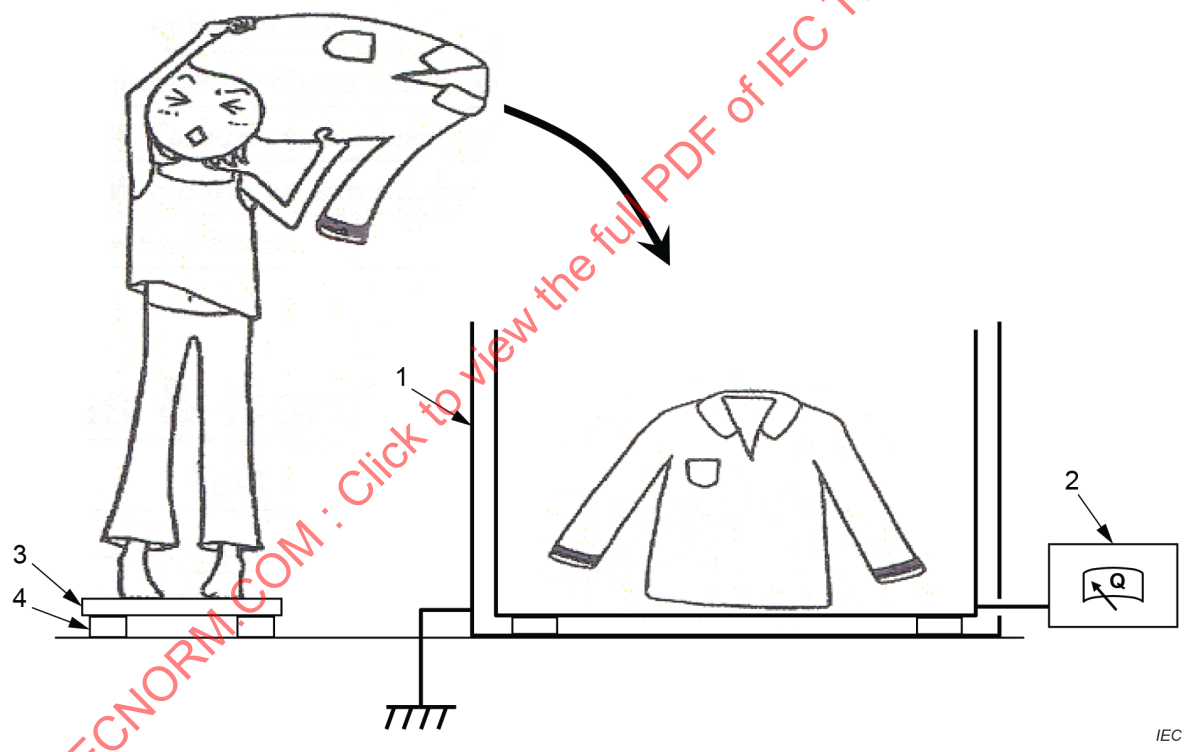
- Mannequin (optional). The organization's compliance verification plan should specify the design and electrical characteristics (surface resistance of covering, capacitance, etc.) of the mannequin.

B.3.5 Test procedure for measuring charge on garments

This test procedure is based on a similar procedure described in IEC TS 61340-4-2:2013, Clause A.2 and C.2.4.

- The test person puts on the garment under test, or it is placed on the mannequin.
- The garment under test is put on top of the reference garment.
- The test person stands on the metal base plate.
- Momentarily ground the test person or mannequin, and the Faraday pail.
- Remove the garment under test and drop it into the Faraday pail.
- From the reading on the measuring instrument, determine the charge on the garment under test.

An example of a suitable test setup is shown in Figure B.4.



Key

1 Faraday pail

2 charge measuring instrument

3 metal base plate

4 insulating support

Figure B.4 – Example of a test setup for measuring charge on garments

B.3.6 Test equipment for measuring electrostatic field or surface voltage on garments

See Clause 5 for general description of test equipment and IEC TS 61340-4-2:2013, Clause E.1.

- Electrostatic field meter or non-contacting electrostatic voltmeter.
- Reference rubbing materials: objects (e.g. plastic pipes, blocks, balls) or pieces of fabric. These should be representative of the materials likely to contact the garments under test when in use, or that are known to generate high levels of charge on non-static control garments. In the latter case, at least two reference materials should be used: one electropositive and one electronegative. Examples of suitable materials include polyamide, wool, leather, polyester, polyvinylchloride and polytetrafluoroethylene.
- Metal base plate for person to stand on. The metal base plate is placed on an insulating support and can either be kept isolated during measurements or connected to ground via a resistor of specified value. Measurements can also be made with the person grounded as they would be in normal operations, in which case a base plate is not required. The organization's compliance verification plan should specify if measurements are made on isolated persons or with a specific resistance to ground.

B.3.7 Test procedure for measuring electrostatic field or surface voltage on garments

This test procedure is based on a similar procedure described in IEC TS 61340-4-2:2013, Clause E.2.

- The test person puts on the garment under test.
- The test person stands on the metal base plate.
- Momentarily ground the test person.
- The test person makes a normal range of movements, for example bending, swinging arms, so that tribocharging occurs between different surfaces of the garments.
- Measure the electrostatic field or surface voltage at different locations about the body.
- Momentarily ground the test person.
- Rub the garment under test with the reference material.
- Measure the electrostatic field or surface voltage at different locations about the body.

B.3.8 Troubleshooting tribocharging tests

- Verify that the test equipment is operating properly and check/service the battery (if battery operated) following the manufacturer's operating instructions for proper operation.
- Ensure that measuring apertures in field meters and non-contacting voltmeters are clean and free of any obstructions.
- If results of measurements are significantly different to normal based on historical data, consider cleaning or changing reference rubbing materials.
- If results of measurements are still higher than normal, examine the garment, including seams and fastenings, to ensure it is not damaged or unduly soiled.
- Review laundry process:
  - high temperatures from washing, drying or ironing might damage coatings, topical finishes or conductive fibres in the garment;
  - some fabric softeners used in the laundry process can adversely affect electrostatic properties, for example by coating conductive fibres;
  - chlorine bleach can damage conductive fibres (especially silver based fibres);
  - some garments, typically from rental suppliers, require topical finishes or treatments to be re-applied after washing, either in the final rinse or as a separate process.

Defective static control garments that cannot be brought into compliance should be taken out of service and clearly marked as such.

B.4 Charge decay time tests for garments

B.4.1 Objective

The objective of these compliance verification test procedures is to determine if the rate at which electrostatic charge dissipates from garments is within the limits allowed by the user's specification.

Charge can be generated by tribocharging, by corona charging, or by direct connection to a DC high-voltage supply. Charge is not measured directly, but rather by measuring electrostatic field or surface voltage. Charge decay time is expressed as the time taken for the electrostatic field or surface voltage to fall from a defined initial value to a defined lower final value.

B.4.2 Test equipment for measuring charge decay time after tribocharging

Refer to Clause 5. For tests on garments as worn, the equipment used is the same as specified in 20.3, with the addition of a means of recording time. For bench-top tests on garments, the following equipment is used:

- Electrostatic field meter or non-contacting electrostatic voltmeter.
- Stopwatch or timer. Alternatively, the output from the electrostatic field meter or voltmeter can be recorded for subsequent analysis and determination of charge decay time.
- Reference rubbing materials: objects (e.g. plastic pipes, blocks, balls) or pieces of fabric. These should be chosen so as to generate sufficient charge on the garment under test such that the electrostatic field or surface voltage is greater than the initial value required for the test. Examples of suitable materials include polyamide, wool, leather, polyester, polyvinylchloride and polytetrafluoroethylene.
- Garment support surface, which may be insulating, dissipative or conductive. The organization's compliance verification plan should specify the surface resistivity or resistance to ground of the garment support surface.

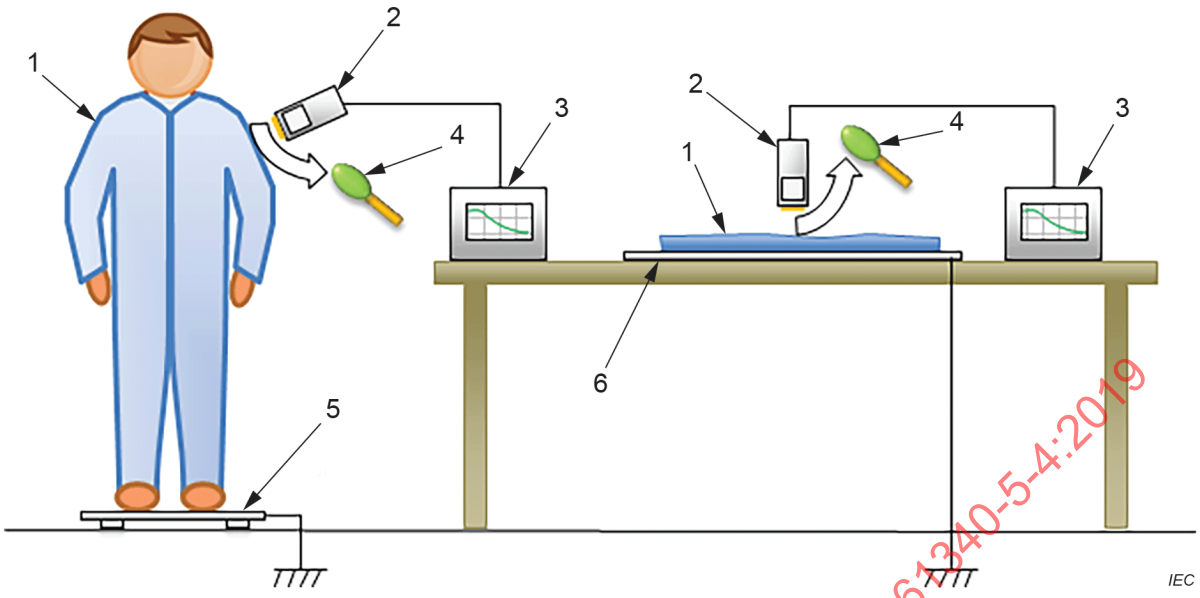
B.4.3 Test procedure for measuring charge decay time after tribocharging

For tests on garments as worn, follow the procedure described in B.3.7 and record the time taken for the electrostatic field or surface voltage to fall from the initial value to the final value.

For bench-top tests on garments, use the following procedure:

- Place the garment under test on the garment support surface so that it touches nothing else.
- If necessary connect the garment to ground. Testing with or without a ground connection, and the means of grounding, if required, should be specified in the organization's compliance verification plan.
- Position the electrostatic field meter or non-contacting electrostatic voltmeter above the area to be charged.
- Rub the garment under test with the reference material.
- Record the time taken for the electrostatic field or surface voltage to fall from the initial value to the final value.

Examples of suitable test setups are shown in Figure B.5.



Key

1 garment under test
2 electrostatic field meter or non-contacting electrostatic voltmeter
3 data recorder
4 rubbing material
5 metal base plate
6 garment support surface

Figure B.5 – Examples of test setups for measuring charge decay time on garments as worn and on a bench-top after tribocharging

B.4.4 Test equipment for measuring charge decay time after corona charging

See Clause 5 for general description of test equipment. The equipment used is the same as specified in B.4.2, except the rubbing material is replaced by a corona array and DC high-voltage supply. The corona array consists of fine conductive points or wires. The configuration of the corona array and the voltage to which it is energized should be specified in the organization's compliance verification plan. Alternatively, for bench-top tests on garments, the test equipment specified in IEC 61340-2-1 may be used.

B.4.5 Test procedure for measuring charge decay time after corona charging

For tests on garments as worn, use the following procedure:

- The test person puts on the garment under test.
- The test person stands on the metal base plate.
- Momentarily ground the test person.
- Position the electrostatic field meter or non-contacting electrostatic voltmeter above the area to be charged.
- Energize the corona array and pass it over the garment under test without the corona array touching the garment.
- Move the corona array at least one metre away from the garment under test and switch it off.
- Record the time taken for the electrostatic field or surface voltage to fall from the initial value to the final value.

For bench-top tests, use the procedure specified in IEC 61340-2-1, or the following procedure:

- Place the garment under test on the garment support surface so that it touches nothing else.
- If necessary connect the garment to ground. Testing with or without a ground connection, and the means of grounding if required should be specified in the organization's compliance verification plan.
- Position the electrostatic field meter or non-contacting electrostatic voltmeter above the area to be charged.
- Energize the corona array and pass it over the garment under test without the corona array touching the garment.
- Move the corona array at least one metre away from the garment under test and switch it off.
- Record the time taken for the electrostatic field or surface voltage to fall from the initial value to the final value.

B.4.6 Test equipment for measuring charge decay time after connection to a DC high-voltage supply

Refer to Clause 5 and IEC TS 61340-4-2:2013, 6.3.4.

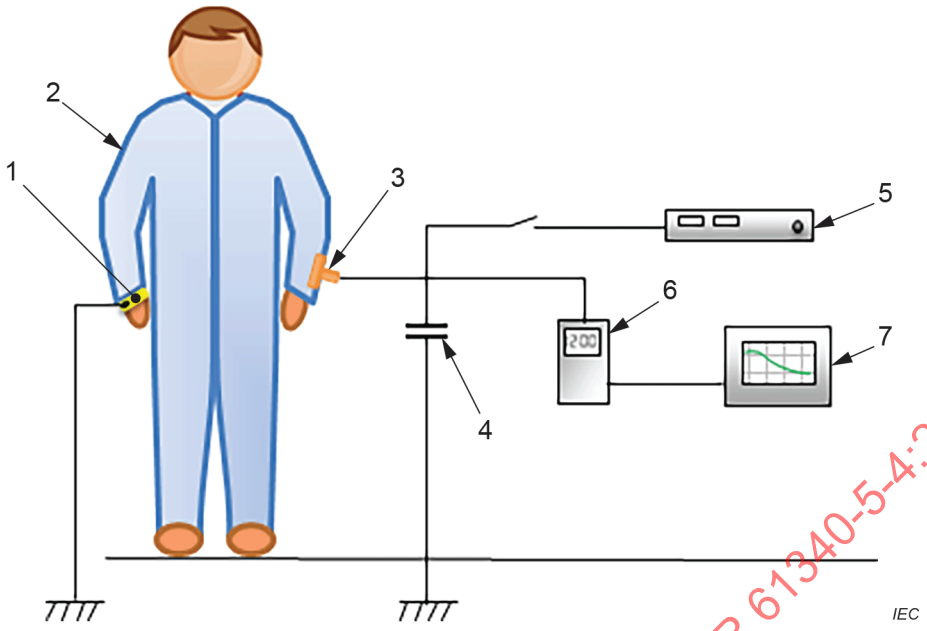
- Charged plate monitor, or combination of DC high-voltage supply, electrostatic voltmeter and timer/recorder.
- 1 nF capacitor (rated to at least 600 V DC).
- Wrist strap or footwear/flooring combination to ground person as in normal operations.
- Insulating base plate (optional).
- Garment contact clamp.

B.4.7 Test procedure for measuring charge decay time after connection to a DC high-voltage supply

This test procedure is based on a similar procedure described in IEC TS 61340-4-2:2013, 6.3.4.

- The test person puts on the garment under test.
- The test person is grounded as in normal operations. The test person may wear a wrist strap connected to ground whilst standing on the insulating base plate, may be grounded via footwear/flooring, or may grounded via a wrist strap and by footwear/flooring. The protocol used for grounding should be specified in the organization's compliance verification plan.
- The capacitor is charged to a convenient value above the initial value. If a DC high-voltage supply is used, disconnect it after charging the capacitor.
- Discharge the capacitor by connecting it to the garment under test via the garment contact clamp.
- Record the time taken for the voltage on the capacitor to fall from the initial value to the final value.

An example of a suitable test setup is shown in Figure B.6.



Key

1 wrist strap
2 garment under test
3 garment contact clamp
4 capacitor
5 DC high-voltage supply
6 electrostatic voltmeter
7 data recorder

Figure B.6 – Example of test setup for measuring charge decay time after connecting a garment to a DC high-voltage supply

B.5 Field suppression tests for garments

Refer to IEC TS 61340-4-2:2013, 6.5.

B.6 Capacitance loading tests for garments

Refer to IEC TS 61340-4-2:2013, 6.8 and Annex D.

Annex C
(normative)

Electrical soldering/desoldering hand tools

C.1 Basis of test procedure

This compliance verification test procedure is based on the following publication:

- ANSI/ESD STM13.1.

C.2 Objective

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

C.3 Test equipment

See Clause 5 for general description of test equipment.

- equipment capable of user defined measurement range;
- tool touch plate.

C.4 Test procedure

C.4.1 Soldering/desoldering hand tool tip voltage test procedure (hot iron) using integrated tester or AC millivoltmeter

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

- Use an AC millivoltmeter, or if using an integrated tester, set the function selector of the integrated tester to the mV AC position.
- Connect the power cord of the soldering iron under test in accordance with the AC millivoltmeter or integrated tester's instruction manual. Turn the soldering iron under test on and allow it to stabilize.
- Touch the tip of the soldering iron to the sensor point (see Figure C.1).
- Evaluate the indicated voltage against the maximum voltage requirement.