IEC 61340-4-9

Edition 3.0 2024-10
COMMENTED VERSION

INTERNATIONAL STANDARD

colour inside

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

IEC 61340-4-9:2024-10 CMV(en)

IEC Secretariat
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 It also gives information on projects, replaced and withdrawn publications.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.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC 61340-4-9

Edition 3.0 2024-10
COMMENTED VERSION

INTERNATIONAL STANDARD

colour inside

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 17.200.99, 29.020

ISBN 978-2-8322-9965-4

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

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

ELECTROSTATICS –

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

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

This commented version (CMV) of the official standard IEC 61340-4-9:2024 edition 3.0 allows the user to identify the changes made to the previous IEC 61340-4-9:2016 edition 2.0. Furthermore, comments from IEC TC 101 experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

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

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

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

a) IEC 61010-1 and IEC 61010-2-030 added as requirements for measurement equipment;
b) testing voltage range for personnel ground path changed from "7 V DC to 30 V DC" to "7 V DC to 100 V DC";
c) cleaning requirements changed from a minimum of five cycles of cleaning to a minimum of three cycles of cleaning;
d) moderate humidity requirements deleted;
e) figures replaced with generic drawings.

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

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

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

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

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

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

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

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document 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

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

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

Three categories of garments are considered in this document.

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

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

c) A groundable static control garment system provides a ground path for a person that suppresses the electrical field from clothing worn underneath the garment and also bonds the skin of the wearer to an identified ground path. Groundable static control garment systems ~~may~~ can also be used in conjunction with a continuous or constant monitoring system in a manner similar to those used in continuous monitoring of wrist straps in an ESD protected area (EPA).

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

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

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

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

ELECTROSTATICS –

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

1 Scope

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

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

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

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

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

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

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

2 Normative references

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

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

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

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

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

3 Terms and definitions

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

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

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

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

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

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

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

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

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

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

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

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

Note 1 to entry: ~~The garment shall also meet all the requirements included in the definition for groundable static control garments.~~ The garment is a groundable static control garment as defined in 3.6, with additional features to enable grounding of the wearer.

4 Atmosphere for conditioning and testing

~~4.1 General~~

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

~~4.2 Low humidity~~

Unless otherwise agreed, the atmosphere for conditioning and testing for laboratory evaluations ~~at low humidity~~ shall be at a temperature of 23 °C ± 2 °C and 12 % ± 3 % relative humidity. The conditioning time prior to testing shall be at least 48 h. 1

~~4.3 Moderate humidity~~

~~The atmosphere for conditioning and testing for laboratory evaluations at moderate humidity shall be at a temperature of 23 °C ± 2 °C and 50 % ± 2 % relative humidity. The conditioning time prior to testing shall be at least 48 h.~~

5 Equipment and materials

~~5.1 Test equipment requirements~~

5.1 Resistance measurement apparatus

5.1.1 General

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

5.1.2 Product qualification

The meter shall have a circuit voltage while under load of ~~100 V (±5 %)~~ (100 ± 5) V for measurements of 1,0 × 10^6 Ω and above, and ~~10 V (±5 %)~~ (10 ± 0,5) V for measurements ~~less than 1,0 × 10^6 Ω~~ from 1,0 × 10^4 Ω to 1,0 × 10^6 Ω. The meter shall have an open circuit or under load voltage of (10 ± 0,5) V) for measurement from 1,0 × 10^3 Ω to 1,0 × 10^4 Ω. 2

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

5.1.3 Acceptance testing

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

The meter shall have an open circuit voltage of ~~100 V (±5 %)~~ (100 ± 5) V for measurements of 1,0 × 10^6 Ω and above, and ~~10 V (±5 %)~~ (10 ± 0,5) V for measurements less than 1,0 × 10^6 Ω.

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

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

5.1.4 Ohmmeter for testing personnel ground path

Integrated tester or meter, whether it is a single meter (ohmmeter) or a collection of instruments that are capable of measuring from 5,0 × 10^4 Ω to at least 1,0 × 10^8 Ω with a test voltage from 7 V DC to ~~30~~ 100 V DC open circuit. If the test voltage exceeds 60 V DC, or 35 V DC in wet

locations, the additional safety limits for current and capacitive charge specified in IEC 61010-1 shall be applied.

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

5.2 Resistance measurement electrodes

5.2.1 Cylindrical electrodes

A cylindrical 2,5 kg ± 0,25 kg ~~rubber~~ electrode with a diameter of ~~65 mm ± 0,5 mm~~ 63,5 mm ± 1 mm, having a contact of electrically conductive material with a Shore-A ~~(IRHD)~~ durometer hardness between 50 and 70. The resistance between two electrodes should be less than $1,0 \times 10^3$ Ω when measured at 10 V on a metallic surface.

5.2.2 Clamps~~/~~ or electrodes

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

5.2.3 Cuff test fixture

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

5.2.4 Hand-held electrode

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

5.3 Support surface

5.3.1 Insulative support surface

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

5.3.2 Insulative sleeve inserts

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

5.3.3 Insulative hangers

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

6 Test procedure

6.1 Sample preparation

6.1.1 General

~~The test samples shall be processed through a minimum of five cycles of the garment manufacturer's prescribed or user defined cleaning process prior to performing laboratory tests.~~

~~6.1.2 Sample size~~

~~Test a minimum of three samples for each style and manufacturer for product qualification. For acceptance testing, the sample size shall be determined by the user.~~

~~6.1.3 Sample sketch~~

Garments can have a temporary finish on them, either a residue from processing treatments or deliberately applied by garment manufacturers, that can reduce electrical resistance. Such finishes shall be removed before proper evaluation of the long-term properties of garments can be made. This can be achieved by processing garments through a minimum of three cycles of the garment manufacturer's specified or user defined cleaning process, prior to performing laboratory tests. **3**

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

6.1.2 Number of samples

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

6.2 Humidity requirements

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

~~NOTE Laboratory testing has shown that low and moderate humidity conditions do not have a consequential impact on the electrical resistance measurement of a garment in combination with a person.~~

6.3 Test procedures

6.3.1 General

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

6.3.2 Resistance point-to-point

6.3.2.1 Panel-to-panel

Precondition the test samples according to 6.2 as required. Place the garment on an insulative support surface as described in 5.3.1. Place the garment with the front panels opened and laid out as flat as possible (it is possible that larger garments such as overalls ~~may~~ will not allow

this completely). Place the insulative sleeve inserts from 5.3.2 into each sleeve (including the cuff, if so equipped, or leg cuffs of an overall) of the garment under test. Attach test leads from the resistance measuring apparatus (meter) to the electrodes defined in 5.2.1. Place one electrode on a panel of the sample. Place the second electrode on another panel of the same sample. Ensure the panels are on the insulative support surface and do not touch any other part of the garment. Apply 10 V and observe the reading after ~~15~~ 5 s. If the reading is less than 1,0 × 10^6 Ω, record the value. If the reading is greater than or equal to 1,0 × 10^6 Ω, apply 100 V for a minimum of 15 s (or until reading stabilizes) and record the results. Switching the test voltage to 100 V can result in a resistance reading of less than 1,0 × 10^6 Ω. When this occurs the reading made with the 100 V test voltage shall be recorded. Repeat for all electrically interconnected components and panels as well as exterior cuff-to-cuff and sleeve-to-sleeve, making sure that the electrodes are directly above the insulative inserts (see Figure 1, Figure 2 and Figure 3). Resistance point-to-point measurements can give variable results depending on the arrangement of the garment under test and location of electrodes on it. For qualification testing, at least three measurements shall be made with the garment arrangement and electrode location re-arranged between each measurement. The result is the highest of the three measured values 4. Repeat for all test samples.

6.3.2.2 Interior cuff-to-cuff

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

6.3.2.3 Hanging clamp sleeve-to-sleeve

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

6.3.3 Resistance point-to-groundable point

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