IEC 61340-2-1

Edition 2.1 2022-06
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

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HORIZONTAL PUBLICATION

Electrostatics –
Part 2-1: Measurement methods – Ability of materials and products to dissipate static electric charge

IEC 61340-2-1:2015-08+AMD1:2022-06 CSV(en)

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Electrostatics –
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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 17.220.99; 29.020

ISBN 978-2-8322-3945-2

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IEC 61340-2-1

Edition 2.1 2022-06
CONSOLIDATED VERSION

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HORIZONTAL PUBLICATION

Electrostatics –
Part 2-1: Measurement methods – Ability of materials and products to dissipate static electric charge

IEC 61340-2-1:2015-08+AMD1:2022-06 CSV(en)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTROSTATICS –

Part 2-1: Measurement methods – Ability of materials and products to dissipate static electric charge

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 61340-2-1 edition 2.1 contains the second edition (2015-08) [documents 101/446/CDV and 101/462/RVC] and its amendment 1 (2022-06) [documents 101/639/CDV and 101/651/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 61340-2-1 has been prepared by IEC technical committee 101: Electrostatics.

This second edition constitutes a technical revision.

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

a) the first edition supported requirements in IEC TR 61340-5-1, but with the revision of IEC TR 61340-5-1 into an International Standard, this support is no longer required; references to IEC 61340-5-1[1][1] have been removed;
b) the introduction gives additional information on when charge decay time measurements are appropriate, and the applications for which each of the two test methods are best suited;
c) procedures for performance verification of measuring instruments for the corona charging method have been added.

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

It has the status of a horizontal standard in accordance with IEC Guide 108[3].

A list of all the 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 the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under webstore.iec.ch in the data related to the specific publication. At this date, the publication will be

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

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.

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

INTRODUCTION

Measurements of the rate of dissipation of static charge belong to the essential measurement techniques in the field of electrostatics.

For homogeneous conductive materials, this property can be evaluated indirectly by measuring resistance or resistivity parameters. Care should be exercised when determining the homogeneity of materials, as some materials that appear homogenous do exhibit non−homogeneous electrical characteristics. If the homogeneity of materials is not known and cannot be otherwise verified, it is possible that resistance measurements ~~may~~ will not be reliable or ~~may~~ will not give enough information. It is also possible that resistance measurements ~~may also~~ will not be reliable when evaluating materials in the dissipative or insulative range and especially for high ohmic materials ~~including~~ that include conductive fibres (e.g. textiles with a metallic grid). In such cases, the rate of dissipation of static charge should be measured directly.

ELECTROSTATICS –

**Part 2-1: Measurement methods –
Ability of materials and products
to dissipate static electric charge**

1 Scope

This part of IEC 61340 describes test methods for measuring the rate of dissipation of static charge of insulating and static dissipative materials and products.

It includes a generic description of test methods and detailed test procedures for specific applications.

The two test methods for measuring charge decay time, one using corona charging and one using a charged metal plate are different and it is possible that they ~~may~~ will not give equivalent results. Nevertheless, each method has a range of applications for which it is best suited. The corona charging method is suitable for evaluating the ability of materials, ~~e.g.~~ for example textiles, packaging, ~~etc.,~~ to dissipate charge from their own surfaces. The charged metal plate method is suitable for evaluating the ability of materials and objects such as gloves, finger cots, hand tools, ~~etc.~~ to dissipate charge from conductive objects placed on or in contact with them. It is possible that the charged plate method ~~may~~ will not be suitable for evaluating the ability of materials to dissipate charge from their own surfaces.

In addition to its general application, this horizontal standard is also intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 108.

One of the responsibilities of a technical committee is, wherever applicable, to make use of horizontal standards in the preparation of its publications. The contents of this horizontal standard shall not apply unless specifically referred to or included in the relevant publications.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 61340-4-6, *Electrostatics – Part 4-6: Standard test methods for specific applications – Wrist straps*

IEC 61340-4-7, *Electrostatics – Part 4-7: Standard test methods for specific applications – Ionization*

3 Terms and definitions

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

3.1
charge decay
migration of charge across or through a material leading to a reduction of charge density or surface potential at the area where the charge was deposited

3.2
charge decay time
time from an initial voltage to a set fraction of the initial voltage

Note 1 to entry: 1/e and 10 % are appropriate fractions (e is the base of natural logarithms, equal to 2,718). If the initial voltage is low, the accuracy of decay time measurements to a small fraction of the initial voltage ~~may~~ can be susceptible to the noise level of the fieldmeter.

3.3
charged plate monitor
CPM
instrument using a charged metal plate of a defined capacitance and geometry which is discharged in order to measure charge dissipation/neutralization properties of products or materials

Note 1 to entry: This note only applies to the French language.

3.4
corona
corona discharge
generation of ions of either polarities by a high electric field

3.5
static dissipative material
material which allows charge to migrate over its surface and/or through its volume in a time which is short compared to the time scale of the actions creating the charge, or short compared to the time within which this charge will cause an electrostatic problem

Note 1 to entry: Materials that ~~may be~~ are considered conductive in other contexts are included within this definition for the purposes of this part of IEC 61340.

3.6
initial voltage
< corona charge decay> surface potential at a time after the end of charge deposition that is a sensible match to the time it takes material surfaces to separate in practical situations

Note 1 to entry: A time of 100 ms is appropriate for manual tribocharging actions.

3.7
initial voltage
<contact charge decay> voltage applied to the conductive plate of a charged plate monitor

3.8
insulator
material with very low mobility of charge so that any charge on the surface will remain there for a time which is long compared to the time scale of the actions creating the charge

4 Method of measurement of charge decay

4.1 Principles

Two methods are described.

The first method determines the dissipation of charge deposited on the surface of the material by a corona discharge. The resulting decrease in surface potential is observed using a fieldmeter or other equivalent equipment. This method is applicable to measurement of charge dissipation from surfaces and materials.

The second method determines the dissipation of charge from a charged plate through an object under test by applying a potential to the metallic plate, disconnecting the voltage source and observing the decrease in potential of the plate by means of a fieldmeter or other equivalent equipment. This method is applicable to measurement of charge dissipation via products such as finger cots, gloves and hand tools.

NOTE There are more methods to charge materials other than the charging methods described here (for example tribocharging or inductive charging) but they are not relevant for this standard.

~~CAUTION~~ WARNING – The test methods specified in this ~~International Standard~~ document involve the use of high-voltage power supplies that ~~may~~ can present hazards if handled incorrectly, particularly by unqualified or inexperienced personnel. Users of this ~~International Standard~~ document are encouraged to carry out proper risk assessments and pay due regard to local regulations before undertaking any of the test procedures. Electrical equipment for measurements shall comply with the safety requirements specified in IEC 61010-1 and IEC 61010-2-030.

4.2 Environmental conditions

The electrical properties of materials vary with temperature and the absorption of moisture.

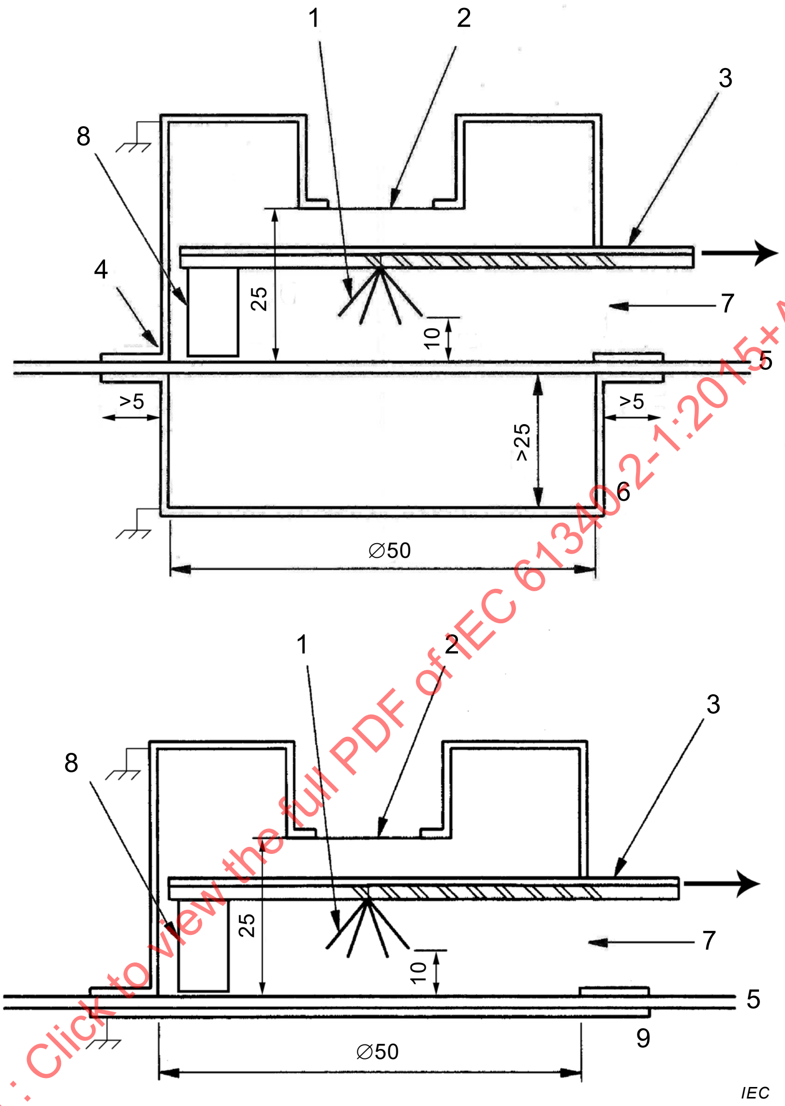
Unless otherwise agreed, the atmosphere for conditioning and testing shall be (23 ± 2) °C and (12 ± 3) % relative humidity, and the conditioning time prior to testing shall be at least 48 h.

For measurements in practical situations the ambient temperature and relative humidity shall be recorded.

4.3 Apparatus for measurement of corona charge decay

4.3.1 Physical design features

Dimensions in millimetres with a tolerance of ± 1 mm.



Key

1 Array of corona points, the tips of which form a circle (10 ± 1) mm in diameter

2 Fieldmeter sensing aperture

3 Movable plate:

– insulating plate to mount corona points (resistance to ground > 10^{14} Ω)

– earthed top surface to shield fieldmeter

4 Earthed casing

5 Sample

6 Metal plate (open backing)

7 Aperture through which the movable plate is withdrawn

8 Air dam

9 Metal plate (earthed backing)

Figure 1 – Example of an arrangement for measurement of dissipation of charge using corona charging

A typical arrangement and relevant dimensions of the test apparatus are shown in Figure 1. Other equipment giving similar results may be used.

The test aperture for deposition and measurement of deposited charge shall be (50 ± 1) mm diameter or an equivalent area quasi-square aperture. An array of corona points is mounted on a movable plate above the centre of the test aperture. The fieldmeter sensing aperture shall be (25 ± 1) mm above the centre of the test area. When the plate with the corona points is moved fully away, the test area shall be clear up to the plane of the fieldmeter sensing aperture.

4.3.2 Containment of test material

With an installed material, the test aperture in the instrument base plate shall rest directly on its surface. Sheet or flexible materials shall be supported as follows:

a) for testing materials with open backing, the material shall be rested against an earthed metal plate with an aperture aligned with the instrument test aperture and with a width of at least 5 mm extending beyond the aperture. A shield over the reverse side of the test area shall be earthed and be at least 25 mm away over the whole test area;

b) for testing materials against an earthed backing, the material shall be mounted between the instrument base plate and a flat earthed metal plate.

NOTE If charge moves more readily through the bulk test material than across its surface, then placing an earthed metal plate immediately behind the test area can increase the rate of charge dissipation. On the other hand, if charge moves more readily across the surface of the test material, then the rate of charge dissipation can decrease if an earthed metal plate is used because its presence will increase the capacitive loading. To gain a full understanding of charge dissipation from the test material, it is desirable to make measurements both with and without an earthed metal plate backing the test area.

In practical terms, earthed backing represents a material in intimate contact with an earthed surface, for example, a garment fitted close to the body of the wearer, or a work surface on top of a metal bench. Open-backed measurements represent the other practical extreme where materials are separated from earthed surfaces, for example, the bottom edge of a coat or smock which hangs away from the body of the wearer.

4.3.3 Corona charge deposition

Corona charging is achieved with at least five corona points, the tips of which form a (10 ± 1) mm diameter circle, (10 ± 1) mm above the centre of the test area. The corona points shall be made from non-corrosive metal wire of a diameter in the range 0,1 mm to 0,5 mm. The exact size and distribution of charge on the material is not well defined, particularly with the more conductive surfaces, but the arrangement provides a consistent pattern of deposited charge and decay time measurements.

NOTE 1 Typical voltages for corona charging equipment are between 5 kV and 10 kV.

The corona duration shall be no more than 50 ms, and 10 ms or 20 ms is usually appropriate in order to achieve an adequate initial peak voltage for measurements. Excessively long deposition times (more than some seconds) ~~may~~ can damage the material.

The materials shall be tested with positive and negative polarity.

The equipment for charge deposition shall move fully away from the region of fieldmeter observation in less than 20 ms.

NOTE 2 For corona voltages of 7 kV to 8 kV, the initial surface voltage with relatively high insulating materials will be up to about 3 kV. For materials with fast charge decay rates the initial voltage can be much lower – for example only 50 V to 100 V.

4.3.4 Fieldmeter

The fieldmeter shall be able to measure the surface voltage with an accuracy of ±5 V to below the lower limit of surface voltage that is required to be measured. The response time (10 % to 90 %) shall be at least one-tenth of the faster decay time required to be measured. The stability of the zero shall allow measurement of surface voltage with this accuracy over the longest decay times to be measured. Therefore, a rotating vane ‘field mill’ type of fieldmeter is preferred.

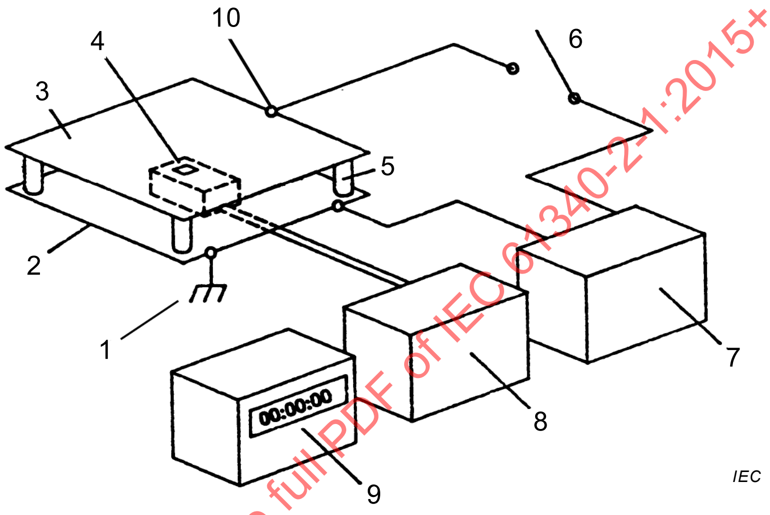
During corona charge deposition and decay time measurement, the fieldmeter sensing aperture shall be well shielded from any connections or surfaces associated with corona high-voltage supplies. There shall be no insulating materials around the region between the fieldmeter and the test aperture during the operation of the fieldmeter.

Any residual ionization shall contribute less than 20 V to the measurement of the surface voltage. ~~(~~Excess ionization ~~may~~ shall be removed, for example, by using an air dam~~)~~. This ~~may~~ can be tested by measurements on a fully conducting test surface.

4.4 Apparatus for measurement of contact charge decay

4.4.1 Physical design features

The basic arrangement and relevant dimensions of the test apparatus are shown in Figure 2. Other equipment giving similar results may be used.



Key

1 Ground
2 Grounded surface, greater than 150 mm square
3 Conductive plate ~~(150 ± 1) mm × (150 ± 1) mm~~ (e.g. nominal dimensions 150 mm × 150 mm)
4 Probe
5 Supporting insulator (resistance to ground > 10^{14} Ω)
6 Switch
7 High-voltage power supply – current limited
8 Fieldmeter or equivalent
9 Discharge timer
10 High-voltage plate contact

Figure 2 – Example of an arrangement for measurement of dissipation of charge using a charged plate[2]

The instrument to measure the charge dissipation of objects under test is the charged plate monitor (see Figure 2). The capacitance of the conductive plate shall be ~~(150 ± 1) mm × (150 ± 1) mm with a capacitance of 20 pF ± 2pF~~ (20 ± 2) pF when mounted in the test fixture. The dimensions of the plate do not significantly affect results and any practical size may be used (e.g. nominal dimensions 150 mm × 150 mm). The wire between the switch and the plate shall be as short as possible.

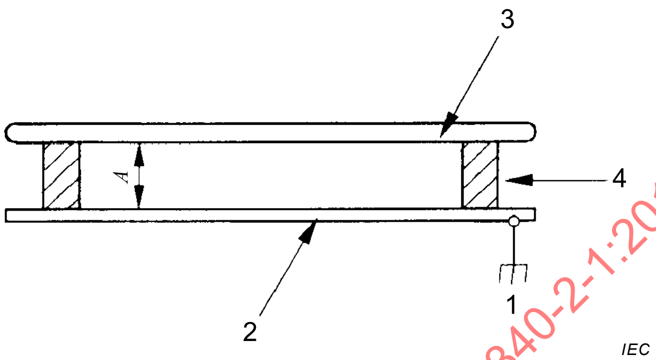
There shall be no objects grounded or otherwise closer than dimension A of Figure 3 to the conductive plate, except the supporting insulators as shown in Figures 2 and 3, or the high-

2 If the different components are integrated into one instrument, this is referred to as a charged plate monitor (CPM).

voltage plate contact as shown in Figure 2. The resistance to ground of the supporting insulators shall be $>10^{14}\ \Omega$. Dimension A is selected to achieve the desired capacitance. The isolated conductive plate, when charged to the desired test voltage, shall not discharge more than 10 % of the test voltage within 5 min under the environmental conditions specified in 4.2. The response time of the monitoring device shall be sufficient to accurately measure charging plate voltages.

The capacitance of the plate and the wires shall be determined according to Clause A.2.

Further design requirements, including requirements for alternative charged plate monitor designs, are specified in IEC 61340-4-7.



Key

1 Ground

2 Grounded surface, greater than 150 mm square

3 Conductive plate (150 ± 1) mm × (150 ± 1) mm

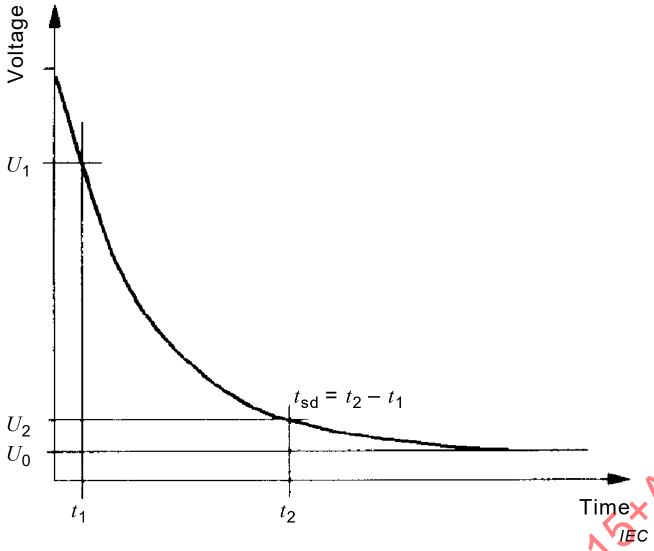
4 Supporting insulator

Figure 3 – Charged plate detail

4.4.2 Charge decay time (t_{sd})

The charge decay time is the period to reduce the initial voltage U_1 on the charged plate to a defined lower voltage level U_2, for example the time from 1 000 V to 100 V for positive or negative polarity (see Figure 4).

There ~~may~~ can be occasions when the potential decay approaches a non-zero value. This final offset voltage is designated U_0.



NOTE The decay curve ~~may or may not~~ can go down to 0 V or not.

Figure 4 – Charge decay time (t_{sd}) and offset voltage (U_0)

5 Practical application of test methods and procedures

5.1 General

Clause 5 describes the application of the test methods for evaluating specific materials and products. The test methods have wider applicability and can be used to evaluate many different materials and products in addition to those included in Clause 5.

5.2 Charge decay test for textile materials

5.2.1 Selection of test method

For charge decay tests on textile materials, the corona charging method shall be used.

5.2.2 Test surface preparation

The sample presented for test shall be big enough to completely cover the test fixture and shall be clean and free from loose dust.

Remove any loose dust by gentle brushing or blowing with clean dry air. If the surface is obviously contaminated, either test an alternative area of the material or make measurements with the contamination present and report the condition of testing ‘as received’.

For laboratory measurements, the materials shall be cleaned according to the manufacturer’s instructions. The materials used for cleaning and the method used shall be reported.

For measurements in practical or installed applications, the materials shall be tested without any “special” cleaning. If cleaning is part of the process, for example, washing of garments, measurements should be taken before and after cleaning where practical. The materials and the method used to clean shall be reported.

Contamination of samples is best avoided by only handling with tweezers or gloved hands.

5.2.3 Testing

Rest the test aperture on the surface to be tested, set up appropriate charging conditions and make the required number of charge decay measurements.

The test equipment shall remain steady and undisturbed on the surface for the duration of each measurement.

Movement of the test equipment relative to the surface can cause tribocharging and result in a sudden change of observed charge distribution, which requires the test to be re-started.

Make measurements with both positive and negative polarities.

Make measurements on sheet and film materials, both with open-shielded backing and with an earthed surface backing.

At least three measurements shall be made for each set of test conditions with each sample. The time between measurements shall be such that the surface voltage falls to below 5 % of the expected initial voltage before starting the next measurement.

All measurements shall be made on different locations.

5.2.4 Results

The charge decay time values are the measured times for the surface voltage to fall from the initial voltage to a defined fraction of the initial voltage.

Charge decay time values quoted shall be the average of the values measured under the test conditions that provide the longest decay times.

If it is not possible to achieve the required initial surface voltage with a corona voltage of at least 7 kV, then this fact shall be recorded together with the actual surface voltage achieved.

5.2.5 Test report

The test report shall include at least the following information:

- reference to this International Standard, i.e. IEC 61340-2-1;
- test results (all values plus charge decay time according to 5.2.4);
- number of samples tested;
- date and time of measurements;
- description and/or identification of material tested;
- charging conditions used (for example, polarity, corona voltage, charging duration, electrode dimensions, time between tests);
- whether the sample is supported with an open backing or an earthed backing surface;
- temperature and relative humidity at the time measurements are made, and where pre-conditioning is used, the temperature, relative humidity, duration of pre-conditioning, and the time between pre-conditioning and testing, if the conditions are different;
- identification of instrumentation used and date of most recent and next calibration.

5.3 Charge decay test via gloves, finger cots or tools

5.3.1 Selection of test method

For charge decay tests on gloves, finger cots or tools, a charged plate monitor according to 4.4 and a wrist strap according to IEC 61340-4-6 shall be used. For the following procedure, all technical values shall be observed within 10 %, or as otherwise agreed.

5.3.2 Common steps in testing

A null test shall be performed at the start of each test sequence to determine if tribocharging makes a significant contribution to the voltage values. The voltage of the null test shall be reported with the test data.

Decay time recording from a bare hand shall also be performed at the start of each test sequence to check the ground system through the wrist strap, and the response time of the measuring system.

In order to measure decay times from 1 000 V under near constant capacitance conditions, it is necessary to charge the conductive plate to greater than 1 000 V.

If the reading after lifting the finger, hand or tool is higher than in the null test, it shall be concluded that there has been no significant discharge and the changing voltage was dominated by the changing capacitance between the finger, hand or tool and the conductive plate.

NOTE 1 Total capacitance during testing will be affected by the capacitance added by contact to the test item, so the pressure applied when testing a finger cot, glove or tool can be relevant. Pressure applied during testing can be monitored by placing the CPM apparatus on a suitable balance or force indicating equipment.

NOTE 2 For highly resistive materials, it can be beneficial to make measurements with both positive and negative polarity. Other documents (standards, specifications, etc.) can specify that measurements are made with both positive and negative polarity.

5.3.3 Test procedure for charge decay properties of finger cots as worn

Hydration of finger cots after wearing for a short time can significantly affect the results of this test procedure. Performance requirements referencing this test procedure shall specify the wearing time before measurements are made.

The following steps shall be taken:

1) Put on a wrist strap and connect it to ground.
2) Perform the null test as described in 5.4.
3) Charge the conductive plate up to 1 100 V.
4) Disconnect the high-voltage power supply from the charged plate.
5) Touch the charged plate with a finger without a finger cot (wearing a wrist strap), lift the finger up after 2 s and do not put it down again; record the decay time from 1 000 V to 100 V as a reference test.
6) Put on a finger cot.
7) Charge the conductive plate up to 1 100 V.
8) Disconnect the high-voltage power supply from the charged plate.
9) Touch the charged plate with a finger wearing a finger cot (wearing a wrist strap), lift the finger up after 2 s and do not put it down again.
10) Record the decay time to from 1 000 V to 100 V.
11) Repeat steps 7) to 10) twice to have three test results.

5.3.4 Test procedure for the charge decay properties of gloves as worn

Hydration of gloves after wearing for a short time can significantly affect the results of this test procedure. Performance requirements referencing this test procedure shall specify the wearing time before measurements are made.

The following steps shall be taken:

1) Put on a wrist strap and connect it to ground.
2) Perform the null test as described in 5.4.
3) Charge the conductive plate up to 1 100 V.
4) Disconnect the high-voltage power supply from the charged plate.
5) Touch the charged plate with the hand flat, without gloves (wearing a wrist strap), lift the hand up after 2 s and do not put it down again; record the decay time from 1 000 V to 100 V as a reference test.
6) Put on a glove.
7) Charge the conductive plate up to 1 100 V.
8) Disconnect the high-voltage power supply from the charged plate.
9) Touch the charged plate with the hand flat, wearing a glove (wearing a wrist strap), lift the hand up after 2 s and do not put it down again.
10) Record the decay time from 1 000 V to 100 V.
11) Repeat steps 7) to 10) twice to have three test results.

5.3.5 Test report for finger cots or gloves

The test report shall include at least the following information:

– reference to this standard, i.e. IEC 61340-2-1;
– test results (all three separately);
– null test voltage;
– date and time of measurements;
– description and/or identification of material tested;
– conditions used (for example, polarity, voltage, time between tests);
– temperature and relative humidity at the time measurements are made, and where pre-conditioning is used, the temperature, relative humidity, duration of pre-conditioning and the time between pre-conditioning and testing, if the conditions are different;
– time between putting on gloves or finger cots and the start of testing;
– identification of instrumentation used.

5.3.6 Test procedure for the charge decay properties of tools

The following steps shall be taken:

1) Put on a wrist strap and connect it to ground.
2) Perform the null test as described in 5.4.
3) Charge the conductive plate up to 1 100 V.
4) Disconnect the high-voltage power supply from the charged plate.
5) Touch the charged plate with the hand without a tool (wearing a wrist strap), lift the hand up after 2 s and do not put it down again; record the decay time from 1 000 V to 100 V as a reference test.
6) Take the tool under test in the hand.
7) Charge the conductive plate up to 1 100 V.

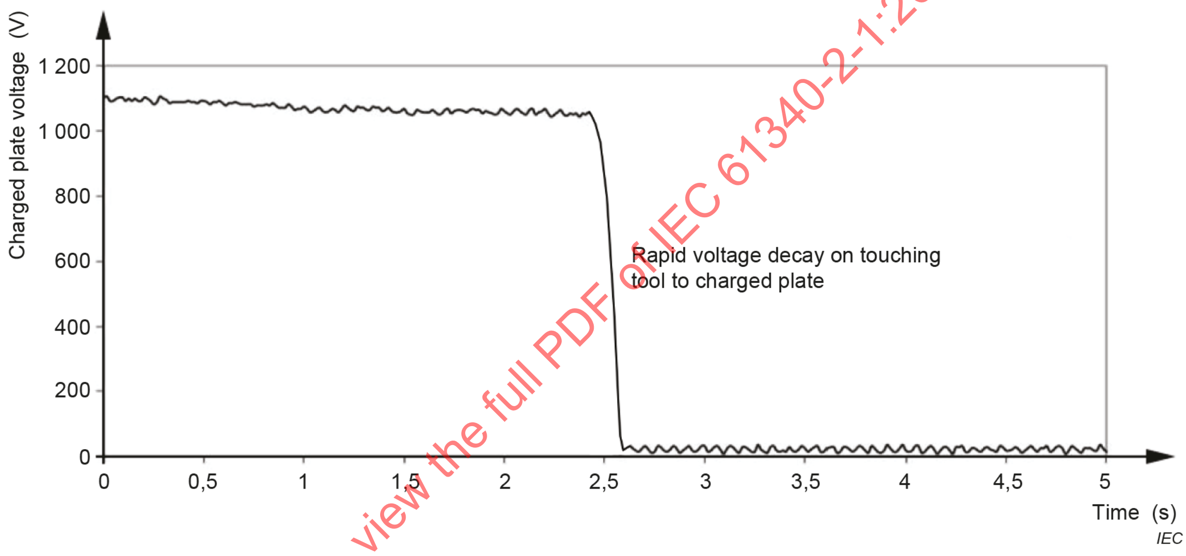
8) Disconnect the high-voltage power supply from the charged plate.

9) Touch the charged plate with the tool in the hand (wearing a wrist strap), lift the tool up after 2 s and do not put it down again.

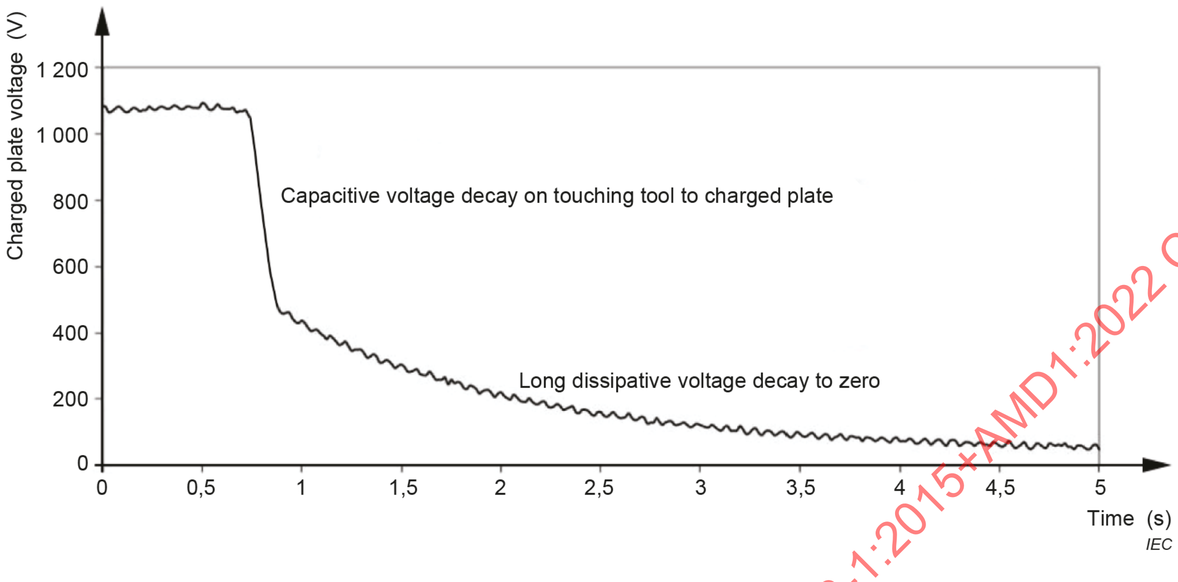
10) Record the decay time from 1 100 V to 100 V.

11) Repeat steps 7) to 10) twice to have three test results

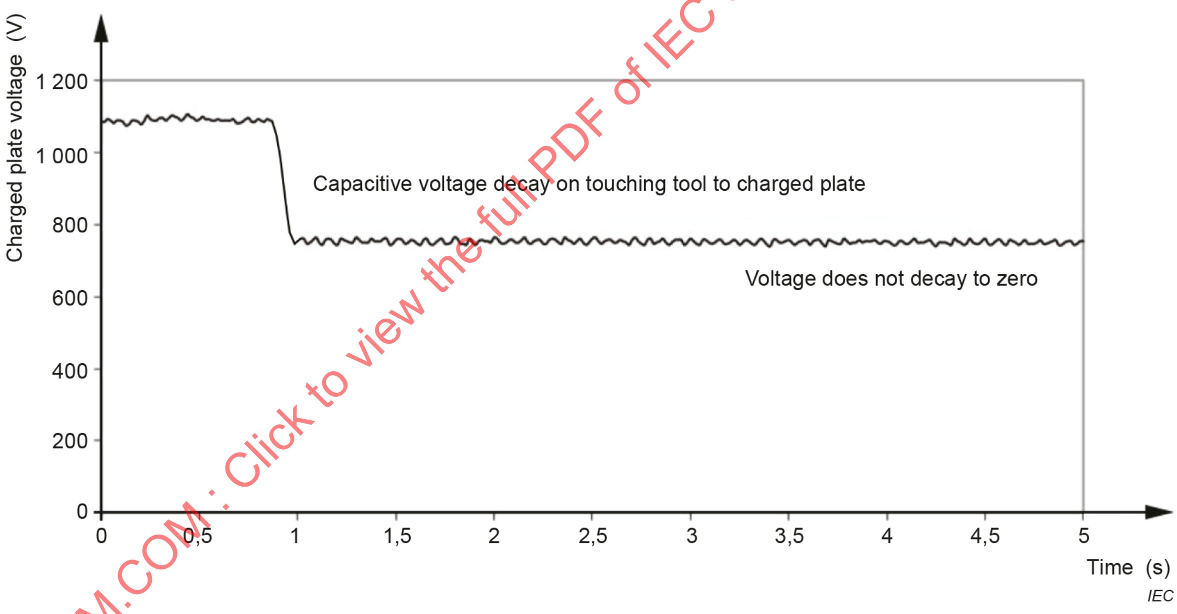
An example of a waveform for a tool showing a fast decay to low voltage is shown in Figure 5 a). A tool with a high resistance or insulating handle can sometimes give an initial apparent fast decay to an intermediate voltage, either followed by a slow decay for the remaining voltage (Figure 5 b)) or no further voltage decay (Figure 5 c)). The initial decay in these cases is caused by discharging of the charged plate into the capacitance between the tool and hand, rather than dissipation through resistance. In some cases, the voltage can fall rapidly below 100 V when the tool touches the charged plate, but then rise above 100 V again when the tool is removed, as shown in Figure 5 d). Performance requirements referencing this test procedure should take account of the possibility of these effects occurring.



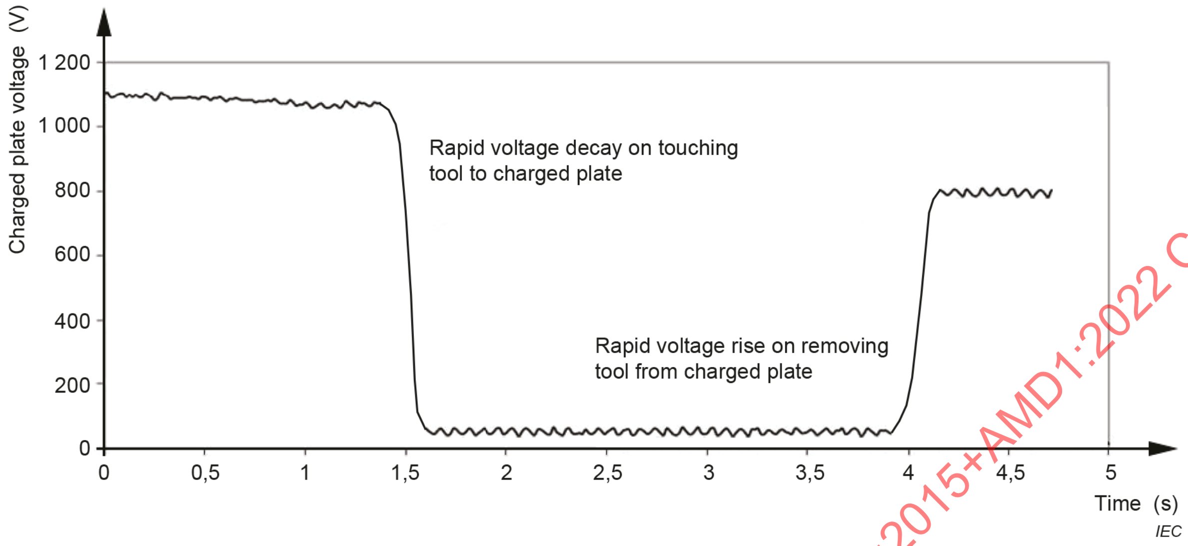
a) Example of a decay waveform for a tool showing a fast decay to low voltage



b) Example of a decay waveform showing initial fast decay caused by a capacitance effect, followed by slow decay via resistance



c) Example of a decay waveform showing no further decay after initial fast decay caused by a capacitance effect



d) Example of a waveform showing rapid changes in charged plate voltage caused by a capacitance effect

Figure 5 – Examples of decay waveforms when testing tools

5.3.7 Test report for tools

The test report shall include at least the following information:

– reference to this standard, i.e. IEC 61340-2-1;
– test results (all three separately);
– null test voltage;
– date and time of measurements;
– description and/or identification of the tool tested;
– test conditions used (for example, polarity, voltage, time between tests);
– temperature and relative humidity at the time measurements are made, and where pre-conditioning is used, the temperature, relative humidity, duration of pre-conditioning, and the time between pre-conditioning and testing, if the conditions are different;
– identification of instrumentation used.

5.4 Null test for CPM

The following steps shall be taken:

1) Put on a wrist strap and connect it to ground.
2) Disconnect the high-voltage power supply from the conductive plate.
3) Ground the conductive plate and zero the fieldmeter.
4) Touch the conductive plate with the item to be tested in the same way as for the real test. Be careful only to touch it and do not rub the item across the conductive plate.
5) Isolate the conductive plate.
6) Raise the item to be tested from the conductive plate.
7) Read the voltage on the conductive plate.
8) This is the voltage generated by the separation of the item to be tested from the plate. This shall be noted in the final report.

Annex A
(normative)

Performance verification of measuring instrumentation

A.1 Verification of corona charge decay measuring instrumentation

A.1.1 Aspects to be verified

Verification of charge decay measurement instrumentation involves two parts:

a) verification of the surface potential sensitivity of the fieldmeter;

b) verification of the decay time measurement performance.

Formal calibration requires the establishment of measurement uncertainty (see ISO/IEC Guide 98-1[2]).

A.1.2 Surface potential sensitivity verification

The surface potential sensitivity verification is made in terms of a uniform potential on a plane conducting surface covering the whole test aperture area. The voltage source shall provide a stable, low ripple voltage of both polarities to at least 1 000 V. The voltage measuring system shall cover the measurement of both polarities and be separate from the voltage source so it ~~may~~ can be formally verified independently. The accuracy of voltage measurement shall be better than 0,2 %. The stability of the verification voltage shall be 0,2 %.

A.1.3 Decay time verification

Calibrated resistors and capacitors are connected in parallel between earth and the conducting verification plate over the test aperture. The resistors and capacitors shall be of good quality, with linear characteristics with voltage and be capable of withstanding voltages up to 3 kV.

Decay time values, in seconds, are derived from the product of the values of the resistors (ohms) and capacitance (farads). Decay time values shall be provided for each decade of time over the main operating range of the instrument. To cover the range of interest of materials used for static control, the decay time values provided should cover the range 100 ms to 100 s.

A.1.4 Verification procedure

The charge decay measuring instrument is mounted on the verification equipment, switched on and allowed to stabilize. Connect the verification plate to earth and measure the initial zero surface potential reading by the fieldmeter. Apply verified voltages to the plate to give readings at well-spaced voltage levels from 50 V to 1 000 V. Repeat measurements for the other voltage polarity.

Connect a combination set of resistance and capacitance values from earth to the verification plate. Operate the charge decay measuring instrument to apply sufficient charge to the verification plate to achieve an initial peak surface potential suitable for decay time measurement. Initial surface potentials in the range 100 V to 1 000 V are convenient. Measure the time from the initial peak surface potential to 1/e of this using the normal instrument charge decay time measurement facilities. If both electronic and software decay time measurement facilities are available then both shall be used together.

At least three decay time measurements shall be made for each charge polarity for each decay time value setting. From each set of six readings, the average decay time value and the standard deviation shall be calculated.

A.2 Methods for verification of the capacitance of an isolated conductive plate

A.2.1 General

The measurement of the capacitance of an isolated conductive plate shall either be made using a suitable capacitance meter, by measuring the charge on it or by using the charge sharing method.

A.2.2 Capacitance meter method

A capacitance meter with a resolution of 0,1 pF and an accuracy of 5 % can be used to directly measure the capacitance of the isolated conductive plate. The conductive plate shall be discharged to ground potential before connecting the capacitance meter. The test leads of the capacitance meter shall be as short as is practical. The capacitance of the test leads shall be subtracted from the measured capacitance.

A.2.3 Charge measuring method

A.2.3.1 General

This method for measuring the capacitance of an isolated conductive plate (including the wires) to within an accuracy of 5 % requires a voltage source and a coulomb meter. The capacitance of the plate is determined from the equation:

$$C = Q/U \tag{A.1}$$

where

Q is the charge on the plate in coulombs (C);

U is the voltage on the plate in volts (V);

C is the capacitance of the plate in farads (F).

The voltage on the plate is determined by charging it with a known voltage, U, and the charge Q on the plate is measured by discharging into a coulomb meter. The ratio of these two measured numbers, as shown by Equation (A.1), gives the capacitance of the isolated conductive plate.

If the capacitance is in the range of 20 pF ± 2 pF, it is convenient to use 100 V for the value U. 100 V on a conductive plate with a capacitance of 20 pF results in a charge of 2 nC on the plate.

A.2.3.2 Equipment

The following equipment shall be used:

– a d.c. voltage source of 100 V with a tolerance of ± 20 %, and measured to ±2 %, with a current limit of 100 μA.

– a coulomb meter with a resolution of 0,02 nC on a suitable scale (for example, 3 nC full scale).

A.2.3.3 Procedure

Charge the plate (see Figure 3) to U by momentarily touching it with the probe from the voltage source. Remove the charge on the plate by touching it with the probe from the coulomb meter and record the charge reading. Repeat the experiment 10 times to determine average values and standard deviation. The standard deviation should be less than 0,5 pF.

A.2.4 Charge-sharing method

The principle of the charge sharing method for measuring the capacitance of a CPM is to connect the monitor plate, at a known potential, to a reference capacitor that is much larger than the capacitance expected for the CPM itself (see Figure A.1) Charge will be shared between the reference capacitor and the CPM in the same ratio as their respective capacitances. For example, if the CPM has a capacitance of 20 pF and the reference capacitor is 2 nF then 0,99 % of the total charge will remain on the CPM and 99,01% will be transferred to the reference capacitor. For practical purposes, if a reference capacitor is used that is at least 100 times larger than the capacitance expected for the CPM, then it can be assumed all the charge is transferred to the reference capacitor.

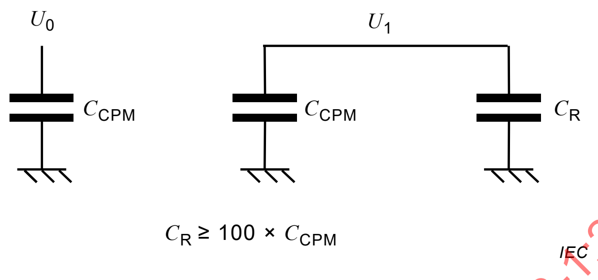


Figure A.1 – Equivalent circuit for CPM and reference capacitor

By measuring the potential difference across the reference capacitor, the amount of charge can be determined. From this result and the known potential to which the CPM was originally charged it is simple to calculate the capacitance of the CPM.

The total charge, Q, originally stored on the charged plate monitor is equal to:

$$Q = U_0 \times C_{CPM} \tag{A.2}$$

If part of the charge is transferred to the reference capacitor, C_R, we have

$$Q = (U_1 \times C_R) + (U_1 \times C_{CPM}) = U_1 \times (C_R + C_{CPM}) \tag{A.3}$$

Since the total charge remains equal, we have:

$$U_0 \times C_{CPM} = U_1 \times (C_R + C_{CPM}) = U_1 \times C_R\,(1 + C_{CPM}/C_R) \tag{A.4}$$

If $C_R >> C_{CPM}$, C_{CPM}/C_R can be neglected in Equation (A.4). So the capacitance of the charged plate monitor can be calculated from:

$$C_{CPM} = (U_1/U_0) \times C_R \tag{A.5}$$

Bibliography

[1] IEC 61340-5-1, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

[2] ISO/IEC Guide 98-1, *Uncertainty of measurement – Part 1: Introduction to the expression of uncertainty in measurement*

[3] IEC Guide 108, *Guidelines for ensuring the coherency of IEC publications – Application of horizontal standards*

Additional non-cited references

IEC TR 61340-1, *Electrostatics – Part 1: Electrostatic phenomena – Principles and measurements*

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IEC 61340-2-1

Edition 2.1 2022-06
CONSOLIDATED VERSION

FINAL VERSION

HORIZONTAL PUBLICATION

Electrostatics –
Part 2-1: Measurement methods – Ability of materials and products to dissipate static electric charge

IEC 61340-2-1:2015-08+AMD1:2022-06 CSV(en)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTROSTATICS –

Part 2-1: Measurement methods – Ability of materials and products to dissipate static electric charge

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.
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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 61340-2-1 edition 2.1 contains the second edition (2015-08) [documents 101/446/CDV and 101/462/RVC] and its amendment 1 (2022-06) [documents 101/639/CDV and 101/651/RVC].

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

International Standard IEC 61340-2-1 has been prepared by IEC technical committee 101: Electrostatics.

This second edition constitutes a technical revision.

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

a) the first edition supported requirements in IEC TR 61340-5-1, but with the revision of IEC TR 61340-5-1 into an International Standard, this support is no longer required; references to IEC 61340-5-1[1][1] have been removed;
b) the introduction gives additional information on when charge decay time measurements are appropriate, and the applications for which each of the two test methods are best suited;
c) procedures for performance verification of measuring instruments for the corona charging method have been added.

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

It has the status of a horizontal standard in accordance with IEC Guide 108[3].

A list of all the 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 the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under webstore.iec.ch in the data related to the specific publication. At this date, the publication will be

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

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

INTRODUCTION

Measurements of the rate of dissipation of static charge belong to the essential measurement techniques in the field of electrostatics.

For homogeneous conductive materials, this property can be evaluated indirectly by measuring resistance or resistivity parameters. Care should be exercised when determining the homogeneity of materials, as some materials that appear homogenous do exhibit non−homogeneous electrical characteristics. If the homogeneity of materials is not known and cannot be otherwise verified, it is possible that resistance measurements will not be reliable or will not give enough information. It is also possible that resistance measurements will not be reliable when evaluating materials in the dissipative or insulative range and especially for high ohmic materials that include conductive fibres (e.g. textiles with a metallic grid). In such cases, the rate of dissipation of static charge should be measured directly.

ELECTROSTATICS –

Part 2-1: Measurement methods – Ability of materials and products to dissipate static electric charge

1 Scope

This part of IEC 61340 describes test methods for measuring the rate of dissipation of static charge of insulating and static dissipative materials and products.

It includes a generic description of test methods and detailed test procedures for specific applications.

The two test methods for measuring charge decay time, one using corona charging and one using a charged metal plate are different and it is possible that they will not give equivalent results. Nevertheless, each method has a range of applications for which it is best suited. The corona charging method is suitable for evaluating the ability of materials, for example textiles, packaging, to dissipate charge from their own surfaces. The charged metal plate method is suitable for evaluating the ability of materials and objects such as gloves, finger cots, hand tools, to dissipate charge from conductive objects placed on or in contact with them. It is possible that the charged plate method will not be suitable for evaluating the ability of materials to dissipate charge from their own surfaces.

In addition to its general application, this horizontal standard is also intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 108.

One of the responsibilities of a technical committee is, wherever applicable, to make use of horizontal standards in the preparation of its publications. The contents of this horizontal standard shall not apply unless specifically referred to or included in the relevant publications.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 61340-4-6, *Electrostatics – Part 4-6: Standard test methods for specific applications – Wrist straps*

IEC 61340-4-7, *Electrostatics – Part 4-7: Standard test methods for specific applications – Ionization*

3 Terms and definitions

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

3.1
charge decay
migration of charge across or through a material leading to a reduction of charge density or surface potential at the area where the charge was deposited

3.2
charge decay time
time from an initial voltage to a set fraction of the initial voltage

Note 1 to entry: 1/e and 10 % are appropriate fractions (e is the base of natural logarithms, equal to 2,718). If the initial voltage is low, the accuracy of decay time measurements to a small fraction of the initial voltage can be susceptible to the noise level of the fieldmeter.

3.3
charged plate monitor
CPM
instrument using a charged metal plate of a defined capacitance and geometry which is discharged in order to measure charge dissipation/neutralization properties of products or materials

Note 1 to entry: This note only applies to the French language.

3.4
corona
corona discharge
generation of ions of either polarities by a high electric field

3.5
static dissipative material
material which allows charge to migrate over its surface and/or through its volume in a time which is short compared to the time scale of the actions creating the charge, or short compared to the time within which this charge will cause an electrostatic problem

Note 1 to entry: Materials that are considered conductive in other contexts are included within this definition for the purposes of this part of IEC 61340.

3.6
initial voltage
< corona charge decay> surface potential at a time after the end of charge deposition that is a sensible match to the time it takes material surfaces to separate in practical situations

Note 1 to entry: A time of 100 ms is appropriate for manual tribocharging actions.

3.7
initial voltage
<contact charge decay> voltage applied to the conductive plate of a charged plate monitor

3.8
insulator
material with very low mobility of charge so that any charge on the surface will remain there for a time which is long compared to the time scale of the actions creating the charge

4 Method of measurement of charge decay

4.1 Principles

Two methods are described.

The first method determines the dissipation of charge deposited on the surface of the material by a corona discharge. The resulting decrease in surface potential is observed using a fieldmeter or other equivalent equipment. This method is applicable to measurement of charge dissipation from surfaces and materials.

The second method determines the dissipation of charge from a charged plate through an object under test by applying a potential to the metallic plate, disconnecting the voltage source and observing the decrease in potential of the plate by means of a fieldmeter or other equivalent equipment. This method is applicable to measurement of charge dissipation via products such as finger cots, gloves and hand tools.

NOTE There are more methods to charge materials other than the charging methods described here (for example tribocharging or inductive charging) but they are not relevant for this standard.

WARNING – The test methods specified in this document involve the use of high-voltage power supplies that can present hazards if handled incorrectly, particularly by unqualified or inexperienced personnel. Users of this document are encouraged to carry out proper risk assessments and pay due regard to local regulations before undertaking any of the test procedures. Electrical equipment for measurements shall comply with the safety requirements specified in IEC 61010-1 and IEC 61010-2-030.

4.2 Environmental conditions

The electrical properties of materials vary with temperature and the absorption of moisture.

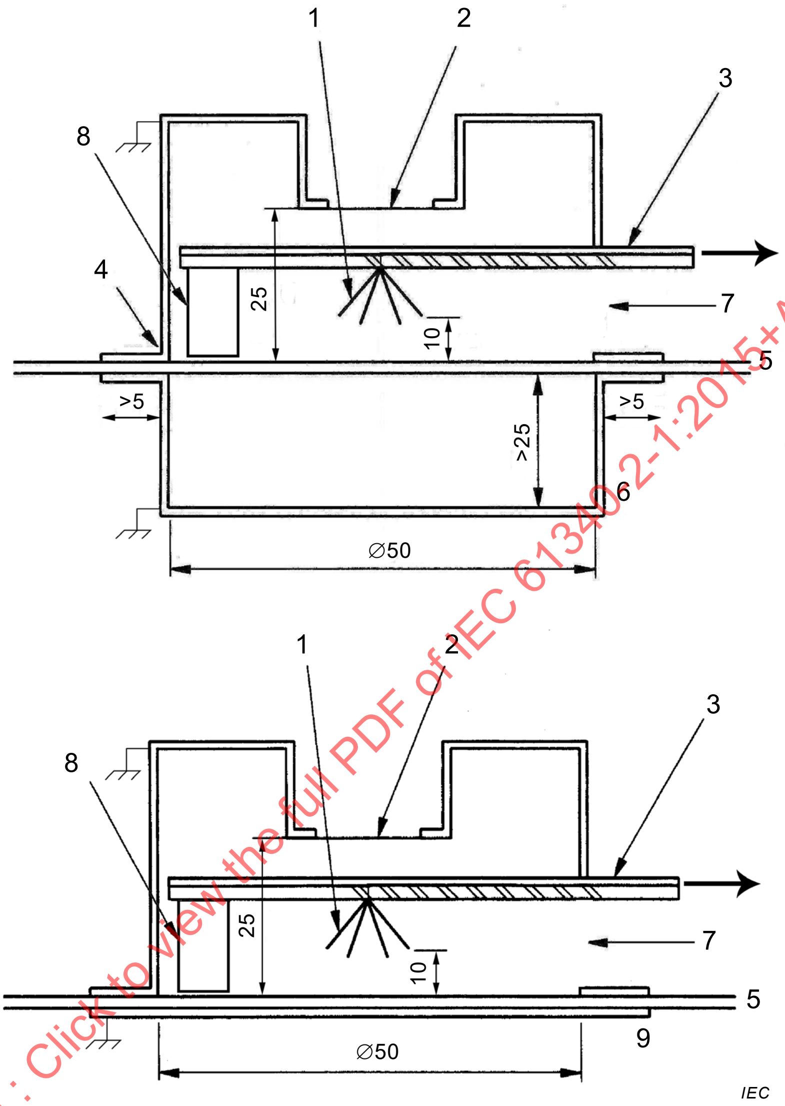
Unless otherwise agreed, the atmosphere for conditioning and testing shall be (23 ± 2) °C and (12 ± 3) % relative humidity, and the conditioning time prior to testing shall be at least 48 h.

For measurements in practical situations the ambient temperature and relative humidity shall be recorded.

4.3 Apparatus for measurement of corona charge decay

4.3.1 Physical design features

Dimensions in millimetres with a tolerance of ± 1 mm.



Key

1 Array of corona points, the tips of which form a circle (10 ± 1) mm in diameter
2 Fieldmeter sensing aperture
3 Movable plate:
 – insulating plate to mount corona points (resistance to ground > 10^{14} Ω)
 – earthed top surface to shield fieldmeter
4 Earthed casing
5 Sample
6 Metal plate (open backing)
7 Aperture through which the movable plate is withdrawn
8 Air dam
9 Metal plate (earthed backing)

Figure 1 – Example of an arrangement for measurement of dissipation of charge using corona charging

A typical arrangement and relevant dimensions of the test apparatus are shown in Figure 1. Other equipment giving similar results may be used.

The test aperture for deposition and measurement of deposited charge shall be (50 ± 1) mm diameter or an equivalent area quasi-square aperture. An array of corona points is mounted on a movable plate above the centre of the test aperture. The fieldmeter sensing aperture shall be (25 ± 1) mm above the centre of the test area. When the plate with the corona points is moved fully away, the test area shall be clear up to the plane of the fieldmeter sensing aperture.

4.3.2 Containment of test material

With an installed material, the test aperture in the instrument base plate shall rest directly on its surface. Sheet or flexible materials shall be supported as follows:

a) for testing materials with open backing, the material shall be rested against an earthed metal plate with an aperture aligned with the instrument test aperture and with a width of at least 5 mm extending beyond the aperture. A shield over the reverse side of the test area shall be earthed and be at least 25 mm away over the whole test area;

b) for testing materials against an earthed backing, the material shall be mounted between the instrument base plate and a flat earthed metal plate.

NOTE If charge moves more readily through the bulk test material than across its surface, then placing an earthed metal plate immediately behind the test area can increase the rate of charge dissipation. On the other hand, if charge moves more readily across the surface of the test material, then the rate of charge dissipation can decrease if an earthed metal plate is used because its presence will increase the capacitive loading. To gain a full understanding of charge dissipation from the test material, it is desirable to make measurements both with and without an earthed metal plate backing the test area.

In practical terms, earthed backing represents a material in intimate contact with an earthed surface, for example, a garment fitted close to the body of the wearer, or a work surface on top of a metal bench. Open-backed measurements represent the other practical extreme where materials are separated from earthed surfaces, for example, the bottom edge of a coat or smock which hangs away from the body of the wearer.

4.3.3 Corona charge deposition

Corona charging is achieved with at least five corona points, the tips of which form a (10 ± 1) mm diameter circle, (10 ± 1) mm above the centre of the test area. The corona points shall be made from non-corrosive metal wire of a diameter in the range 0,1 mm to 0,5 mm. The exact size and distribution of charge on the material is not well defined, particularly with the more conductive surfaces, but the arrangement provides a consistent pattern of deposited charge and decay time measurements.

NOTE 1 Typical voltages for corona charging equipment are between 5 kV and 10 kV.

The corona duration shall be no more than 50 ms, and 10 ms or 20 ms is usually appropriate in order to achieve an adequate initial peak voltage for measurements. Excessively long deposition times (more than some seconds) can damage the material.

The materials shall be tested with positive and negative polarity.

The equipment for charge deposition shall move fully away from the region of fieldmeter observation in less than 20 ms.

NOTE 2 For corona voltages of 7 kV to 8 kV, the initial surface voltage with relatively high insulating materials will be up to about 3 kV. For materials with fast charge decay rates the initial voltage can be much lower – for example only 50 V to 100 V.

4.3.4 Fieldmeter

The fieldmeter shall be able to measure the surface voltage with an accuracy of ±5 V to below the lower limit of surface voltage that is required to be measured. The response time (10 % to 90 %) shall be at least one-tenth of the faster decay time required to be measured. The stability of the zero shall allow measurement of surface voltage with this accuracy over the longest decay times to be measured. Therefore, a rotating vane 'field mill' type of fieldmeter is preferred.

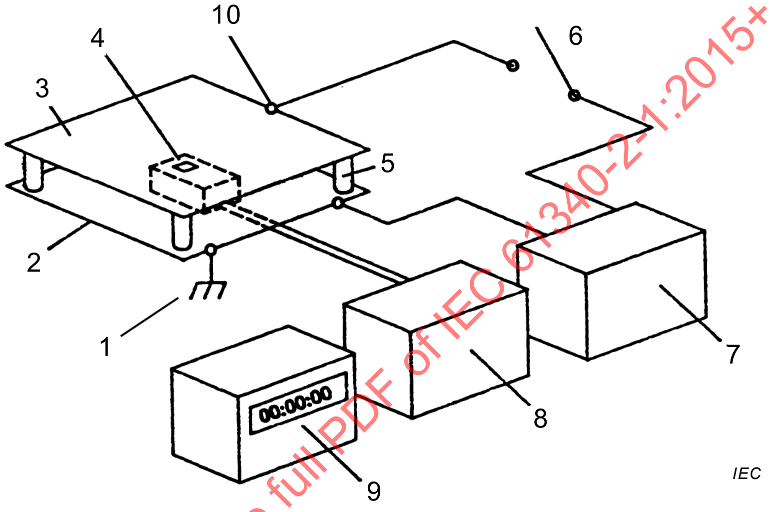
During corona charge deposition and decay time measurement, the fieldmeter sensing aperture shall be well shielded from any connections or surfaces associated with corona high-voltage supplies. There shall be no insulating materials around the region between the fieldmeter and the test aperture during the operation of the fieldmeter.

Any residual ionization shall contribute less than 20 V to the measurement of the surface voltage. Excess ionization shall be removed, for example, by using an air dam. This can be tested by measurements on a fully conducting test surface.

4.4 Apparatus for measurement of contact charge decay

4.4.1 Physical design features

The basic arrangement and relevant dimensions of the test apparatus are shown in Figure 2. Other equipment giving similar results may be used.



Key

1 Ground
2 Grounded surface, greater than 150 mm square
3 Conductive plate (e.g. nominal dimensions 150 mm × 150 mm)
4 Probe
5 Supporting insulator (resistance to ground > 10^{14} Ω)
6 Switch
7 High-voltage power supply – current limited
8 Fieldmeter or equivalent
9 Discharge timer
10 High-voltage plate contact

Figure 2 – Example of an arrangement for measurement of dissipation of charge using a charged plate[2]

The instrument to measure the charge dissipation of objects under test is the charged plate monitor (see Figure 2). The capacitance of the conductive plate shall be (20 ± 2) pF when mounted in the test fixture. The dimensions of the plate do not significantly affect results and any practical size may be used (e.g. nominal dimensions 150 mm × 150 mm). The wire between the switch and the plate shall be as short as possible.

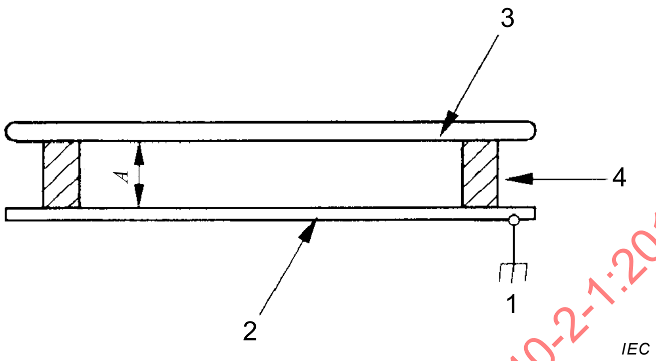
There shall be no objects grounded or otherwise closer than dimension A of Figure 3 to the conductive plate, except the supporting insulators as shown in Figures 2 and 3, or the high-voltage plate contact as shown in Figure 2. The resistance to ground of the supporting

2 If the different components are integrated into one instrument, this is referred to as a charged plate monitor (CPM).

insulators shall be $>10^{14}$ Ω. Dimension A is selected to achieve the desired capacitance. The isolated conductive plate, when charged to the desired test voltage, shall not discharge more than 10 % of the test voltage within 5 min under the environmental conditions specified in 4.2. The response time of the monitoring device shall be sufficient to accurately measure charging plate voltages.

The capacitance of the plate and the wires shall be determined according to Clause A.2.

Further design requirements, including requirements for alternative charged plate monitor designs, are specified in IEC 61340-4-7.



Key

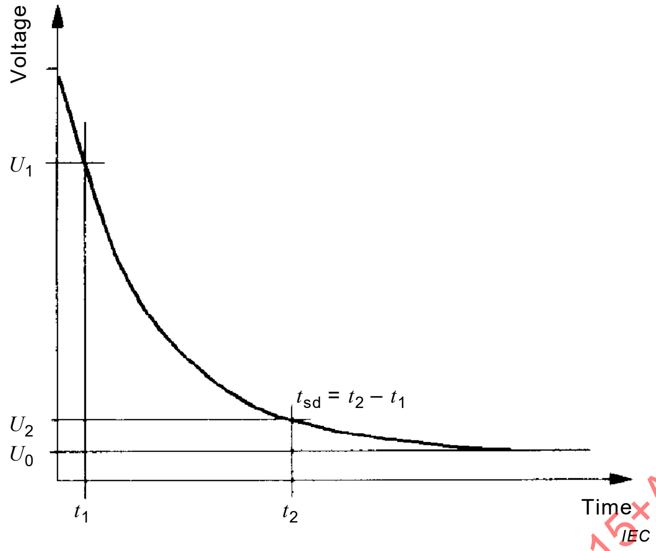
1 Ground
2 Grounded surface, greater than 150 mm square
3 Conductive plate (150 ± 1) mm × (150 ± 1) mm
4 Supporting insulator

Figure 3 – Charged plate detail

4.4.2 Charge decay time (t_{sd})

The charge decay time is the period to reduce the initial voltage U_1 on the charged plate to a defined lower voltage level U_2, for example the time from 1 000 V to 100 V for positive or negative polarity (see Figure 4).

There can be occasions when the potential decay approaches a non-zero value. This final offset voltage is designated U_0.



NOTE The decay curve can go down to 0 V or not.

Figure 4 – Charge decay time (t_{sd}) and offset voltage (U_0)

5 Practical application of test methods and procedures

5.1 General

Clause 5 describes the application of the test methods for evaluating specific materials and products. The test methods have wider applicability and can be used to evaluate many different materials and products in addition to those included in Clause 5.

5.2 Charge decay test for textile materials

5.2.1 Selection of test method

For charge decay tests on textile materials, the corona charging method shall be used.

5.2.2 Test surface preparation

The sample presented for test shall be big enough to completely cover the test fixture and shall be clean and free from loose dust.

Remove any loose dust by gentle brushing or blowing with clean dry air. If the surface is obviously contaminated, either test an alternative area of the material or make measurements with the contamination present and report the condition of testing 'as received'.

For laboratory measurements, the materials shall be cleaned according to the manufacturer's instructions. The materials used for cleaning and the method used shall be reported.

For measurements in practical or installed applications, the materials shall be tested without any "special" cleaning. If cleaning is part of the process, for example, washing of garments, measurements should be taken before and after cleaning where practical. The materials and the method used to clean shall be reported.

Contamination of samples is best avoided by only handling with tweezers or gloved hands.

5.2.3 Testing

Rest the test aperture on the surface to be tested, set up appropriate charging conditions and make the required number of charge decay measurements.

The test equipment shall remain steady and undisturbed on the surface for the duration of each measurement.

Movement of the test equipment relative to the surface can cause tribocharging and result in a sudden change of observed charge distribution, which requires the test to be re-started.

Make measurements with both positive and negative polarities.

Make measurements on sheet and film materials, both with open-shielded backing and with an earthed surface backing.

At least three measurements shall be made for each set of test conditions with each sample. The time between measurements shall be such that the surface voltage falls to below 5 % of the expected initial voltage before starting the next measurement.

All measurements shall be made on different locations.

5.2.4 Results

The charge decay time values are the measured times for the surface voltage to fall from the initial voltage to a defined fraction of the initial voltage.

Charge decay time values quoted shall be the average of the values measured under the test conditions that provide the longest decay times.

If it is not possible to achieve the required initial surface voltage with a corona voltage of at least 7 kV, then this fact shall be recorded together with the actual surface voltage achieved.

5.2.5 Test report

The test report shall include at least the following information:

– reference to this International Standard, i.e. IEC 61340-2-1;
– test results (all values plus charge decay time according to 5.2.4);
– number of samples tested;
– date and time of measurements;
– description and/or identification of material tested;
– charging conditions used (for example, polarity, corona voltage, charging duration, electrode dimensions, time between tests);
– whether the sample is supported with an open backing or an earthed backing surface;
– temperature and relative humidity at the time measurements are made, and where pre-conditioning is used, the temperature, relative humidity, duration of pre-conditioning, and the time between pre-conditioning and testing, if the conditions are different;
– identification of instrumentation used and date of most recent and next calibration.