

Test method to determine the limitation of surface potential created by electrostatic charge retained on materials.

Introduction

The surface potential created by electrostatic charge retained on materials is a parameter of major importance to the useful applications of static electricity and to many of the risks and problems that static electricity can cause. The two features of importance are:

- 1) the surface potentials that may arise;
- 2) the time that significant surface potentials are present.

The quantity of electrostatic charge transferred to materials by rubbing and sliding type actions is limited by the intensity of the mechanical operation and by the character of the materials involved. What is then important is the maximum surface potential that will arise for the maximum likely quantity of charge. This potential will be limited if the timescale for dissipation of charge is short compared to the time at which the rubbing surfaces separate. It will also be limited if the separated charge experiences a high capacitance that suppresses the surface potential. Either or both aspects may be used to assess whether risks and problems can be avoided with particular materials.

This standard describes how to measure the timescale for the decay of charge on materials and the capacitance effect experienced by charge.

Studies have shown that the ability of materials to dissipate triboelectric charge, generated on their own surface by contact or sliding actions, is well matched by the decay of charge deposited from a high voltage corona discharge. The advantage of using corona charging for charge decay measurements is that it forms the basis of easy to use instrumentation that gives quick and repeatable assessment of a wide variety of materials (including liquids and powders) under a range of test conditions. With measurement of the quantity of charge transferred to the test surface the initial peak surface potential and the effective capacitance experienced by charge on the surface can be calculated.

A number of papers published on the method and its application are listed in Annex A. The steps involved in making practical measurements to predict maximum surface voltages on cleanroom garments are outlined in Annex D.

1 Scope

This standard describes a test method to determine the limitation of surface potential created by electrostatic charge retained on materials by measuring the rate of self-dissipation of static charge and the capacitance effect experienced by surface charge. This is applicable for static dissipative and insulative materials and surfaces.

It includes a generic description of the test instrumentation and method of measurement.

2. Definitions

For the purpose of this standard, the following definitions apply:

2.1 capacitance loading

the surface potential achieved per unit quantity of charge for a thin film of a good dielectric divided by the surface potential achieved per unit of charge with a similar surface charge distribution on the test material

Method for measurement of corona charge decay and capacitance loading**2.2 charge decay**

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

2.3 charge decay time

The time from the initial peak voltage created by the charge put on the surface (100%) to a selected, and a stated, end point fraction of this

NOTE: Convenient decay times for comparison between materials are the time from the initial peak surface voltage to $1/e$ of this (e is the base of the natural logarithm 2,7183) and to 10% of this. As the rate of charge decay may vary greatly during the progress of decay it is very useful to record the form of the variation of surface voltage with time.

2.4 conductive material

a material with a high mobility of charge so that the potential on the surface is retained for only a very short time

NOTE: The charge decay time of conductive materials is generally less than 0,05 s.

2.5 corona

the generation of ions of either polarity by a high localised electric field

2.6 dissipative material

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

NOTE: For general avoidance of risks and problems in operations involving manual activities the decay time from the initial peak surface potential to $1/e$ of this needs to be less than 0,25 s. To avoid the risk of incendive sparks the decay time needs to be longer than 0.01s.

2.7 insulative material

a material with very low mobility of charge so that charge on the surface is retained there for a long time

NOTE: The charge decay time of insulative materials is generally greater than 10 s.

2.8 relative capacitance

(see capacitance loading)

2.9 surface potential

the reading from a non-contacting electrostatic voltmeter or fieldmeter in the test equipment calibrated in terms of the potential on a plane conducting surface covering the equipment test aperture

2 Principle

The self-dissipation of static charge by a material is measured by depositing charge on the surface by means of a corona discharge and observing the decay of surface potential by means of a fieldmeter. Capacitance loading values are determined from measurement of the quantity of charge transferred and the initial peak surface potential this creates.

3 Design and operation of test apparatus**3.1 Physical design features**

A typical arrangement and relevant dimensions of the test apparatus is shown in Figures 1 and 2. Other equipment fulfilling the basic design and performance requirements may be used.

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The test aperture for deposition and measurement of deposited charge shall be $50\text{ mm} \pm 1\text{ mm}$ diameter or an equivalent quasi-square aperture area. The corona points are mounted on a movable plate in a $10\text{ mm} \pm 1\text{ mm}$ diameter circle, $10\text{ mm} \pm 1\text{ mm}$ above the centre of the test aperture. The fieldmeter sensing aperture shall be $25\text{ mm} \pm 1\text{ mm}$ 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.

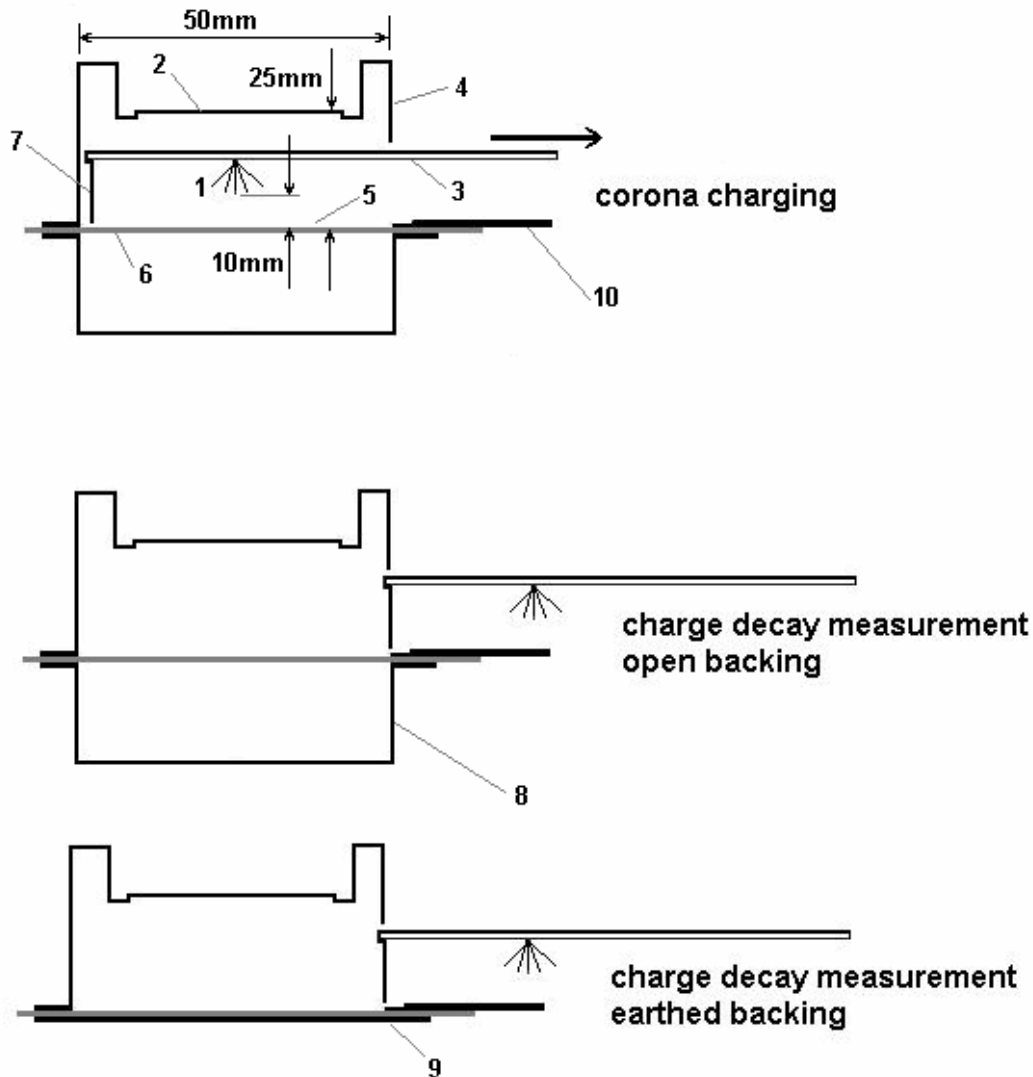


Figure 1 – Example of an arrangement for measurement of corona charge decay

Key to figure 1:

- 1 - 10 mm diameter circle of corona points
- 2 - Fieldmeter sensing aperture
- 3 - Movable plate
 - insulating surface mounting corona points
 - earthed top surface to shield fieldmeter
- 4 - Earthed casing
- 5 - Test aperture: $50\text{ mm} \pm 1\text{ mm}$ diameter or $(50\text{ mm} \pm 1\text{ mm}) \times (50\text{ mm} \pm 1\text{ mm})$ area
- 6 - Specimen under test
- 7 - Air dam to remove residual corona air ionisation
- 8 - Open shielded backing
- 9 - Earthed backing
- 10 - Instrument base plate

3.2 Containment of test material

With an installed material the test aperture in the base plate of the instrument shall be rested directly on its surface.

Sheet or flexible materials shall be tested whilst supported against the test aperture with both 'open backing' and 'earthed backing'. These two arrangements (shown in Figure 1) represent the extreme conditions of practical application. For both arrangements the longer of the two decay times shall be taken for comparison with general acceptance criteria.

In practical terms, 'open backing' measurements represent the condition where materials are well separated from earthed surfaces, for example the bottom edge of a coat or smock hanging away from the body of the wearer. 'Earthed backing' represents the other practical extreme of a material resting 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. The nature of the material used as an 'earthed backing' surface may affect measurements, so a suitable material needs to be used. For example, the insulating nature of anodised aluminium will inhibit vertical charge migration.

For testing of material with 'open backing' the material shall be supported against the base plate of the instrument by an earthed metal aperture aligned with the instrument test aperture and with at least 5 mm width outside the test aperture area. The shield over the reverse side of the test area shall be earthed and at least 25 mm away over the whole test area.

For testing of materials against an 'earthed backing' the material shall be supported against a flat earthed conducting surface and the base plate around the test aperture. The earthed backing surface needs to be smooth, flat and free of insulating oxide films.

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 may decrease the charge decay time. On the other hand, if charge moves more readily across the surface of the test material, then charge decay time may be increased due to increased capacitive loading.

For testing thin flexible films the film needs to be well tensioned to reduce risk of flexing during decay time measurements.

Powders and liquids may be tested while supported in an earthed metal cup beneath the test aperture. When testing light powders that may be easily dispersed into the air, precautions shall be taken to avoid powder particles becoming deposited on surfaces around and inside the fieldmeter sensing region. This may be achieved by, for example, slow retraction of the moving plate and air dam or by an appropriate increase in the separation between the powder surface and the plane of the sensing aperture.

3.3 Corona charge deposition

The exact size and distribution of charge deposited on the material is not well defined. The arrangement provides a consistent pattern of deposited charge for decay time and capacitance loading measurement.

The corona charge deposition time shall be $20 \text{ ms} \pm 10 \text{ ms}$. Longer times may be used if needed to achieve an adequate initial peak surface potential for measurement. Corona deposition times longer than 100 ms will not necessarily provide any enhancement of charging and may create some damage to sensitive surfaces. Samples shall be tested with both positive and negative polarity.

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

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

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NOTE: For corona voltages up to 10 kV the initial surface potential with insulative materials will be up to about 3 kV. For materials with fast charge decay rates and/or high values of capacitance loading the initial surface potential may be much lower - for example only 50 V to 100 V. For low quantities of charge corona voltages down to about 3kV may be appropriate.

3.4 Fieldmeter

The fieldmeter shall be able to measure the surface potential with an accuracy of $\pm 5V$, or better, to below 40 V with a response time (20% to 90%) of less than 10 ms. The stability of the zero shall allow measurement of surface potential with this accuracy over the longest decay times to be measured.

The sensitivity of the fieldmeter shall be set according to the calibration procedure in Annex B to show the surface potential as presented by a plane conducting surface over the full area of the test aperture.

NOTE: A rotating vane 'field mill' type fieldmeter is preferred. Chopper stabilised sensors may be acceptable if the sensitivity, noise levels and zero stability are appropriate. Induction probe instruments are not likely to be suitable, even for fast charge decay measurements, because the influence of even slight residual corona air ionisation will cause zero drift – and the absence of this would need to be tested.

During corona charge deposition and decay time measurement the sensing aperture of the fieldmeter shall be well shielded from any connections or surfaces associated with corona high voltage supplies. There shall be no insulative materials in or around the region of the instrument between the fieldmeter and the test aperture able to contribute signals to fieldmeter observations.

For measurements with materials having initial peak surface potentials less than 200 V it is necessary to remove residual air ionisation created by the corona discharge when the moving plate carrying the corona discharge points is moved away. An air dam on the trailing edge of the moving plate mounting the corona discharge points is a convenient way to remove this air ionisation from the region between the fieldmeter sensing aperture and the test surface. Residual ionisation shall contribute less than 30 V to measurement of surface potential. This may be tested by measurements on a fully conducting test surface.

The value taken of the initial peak surface potential measured by the fieldmeter will be affected by the initial rate of charge decay and the time for removal of the plate carrying the corona discharge points. When the time for removal of the plate is comparable to the rate of decay, the time for plate movement will affect the value of the initial peak surface potential and hence the value of capacitance loading calculated. It is hence important to measure the initial peak surface potential as soon as possible after deposition of charge.

3.5 Charge decay time measurements

The charge decay time is the period for the surface potential to reduce from the initial peak value at the end of corona charging to a lower surface potential set as a defined fraction of the initial peak surface potential. Two convenient 'figures of merit' are the time from initial peak surface potential to $1/e$ of this and (where practical) to 10% of this.

It is useful to record the form of the charge decay curve because in many cases the rate of decay slows up significantly during the progress of decay and appreciable levels of surface charge may be retained for long periods. This effect is also indicated by comparison of the decay times to 10% with that to $1/e$.

Care needs to be taken in the measurement of charge decay times on small signals where signal noise may be significant in relation to signal amplitude. Any signal averaging technique needs to take account of the need for a fast response on the fast initial transients of short decay time curves.

Sample surfaces may become pre-charged by handling when placed ready for testing. It is recommended that when samples are placed in position the moving plate is back, so the fieldmeter can respond to any charge on the sample surface and show these observations. This initial surface potential on relatively insulating samples may be minimised by careful handling with minimum sliding actions.

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Two main options are available if there is appreciable pre-charge:

- to wait until the pre-charge has dissipated. This means waiting for the initial surface potential to fall to say 10 V to 50 V, depending on the quality of observations required.
- to make a study on the decay of this pre-charge without adding any corona charge. This means making a measurement with the corona voltage turned off or set for zero volts. It is to be noted that the decay of such pre-charge may be rather slower than the decay of the local patch of corona charge. It is none the less a useful observation.

It is not recommended that quality measurements are attempted by putting corona charge on to an already well charged surface or material.

It is also not recommended that pre-charge on the material is neutralised by any means other than waiting. Deposition of neutralising charge may only give the appearance of neutrality by creating close-coupled regions of charge.

There are three other possible artefacts are worth noting:

- that if the air dam on the leading edge of the moving plate touches the sample surface then tribocharging may occur. This may arise when testing light fabrics. The fabric surface should be stretched flat under the test aperture, but it may still rise by induced air movement. This effect may be checked by making measurements with no corona charging. It may be avoided by slightly raising the base plate of the instrument off the sample.
- that with some materials a very short (1 ms to 2 ms) transient peak surface potential may be observed before the real charge decay curve. This is usually positive. Occurrence of this transient will upset operation of software timing. This is thought to be due to vertical charge separation between front and back surfaces of the sample at sample flexing.
- that if static charge is retained on the surface of the moving plate facing the test surface then charge may be drawn over the sample by the induction electric field. This effect may be minimised by minimising the non-earthed area on the underside of the moving plate.

The performance of the decay time measuring instrumentation shall be assessed according to the calibration procedure in Annex B.

3.6 Received charge measurement

The charge received by a sample surface can be measured using a sample support arrangement as illustrated in Figure 2.

The aperture for the sample in the mounting plates needs to be larger than the test aperture in the base plate of the charge decay test unit to avoid direct corona charge flow to these plates. This may be tested by checking for negligible 'conduction' charge signal in the absence of a sample. The performance of the surface charge measuring instrumentation shall be assessed according to the calibration procedure in Annex C.

The charge transferred to the test surface is measured in two parts:

- 1) as charge directly coupled to the sample mounting plates;

Method for measurement of corona charge decay and capacitance loading

2) as charge remaining where it is deposited.

Note: The apparently simple approach of measuring the charge leaving the charge decay test unit will not give correct values for charge. The reason is that if charge is retained on the surface of the test material, and does not move quickly out to the sample mounting plates, it will couple back to the structure of the unit and so not be fully available for measurement.

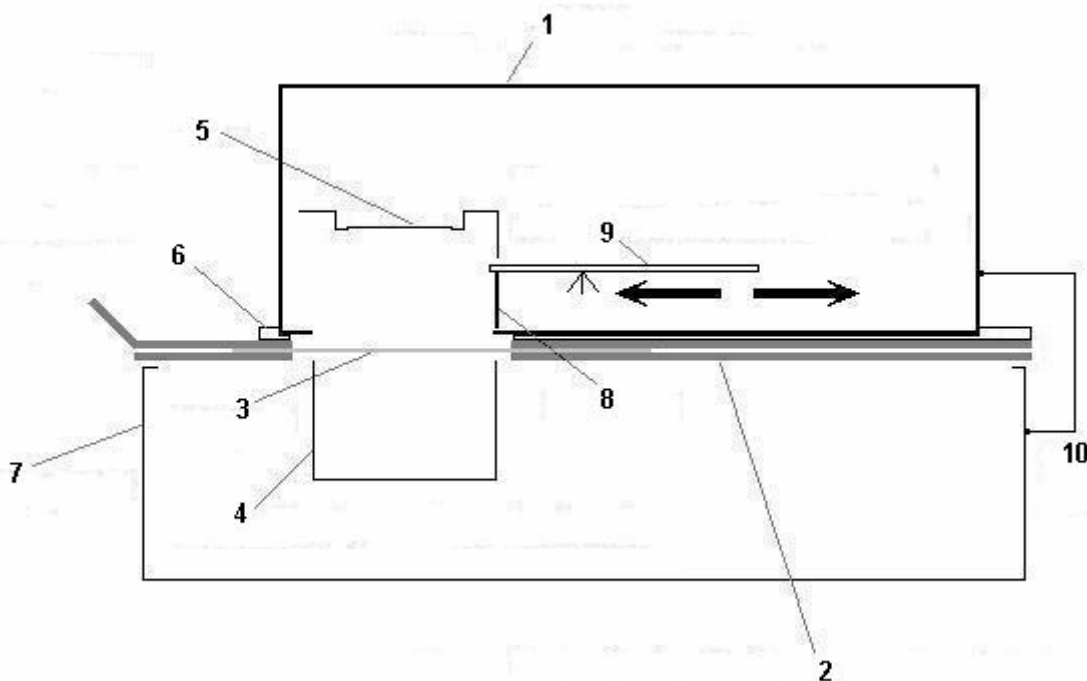


Figure 2 – Arrangement for measuring received charge

Key to Figure 2:

- 1- Charge decay test unit
- 2- 'Conduction' charge measuring support plates
- 3- Sample
- 4- 'Induction' sensing electrode
- 5- Fieldmeter sensing aperture
- 6- Insulation between charge decay test unit and sample mounting plates
- 7- Shielding box
- 8- Air dam
- 9- Moving plate with cluster of corona discharge points
- 10- Earth bonding link from charge decay test unit to shielding box and 0V of charge measurement circuits

The 'conduction' charge coupled directly, and within the time of the observations, to the mounting plates is measured by a suitable virtual earth charge measurement circuit. The charge remaining in the area of deposition is sensed by an induction electrode beneath the open-backed sample. If the form of the induction sensing electrode is similar to the mechanical form of the charge decay apparatus above the test area then the retained charge will couple about half to the equipment and half to the induction electrode. The induction charge component will then be twice the charge received by the induction electrode. The precise sensitivity of induction charge measurements may be determined as specified in Annex C3.

3.7 Calculation of 'capacitance loading' values

The capacitance effect experienced by charge on the test surface is best defined as the ratio of the surface potential achieved per unit of charge for a thin film of a good dielectric divided by the surface potential achieved per unit of charge with a similar surface charge distribution on the test material. This may be thought of as a 'capacitance loading' or as the 'relative capacitance'.

The capacitance loading experienced by charge on the surface is obtained from measurement of the charge received by the test surface and the initial peak surface potential observed. The value is calculated by comparing the observed ratio of initial surface potential per unit of charge to the ratio observed with a very thin layer of good dielectric (e.g. cling film) that has a sufficiently short decay time that a low pre-test surface potential can be achieved in a reasonable time. This ratio is equivalent to the ratio of the apparent capacitance value calculated for the test material C to that for a very thin layer of good dielectric, C^* . The following equations shall be used to calculate capacitance loading:

$$\text{Apparent capacitance of reference material (very thin layer of good dielectric): } C^* = Q_{tot}^* / V_{pk}^* \quad (2)$$

$$\text{Apparent capacitance of test material: } C = Q_{tot} / V_{pk} \quad (3)$$

$$\text{Capacitance loading: } CL = C / C^*$$

$$CL = (Q_{tot} / V_{pk}) / (Q_{tot}^* / V_{pk}^*) \quad (4)$$

where Q_{tot}^* is the total charge received by the reference material, V_{pk}^* is the initial peak surface potential observed on the reference material, Q_{tot} is the total charge received by the test material, and V_{pk} is the initial peak surface potential observed on the test material.

Once a value has been obtained for the apparent capacitance $C^* = Q_{tot}^* / V_{pk}^*$ for the reference material in the particular test arrangement this may be used as a reference value in subsequent capacitance loading measurements, so long as all features of the test arrangement remain the same.

4 Making measurements

4.1 Environmental conditions

The charge decay properties of materials often vary with temperature and relative humidity. It is hence very important that the values of these parameters in the test environment are known, and that they are controlled to agreed values for standardised measurements.

For standardised laboratory measurements samples shall be conditioned in the selected environmental conditions for at least 24 h before testing and measurements made with the conditions shown in Table 1 and in the listed sequence, or as otherwise agreed.

		Temperature °C	Relative humidity %
1	High relative humidity	23 ± 2	50 ± 3
2	Low relative humidity	23 ± 2	12 ± 3

Table 1 – Environment for conditioning and testing

NOTE: To assess whether materials are significantly susceptible measurements should be made with at least 2 levels of humidity, one around 50%RH and the other below 25%RH. If materials are to be used in conditions outside this range of the above standard values (in particular at lower levels of humidity) then their characteristics must be checked under the most extreme conditions likely to be encountered and these conditions reported.

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

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Samples need to be stored in the set environmental conditions in ways that allow air circulation to both surfaces.

Operation of the test equipment may generate heat that will change the temperature and humidity conditions to which the sample is exposed inside the equipment relative to those outside and to which the samples have accommodated. Precautions need to be taken to reduce such changes.

NOTE: It is desirable to measure temperature and humidity within the test equipment to establish that there are no problems. It is also desirable to store samples with easy air circulation and not in the test position.

4.2 Sample handling and preparation

Handle samples only well away from the area to be tested or using tweezers. Avoid breathing in the direction of the sample.

The surface of the material tested shall be clean and free of loose dust. Remove any loose dust by gentle brushing or blowing with clean, dry air. If the surface is obviously contaminated either an alternative area or sample shall be tested, or measurements made with the contamination present and the condition of testing reported to be 'as received'.

NOTE: Solvent or chemical cleaning is not recommended, as this may change surface conditions.

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.

4.3 Measuring procedure

Charge decay and capacitance loading measurements may be made on a wide variety of materials, including film, sheet, composite layer materials and fabrics as well as powders and liquids. The following notes outline general features common to testing all materials. Special arrangements may be appropriate to satisfy user requirements for particular materials.

The test apparatus is placed on the sample in a way that ensures it will remain stable and steady in position throughout the period of measurement. For earthed backing measurements, the test sample is placed flat against the backing plate.

NOTE: Movement of the test equipment relative to the surface can cause tribocharging which will affect observations.

When a sample is presented for testing the initial surface potential on the material shall be observed before the moving plate carrying the corona discharge points is advanced to shield the fieldmeter sensing aperture. If this surface potential is more than 5% of the initial peak surface voltage expected or measured in preceding tests with comparable test conditions, the sample shall be left in place under the instrument until the surface potential has fallen to below this level..

Determine the apparent capacitance of a very thin layer of good dielectric used as a reference material. This determination shall be carried out at least once prior to a series of measurements and the value used in the calculation of capacitance loading for all materials included in the measurement series.

NOTE: Cling film is a suitable thin dielectric layer to use as a reference material

At least three charge decay time/capacitance loading measurements with positive and with negative corona polarity shall be made in testing any material. These shall be made at different positions on the material or on different samples of the same material. Preferably at

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least six measurements shall be made, three with positive corona and three with negative corona.

Where practicable, separate sets of measurements shall be made with 'open backing' and with 'earthed backing' of the sample.

Where decay times are less than 100 s it is useful to make a number of repeat measurements at the same location and to make measurements with high and low corona voltages and with both polarities of charging. These measurements will demonstrate consistency in material behaviour, variations of performance with quantity of charge.

NOTE: It is desirable to make measurements to check if corona is causing any change in sample characteristics, both regarding charge decay time and capacitance loading. Any changes by corona may conveniently be examined by making measurements at the same location initially at low corona charge, then at high corona charge and then again at low charge.

Charge decay and capacitance loading characteristics of materials can vary with the quantity of charge deposited. It is wise to make tests over a range of quantities of charge comparable to those likely to arise in the practical situation. Tribocharging by rubbing may involve quantities of charge in the range 10-50nC. It is hence appropriate to make measurements with quantities of charge from 50nC downwards.

Note: The variation of capacitance loading with quantity of charge is particularly important in measurements on materials such as cleanroom garment fabrics. Measurements need to be made with care to the lowest practical quantity of charge.

5. Test report

The test report shall include at least the following information:

- a) date and time of measurements
- b) description and/or identification of material tested
- c) description and/or identification of reference tested
- d) corona charging conditions used (e.g. polarity, corona voltage, charging duration)
- e) whether the sample is supported with an 'open backing' or an 'earthed backing'
- f) individual values of initial peak surface potential and associated decay times (e.g. time from initial peak surface potential to $1/e$ of this and also to 10% of this). Where multiple measurements have been made it is appropriate to plot the variation of charge decay time with quantity of charge. Results shall be shown and quoted separately for measurements with open and earthed backing. Different polarity measurements may be combined.
- g) individual values of initial peak surface potential, quantity of charge transferred and capacitance loading. Where multiple measurements have been made it is appropriate to plot the variation of capacitance loading with quantity of charge. Results shall be shown and quoted separately for measurements with open and earthed backing. Different polarity measurements may be combined.
- h) mean charge decay time and capacitance loading values at stated quantise of charge
- i) temperature and relative humidity at the time of testing and time for which samples were exposed to these conditions before testing
- j) identification of instrumentation used (e.g. type and serial number) and date and certificate details of most recent calibration

Annex A (Informative)

Bibliography

- [1] R. Gompf "Standard test method for evaluating triboelectric charge generation and decay" *NASA Report MMA-1985-79 Rev 2*, July 1988
- [2] J. N. Chubb "Instrumentation and standards for testing static control materials" *IEEE Trans Ind. Appl.* vol 26 (6) Nov/Dec 1990 p1182.
- [3] J. N. Chubb and P. Malinverni "Experimental comparison of methods of charge decay measurements for a variety of materials" *EOS/ESD Symposium* 1992 p5A.5.1
- [4] J. N. Chubb "Dependence of charge decay characteristics on charging parameters" '*Electrostatics 1995*', York April 3-5, 1995 Inst Phys Confr Series 143 p103
- [5] J. N. Chubb "Corona charging of practical materials for charge decay measurements" *J. Electrostatics* vol 37 1996 p53
- [6] J. N. Chubb "The assessment of materials by tribo and corona charging and charge decay measurements" '*Electrostatics 1999*' Univ Cambridge, March 1999 Inst Phys Int Confr
- [7] R. Gompf, P. Holdstock, J. N. Chubb "Electrostatic test methods compared" *EOS/ESD Symposium*, Sept 26-30 1999
- [8] J. N. Chubb "Measurement of tribo and corona charging features of materials for assessment of risks from static electricity" *IEEE Trans Ind. Appl.* 36 (6) Nov/Dec 2000 p1515.
- [9] J. N. Chubb "New approaches for electrostatic testing of materials" *J. Electrostatics* 54 March 2002 p233 (*Proceedings ESA2000 Annual meeting*, Brock University, Niagara Falls, June 18-21, 2000)
- [10] J. N. Chubb, P. Holdstock, M. Dyer "Can cleanroom garments create electrostatic risks?" '*Cleanroom Technology*' 8 (3) March 2002 p38
- [11] J. N. Chubb, P. Holdstock, M. Dyer "Can surface voltages on inhabited garments be predicted" Inst Phys 'Electrostatics 2003' Conference, Heriot-Watt Univ 23-27 March 2003
- [12] J. N. Chubb, P. Holdstock, M. Dyer "Predicting maximum surface voltages on inhabited cleanroom garments in practical use" ESTECH Phoenix 18-21 May 2003

Annex B (Normative)

Calibration of corona charge decay measuring instrumentation

B1 Aspects to be calibrated

Calibration of charge decay measurement instrumentation involves two parts: calibration of the surface potential sensitivity of the fieldmeter and calibration of the decay time measurement performance.

B2 Equipment

Calibration of the charge decay measuring instrumentation is made using a plane conducting surface covering the whole test aperture area with a small separation (less than 0,5 mm) below the edge of the test aperture so calibration voltages can be applied. A suitable arrangement is shown below.

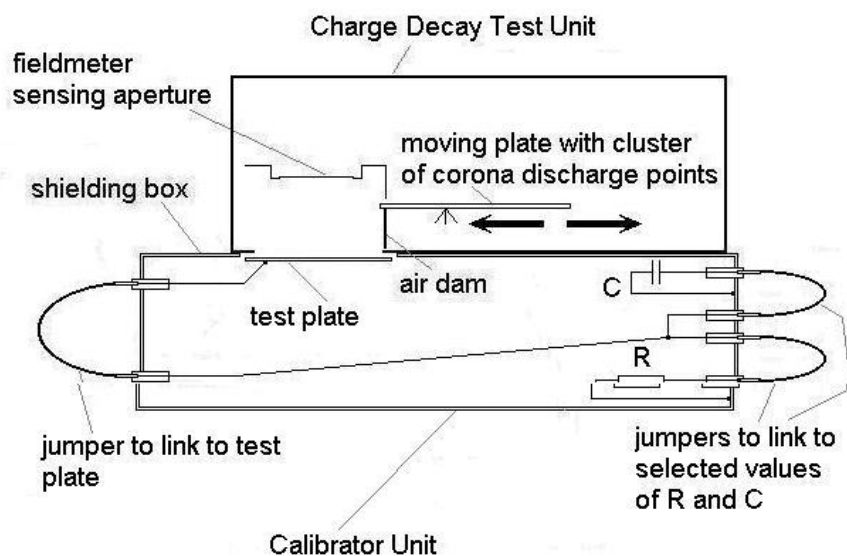


Figure B1 – Arrangement for calibration of surface potential sensitivity and decay time.

B3 Surface potential sensitivity calibration

The surface potential sensitivity calibration is made in terms of a uniform potential on the conducting surface covering the whole test aperture area.

The voltage source shall provide a stable, low ripple voltage of both polarities to at least 1000 V. The voltage measuring system shall cover the measurement of both polarities and be separate from the voltage source so it may be formally calibrated independently. The

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accuracy of voltage measurement shall be better than 0,2%. The stability of the calibration voltage shall be 0,2%.

B4 Decay time calibration

Calibrated resistors and capacitors are connected in parallel between earth and the conducting calibration 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 0,1 s to 100 s.

Formal calibration of the resistors and capacitors shall be made in the equipment as used for calibration of the charge decay instrumentation.

B5 Calibration procedure

The charge decay measuring instrument is mounted on the calibration equipment, switched on and allowed to stabilise. Connect the calibration plate to earth and measure the initial 'zero' surface potential reading by the fieldmeter. Apply calibrated voltages to the plate to give readings at well spaced voltage levels from 50 V to 1000 V. Repeat measurements for the other voltage polarity.

Connect a combination set of resistance and capacitance values from earth to the calibration plate. Operate the charge decay measuring instrument to apply sufficient charge to the calibration plate to achieve an initial peak surface potential suitable for decay time measurement. Initial surface potentials in the range 100 V to 1000 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 3 decay time measurements shall be made for each charge polarity for each decay time range. From each set of 6 readings the average decay time value and the standard deviation shall be calculated.

Annex C (Normative)

Calibration of corona charge transfer measurements

C1 Aspects to be calibrated

Calibration of instrumentation for measurement of the corona charge received by samples involves two parts: calibration of the charge sensitivity of the 'induction' and 'conduction' charge measurement circuits and calibration of the interpretation of induction charge observations.

C2 Induction and Conduction charge measurement sensitivity

A defined quantity of charge is provided by charging a calibrated capacitor to a defined voltage. Charge calibration involves discharging this capacitor directly to the electrodes involved in 'conduction' and in 'induction' charge measurement. If the charge measurement circuits are 'virtual earth input' circuits then all the charge on the capacitor is transferred to the charge measurement circuit, and the signal output can be compared to the known quantity of charge input.

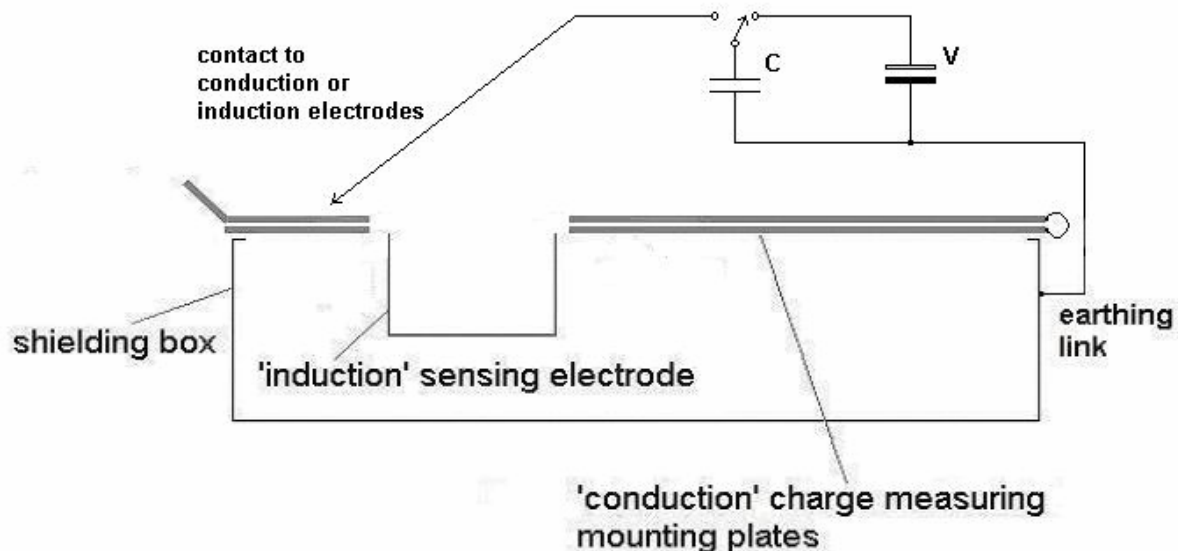


Figure C1 – Arrangement for calibration of charge sensitivity

C3 Relative sensitivity of 'induction' charge measurement

The relative sensitivity of 'induction' charge observations is the charge signal measured compared to the quantity of charge placed on the sample surface at the position of charge deposition. This is best determined by making charge decay studies with the charge decay test unit mounted on the charge measuring sample support using a thin test sample that is a fairly homogeneous dielectric and has a charge decay time of several seconds. Charge measurement signals will initially be solely a 'induction' charge signal. This will progressively move to become just a 'conduction' charge signal. Since the total charge is constant the relative sensitivity factor is the factor by which the decaying 'induction' signal needs to be multiplied so that when this is added to the increasing 'conduction' signal the sum, that is the total charge value, is stable over the time of observation.

The precise sensitivity of 'induction' charge measurements is assessed using a thin sample of a simple dissipative material (for example paper, cellophane or cling film), with a decay time of a few seconds. The variations of conduction Q_c and induction Q_i signals are numerically recorded over the initial period of charge decay, for example to the $1/e$ time. Spreadsheet

Method for measurement of corona charge decay and capacitance loading

modelling may then be used to find the numerical factor, f_1 , by which instantaneous 'induction' signals need to be multiplied so that when added to corresponding instantaneous 'conduction' signals a total signal Q_{tot} is achieved that does not vary over the observation time.

$$Q_{tot} = Q_c + f_1 \cdot Q_i \tag{1}$$

Once a value has been obtained for the factor f_1 , this may be used as a reference value in subsequent charge measurements, so long as all features of the test arrangement remain the same.

Factor to match 'induction' charge measurement = 2.0

