MASTER® BUILDERS SOLUTIONS

Antistatic and ESD Resin Based Flooring Systems

Principles and Standards

A brand of MBCC GROUP

Contents

Introduction

Static electricity can cause more than just minor discomfort. In today's increasingly technological environment, an ordinary static shock received walking across a carpet can cause particularly serious damage and accidents. Depending on the source, environment and target, as well as the intensity of the discharge, electrostatic discharge can have a negative impact on health, safety, productivity, quality and profitability.

MasterTop and Ucrete flooring systems from Master Builders Solutions are part of the solution to protect users, products, goods, devices and equipment against the effects of uncontrolled static discharge.

Static Electricity and Electrostatic Discharge

Electrostatic principles

Electrical charges are a decisive variable in the field of electrical engineering. Every object and individual has positive and negative electrical charges, which are normally in equilibrium (electrically neutral).

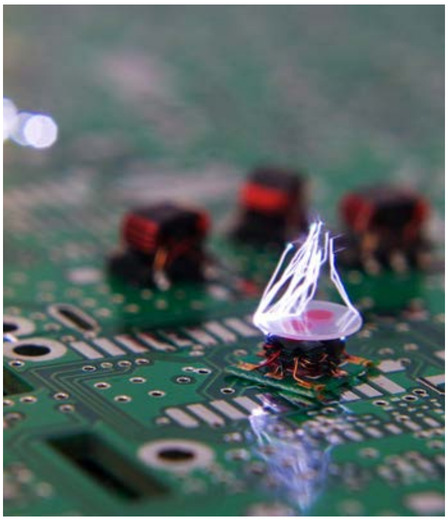
Through mechanical separation, lifting, friction, and crushing processes, the pouring of solid objects and substances, or the flow, pouring and spraying of liquids as well as the flow of gases and vapors that contain slight quantities of finely distributed solids, a charge is ordinarily transferred along the common interfaces of the respective charge carriers, causing a difference in potential.

The charge carriers are electrostatically charged.

Formation of static electricity

Static electricity is formed through or by:

- dissimilar materials coming into contact and moving relative to one another, for example footfall, friction, flows of air, powders, liquids, etc.
- triboelectricity caused by friction
- the separation of dissimilar materials when people walk, jump, get out of a chair, etc.
- induction due to proximity to a charged object. Carriers that are negatively or positively charged emit an electrical field. People and objects can become charged through movement or electrostatic induction. Electrostatic induction is the separation of mobile electrical charges in an initially neutral body that takes place when it is approached by an electrically charged object. Physical contact is not needed.


Effects of a static discharge

An electrostatic discharge contains energy. This energy can affect the source of the discharge, the target that it arcs to, and the environment in between.

- **Source:** this is the body with higher potential, where the charge is accumulated and from where it flows
- **Target:** the body of lower potential that it hits
- **Environment:** the medium or atmosphere through which it arcs

Under certain circumstances, the result of such spontaneous discharges may cause a spark to form. This potential risk must be avoided, not only when combustible liquids explosive substances and combustible dust are present, but also in situations involving electronic devices and electronic components that are sensitive to electrostatic charges.

Every contact between objects, the separation of one item from another, or each sliding of one thing over another can cause a disturbance of electrical charge.

When this occurs faster than the charge redistribution, static charge accumulates. The discharge of this electrostatic charge can lead to sensitive devices, such as integrated circuits, being damaged. A spark can occur as bodies at different electrostatic potential approach each other which can ignite materials such as solvents and dust clouds, leading to fire or explosion.

Undesirable static electricity can:

- damage electronic components
- cause dust explosions
- cause solvent explosion, and the ignition of flammable liquids

Furthermore, static electricity can lead to the unwanted accumulation of dust, and the loss of quality and production time in several industries, i.e. web and sheet processing due to static attraction, and cause discomfort and accidents.

Therefore, the consequences of static discharge may negatively affect the health and safety of people such as workers and end users, decrease the durability of the devices and the quality of the produced goods, and negatively impact productivity.

Additional costs caused by static electricity can range from a few cents to millions of euros, not to mention the human risks and legal consequences that might arise in the event of an accident.

Depending on the type of industry and operating conditions, a variety of areas designed to safeguard against electrostatic discharge may well be found.

Areas to Be Protected against Electrostatic Discharge

ATEX areas

In explosive areas and/or atmospheres (ATEX Regulations), the concern is always the effect on the environment – unless the source and target are explosives.

Solvent, gas and dust explosions, as well as flammable ignition are addressed as risks in ATEX areas.

If there is an ignitable mixture (i.e. solvent vapor in the air), static electricity may become a hazard if a static discharge causes a spark, with enough energy to ignite the mixture.

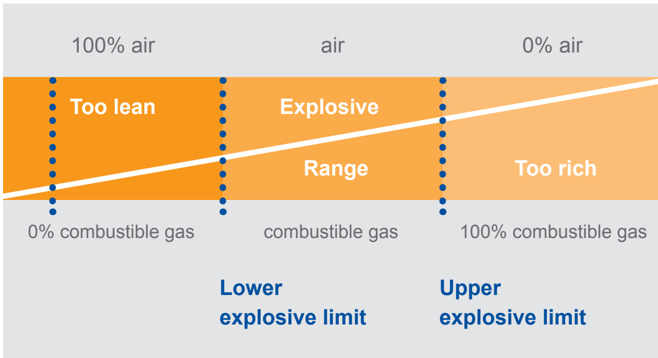
The risk of gas explosion is high, particularly in the petroleum industry, as liquid petroleum has a very low flash point. Gas concentration thus becomes an increasing possibility, and has the capacity to reach a critical concentration where even a single spark generated by electrostatic discharge may be enough to cause an explosion.

An equivalently high risk of explosion can also occur in industries where dust is generated in the production process. In such scenarios, there is also a danger that the dust concentration may reach a critical level where a single spark is enough to cause an explosion. When materials are finely divided, they become more reactive.

The smaller the wood pieces, the easier it is for a fire, to combust, for example. If the pieces are too small (as in sawdust particles), the risk of dust exploding will still exist depending on the conditions: for example, if a high enough concentration of dust is suspended and confined in an oxidant medium (typically air) in combination with an ignition source. Aside from the burning of materials such as coal or wood, resulting in a dust explosion: many other materials, such as aluminum powder or even organic materials (sugar, coffee, flour, etc.) may be dispersed into a dangerous mixture suspended in the air. About 10% of powder explosions are due to electrostatic discharge.

Explosive limits (also known as 'flammable limits'), expressed as a percentage (%), may be defined as the maximum and minimum concentrations of a flammable gas or vapour between which ignition may occur.

Limits of explosives



Undesirable electrostatic discharge is controlled by using dissipative or conductive, grounded materials. Conductive floor toppings should be used for best results.

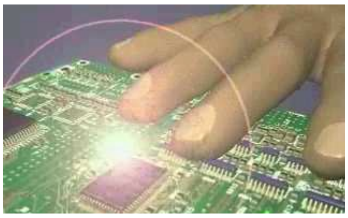
The ATEX directives consists of two EU directives that define the minimum safety requirements of the workplace and equipment used in an explosive atmosphere. ATEX derives its name from “Appareils destinés à être utilisés en ATmosphères EXplosives” (French for Equipment intended for use in EXplosive ATmospheres).

Organizations in the EU must follow directives to protect employees from explosion risk in areas with an explosive atmosphere.

There are two ATEX Directives: One for the manufacturer and one in this context:

- the ATEX 214 "equipment" Directive 2014/34/EU – Equipment and protective systems intended for use in potentially explosive atmospheres
- the ATEX 137 "workplace" Directive 1999/92/EC – Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.

EPA (ESD Protected Areas)



Where ESD Protected Areas (EPAs) are concerned, the focus is on damage that may be done to the source and the effects on the target. The EPA requires that any body voltage generation must be controlled.

The advent of electronic components has created new issues in terms of static electricity and electrostatic discharge.

Materials are susceptible to becoming electrically charged and charged objects have electrostatic fields. Moreover, electrostatic discharge may damage devices.

It is potentially feasible that discharge may cause a failure in a diode, a transistor, a microchip, and an integrated circuitry, etc., thereby damaging the device directly or prematurely.

An electronic component may welll be the source or the target of an electrostatic discharge (ESD). Electrostatic fields may also induct an ESD in an electronic component.

The sensitivity of electronic devices to ESDs depends on the type of components they contain. As the trend shifts towards size reduction, susceptibility is bound to increase at a continuous pace.

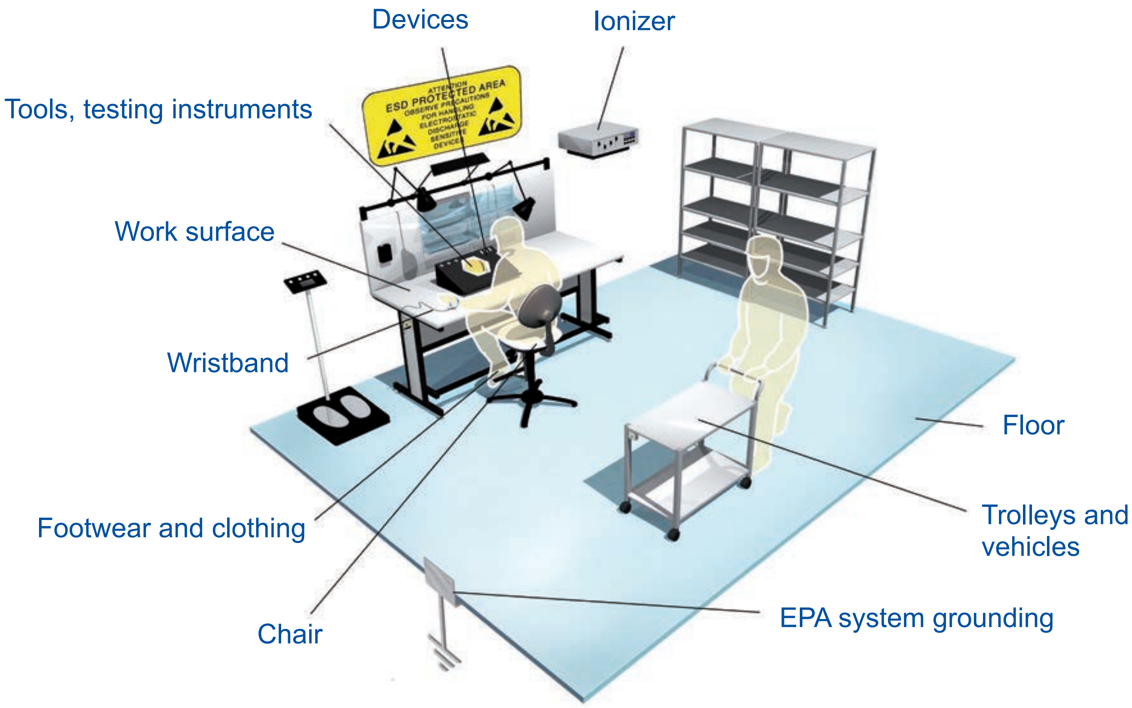
An electrostatic discharge may occur not only during the production process, but also during delivery, maintenance, or service operations, etc.

In today's modern world, electrostatic discharge has an impact on productivity and product reliability alike.

An ESD Protected Area (EPA) is designed to fulfill specific criteria, such as very low body voltage generation when people walk on the floor, enabling ESD-sensitive devices to be used safely. As a consequence, ESD floors are a very important part of the holistic design of an EPA.

Flooring should be seen as one element of a holistic approach to the controlling of ESD.

The international specification IEC 61340-5-1 defines limits for elements protected against ESD.



3. Clean rooms

A clean room is a facility designed to keep the level of particulates, such as dust, organisms or suspended particles, under a certain threshold. The cleanliness level of a clean room is defined by the maximum number of particles per cubic meter.

Clean rooms are used as part of the manufacturing process, for example in research and production areas for drugs and microprocessors.

In this clean environment, the floor design plays a very important role. A seamless, wear-resistant, dustproof surface which is easy to clean, disinfect and maintain is usually what is demanded.

Depending on the type of industry or application, AS or ESD floors are what are called for in order to avoid static discharge and static cling. Any other option may lead to issues with static discharge or dust accumulation.

4. Across all areas – protection against electric shocks

In some cases, independent of the type of industry, a minimum resistance to ground of the flooring system may be required to protect people against electric shock.

IEC 60364-1 prescribes the rules for the design, erection, and verification of electrical installations.

The rules are intended to provide for the safety of individuals, livestock and property against dangers and damage which may arise during the reasonable use of electrical installations and to provide for the proper functioning of those installations.

IEC 60364-4-41:2005+A1:2017 specifies essential requirements regarding protection against individuals or livestock receiving electric shocks. It also covers the application and co-ordination of these requirements in relation to external influences. Requirements are also given for the application of additional protection in certain cases. The relevant flooring requirements are included in this part.

IEC 60364-6:2016 specifies the requirements for the initial and periodic verification of an electrical installation.

Applicable Standards

Terms such as conductive and dissipative should be avoided, as they mean different things to different people.

The exact range of acceptable resistance and test method (including test voltage) should be specified by the end user prior to any resin flooring being selected. Where a resistance value is quoted (in ohms), it should be specified, for instance, whether this refers to surface resistance (the resistance measured between two electrodes placed on the surface of a material after a given time of electrification) or resistance to ground (the resistance measured between a single electrode placed on the surface of a material and a ground point).

Here, it should be specified whether 'ground' refers to the protective earth of the power distribution system (resistance to earth) or, for example, the steel frame of a building used as a return path for electric currents and an arbitrary zero reference point.

The test voltage must be specified as the measured resistance will depend on the applied voltage.

The most relevant test methods and standards for Antistatic and ESD flooring are as follows:

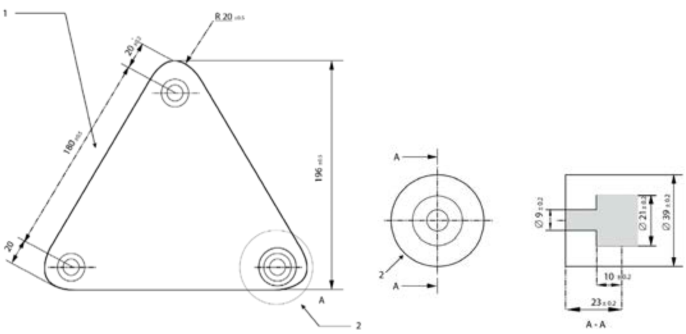
1. EN 1081:2018+A1:2020 – Resilient floor coverings – determination of the electrical resistance

This European Standard describes the measurement method of the following three resistances: the vertical resistance of a floor covering, the surface resistance of a floor covering and the resistance to earth of a floor covering after installation.

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

- Method A – Vertical resistance R_1: the electrical resistance measured between a tripod electrode (see Figure 1) on the surface of a test piece and an electrode attached to the underside of the test piece (see Figure 2).
- Method B – resistance to earth R_2: the electrical resistance measured between a loaded tripod electrode on the surface of a laid floor covering and earth.
- Method C – surface resistance R_3: the electrical resistance measured between two tripod electrodes (see Figure 4) set up at a fixed distance of 100 mm apart on a laid floor covering (see Figure 3).

Fig. 1: Tripod electrode



[1] triangular pitch
[2] rubber foot

Rear view | **Front view**

Please note that only the electrode on the left side must be used; the one on the right in each picture does not conform to the standard and should not be used.

Generally speaking, the measurements are taken by using:

- a single tripod electrode
- force applied when measuring > 30 kg
- temperature and humidity: 23°C / 50% RH.
- voltage 10V if R_G and $R_{P\text{-}P} < 10^6\ \Omega$
- voltage 100V if R_G and $R_{P\text{-}P} > 10^6\ \Omega$

Fig. 2: Testing of vertical resistance

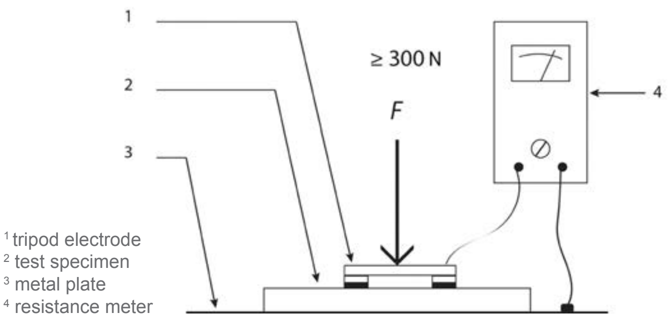


Fig. 3: Distance between sides of tripod electrodes

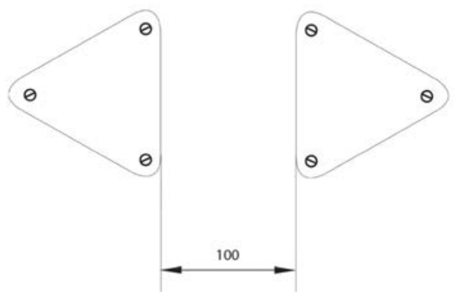


Fig. 4: Testing of surface resistance

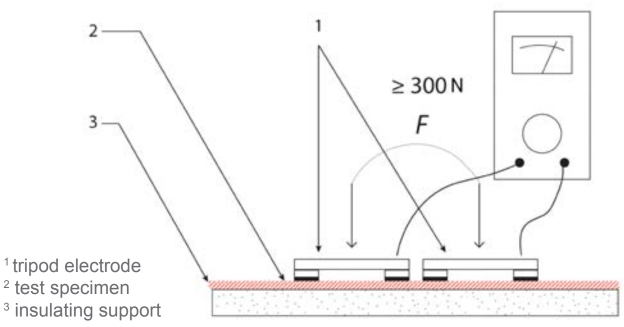
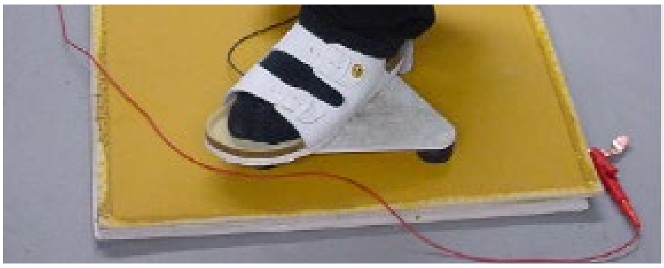


Fig. 5: Testing of surface resistance



Please be aware that there is no limit value indicated in Standard EN 1081. The limit values below are the common requirements for antistatic (AS) systems and flooring systems:

- $10^4\ \Omega < R_2\ (R_g) < 10^6\ \Omega$

2. IEC 61340-5-1:2016. Protection of electronic devices from electrostatic phenomena – General requirements

This technical report specifies the general requirements for the protection of electrostatic discharge sensitive devices (ESDS) from electrostatic discharges and fields.

It can also detail how to design, use and control a protected area to ensure that electrostatic sensitive devices, having a withstand threshold voltage of 100 V (human body model) or higher, can be handled with a minimum risk of damage resulting from electrostatic phenomena.

The limit values defined in EN 61340-5-1:2016 serve as a base for the tests below:

a. Test according to IEC 61340-4-1:
R_{p-p} resistance point to point

b. Test according to IEC 61340-4-1:
R_g resistance to ground

c. Test according to IEC 61340-4-5:
R_g resistance to person/footwear/flooring system

d. Test according to IEC 61340-4-5:
Body voltage generation – walking test (charging of a person by walking on a floor)

2.1. IEC 61340-4-1:2015. Standard test methods for specific applications – Electrical resistance of floor coverings and installed floors

This standard specifies test methods for determining the electrical resistance of all types of floor coverings and installed floors with resistance to ground, point-to-point resistance and vertical resistance. This consolidated version of IEC 61340-4-1 carries the edition number 2.1. It consists of the second edition (2003-12) and its amendment 1 (2015-04).

As mentioned above, under IEC 61340-4-1, two different resistance measurements must be taken (the vertical resistance is not relevant and can only be achieved in the laboratory because a counter-electrode placed on the back of the material is needed to perform this measurement):

Resistance to ground:

Resistance to ground is a measurement that indicates the capability of an item to conduct an electrical charge (current flow) to an attached ground connection. The higher the resistance in the path, the more slowly the charge will move through that defined path.

The resistance in ohms is measured between a single electrode placed on a surface and an earthing point.

As shown in the pictures above, the measurement procedure is as follows:

1. Place the electrode on the floor and connect the probe via the wire to the ohmmeter
2. Connect the second wire firstly with the earth point and secondly with the ohmmeter
3. Take measurements
4. The number of measurements must be coordinated with the customer representative.

Starting with 10 V, take a reading. If the value is > 10^6 Ω, select 100 V. If the value > 10^{11} Ω, select 500 V and perform a final measurement. This also applies to resistance point to point.

	R_g / R_{p-p}		
Voltage	< 10^6 Ω	10^6 Ω < R< 10^{11}	> 10^{11}
10 V	x		
100 V		x	
500 V			x

The number of measurements of resistance to ground as recommended by us is shown in the table below:

Surface of applied area	Number of measurements
> 10 sqm	6 measurements
> 100 sqm	20 measurements
> 1000 sqm	50 measurements
> 5000 sqm	100 measurements

Resistance point to point:
A point-to-point measurement used during the qualification process evaluates floor and work surface materials, garments, chair elements, some packaging items and many other static-control materials. Two electrodes (Fig. 1) connect the item under test at the prescribed spacing.

Fig. 1: Electrode

Fig. 2: Point-to-point measurement

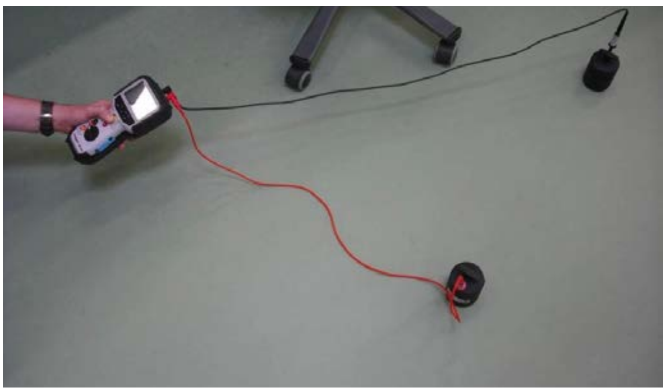


Figure 2 shows the point-to-point concept for a flooring work surface

Below is the measurement of the electrical resistance between two points on the surface of a flooring system.

Fig. 3

Fig. 4

Fig. 5: Measurement set

Point-to-point measurements are important during the qualification process for the proper evaluation of flooring and work surface materials.

After installation, the resistance to ground measurement is more applicable since it emulates how the material really behaves in practice.

3. IEC 61340-4-5:2004. Standard test methods for specific applications - Methods for characterizing the electrostatic protection of footwear and flooring in combination with a person

Person/footwear/flooring system: R_g

This part of IEC 61340 specifies test methods for evaluating electrostatic protection provided by a system of footwear and flooring in combination with a person.

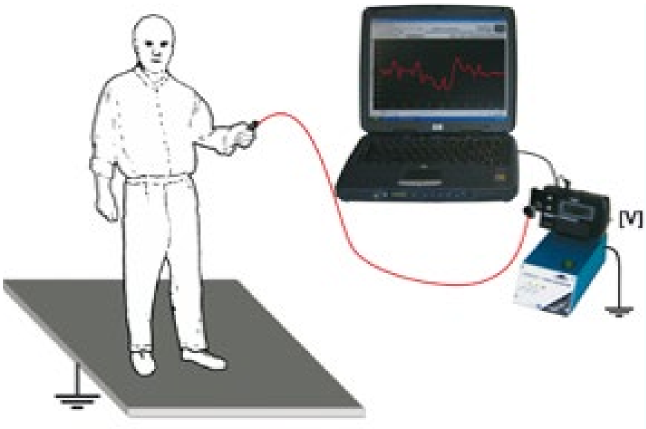
With this system, the resistance between the hand of a person who is wearing ESD footwear and standing on the testing device and earth potential is measured.

Practical experience has shown, for example, that the resistance of the system is highly dependent on the transition resistance between person and footwear as well as footwear and floor.

Together with the ESD footwear, a handheld electrode is used. The handheld electrode is a stainless-steel round stock or tube, approximately 25 mm in diameter and 75 mm in length with a banana plug receptacle or screw connector attached to one end of the cylinder.

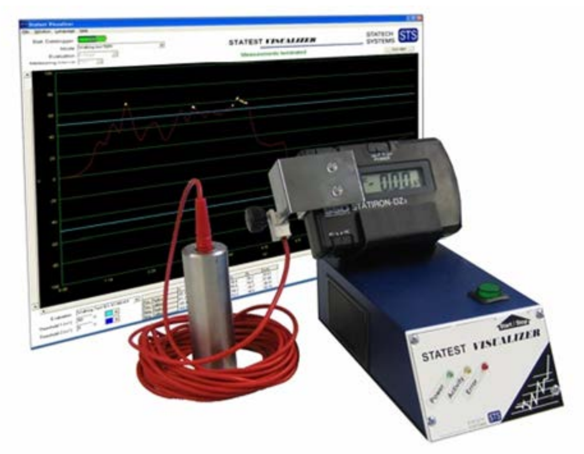
Wear the test footwear on both feet for at least 10 minutes prior to commencing testing. Connect the negative lead of the resistance measuring apparatus to the earthing point or to earth.

Connect the other lead to the handheld electrode. Stand with both feet on the test floor covering and firmly grasp the hand-held electrode.



Starting with a voltage rate of 10 V, take a reading of the resistance 15 s ± 2 s after applying the test voltage. If the value exceeds 10^6 Ω, select 100 V and repeat the measurement.

Record the reading that matches the voltage and resistance range specified (the apparatus needs to have an open circuit voltage of 10 V ± 0,5 V for resistance below 1,0 Ω x 10^6 Ω, and 100 V ± 5 V for resistance of 1,0 Ω x 10^6 Ω and above).



If the resistance falls below 106 Ω, when taking a measurement using 100 V, this reading is to be the one that is recorded.

Repeat the measuring procedure with only the left foot in contact with the test floor covering and with the right foot held in the air about 150 mm above the floor covering.

For tests on installed floor coverings, at least five measurements need to be made for each floor covering material. For large floor areas, at least five measurements per 500 m^2 of each floor covering material need to be made. Where there is evidence of wear, chemical or water spillage or visible dirt, then at least three measurements need to be made on such affected areas.

Body voltage generation (walking test)

In **IEC 61340-4-5**, a measuring technique to determine the charge of a moving person in combination with the floor is described. This technique provides a dynamic measurement of the complete system: ‘walking person’, footwear and flooring system. This means that the voltage that builds up on the person moving on the floor in volts and the time of compensation of voltage through the floor are measured.

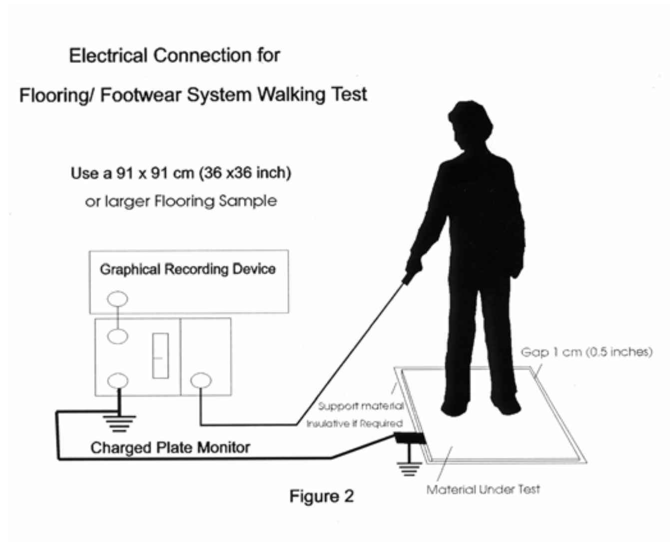
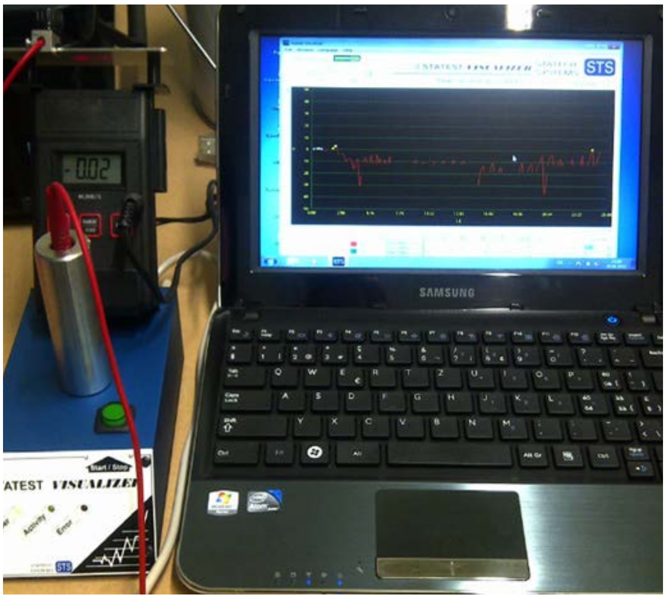


Figure 2

The following minimum conditions should be fulfilled by the ‘person-footwear-floor’ system:

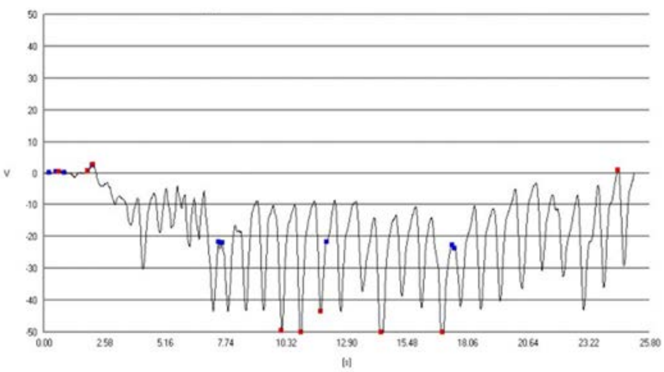
- The maximum charge of persons walking on the floor system should not exceed +/-100 V

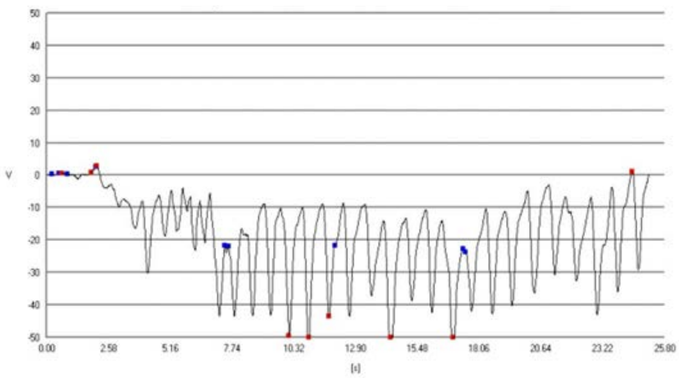
Therefore, when this measuring technique is used, the requirements that are placed are highly dependent on the measuring conditions and the person, footwear and floor system.



Material and equipment used for tests:

- giga ohmmeter MEGGER MIT40X
- cylindrical probe SN: KE-B048 STATECH (according to IEC 61340-4-1)
- handheld electrode STS, L 75mm, ø 25 mm (according to IEC 61340-4-5)
- Statest visualizer STATECH (according to IEC 61340-4-5)
- Statest Floor STATECH
- shoes: UVEX Motion style S1 ESD 6998





4. EC 60364-6:2006 – DIN VDE 0100-0600:2007– Erection of low-voltage installations – Part 6: Verification

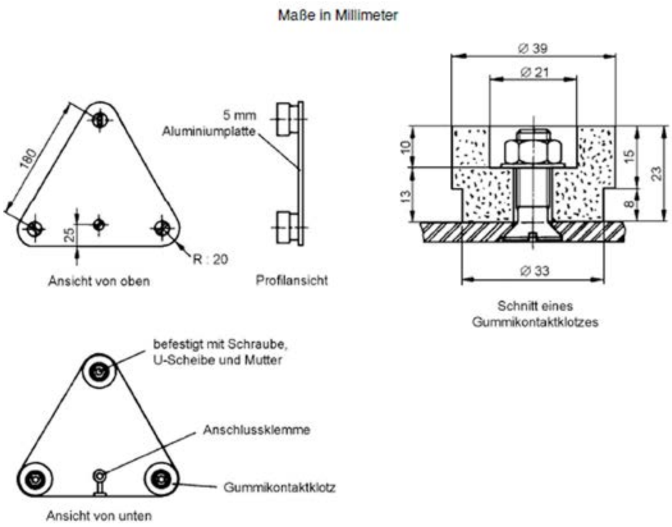
This standard contains requirements for the initial test and the recurrent testing of electrical installations.

The relevant element for us is the determination of the insulation resistance of the flooring system.

The standard also describes the test method:
The test is performed by using a tripod electrode according to EN 1081.

The current I is fed from the output of the current source or an external conductor L to the tripod electrode via a current measuring device. The voltage Ux at the tripod electrode is measured using a voltage measuring device which has an internal resistance of at least 1 MΩ against the protective conductor.

Prior to any measurements, the surface to be tested must be cleaned with a cleaning solution. During the measurements, the force applied on the tripod electrode must be approximately 750 N.



Flooring Requirements

Electrically conductive floors are an important element of safety requirements for protecting individuals and operating facilities, since the build-up of voltage cannot be reduced while walking on an insulated floor. Only when a body with a different potential is touched does the built-up charge flow off spontaneously.

Materials for conductive floor covers are qualified based on their measured electrical properties.

The main requirements for the previously affected areas are described as follows:

ATEX areas

The following flooring requirements for ATEX areas are widely accepted:

- 10^4 Ω < Rg (Resistance to ground) < 10^6 Ω according to EN 1081 or IEC 61340-4-1 and tested according standard conditions.

In specific cases, i.e. explosives manufacturing, handling and storage production, the following requirement is also considered:

- Rg (Resistance to ground) < 5 x 10^4 Ω according to EN 1081 or IEC 61340-4-1 and tested accordance with the standard conditions.

AS

EPA (ESD Protected Areas)

ESD flooring systems must fulfill the following requirement according to Standard IEC 61340-5-1:2016:

- If flooring is not used for grounding personnel that handle ESDS:
  - Resistance to ground Rg < 10^9 Ω according to IEC 61340-4-1 for product qualification and compliance verification.
- If flooring is used for grounding personnel that handle ESDS:
  - person/footwear/flooring system Rg < 10^9 Ω according to IEC 61340-4-5 for product qualification and compliance verification.
  - body voltage generation < 100 V according to IEC 61340-4-5 for product qualification.

The maximum test voltage allowed for measuring ESD flooring that should be used for an ESD program complying with this standard is 100 V.

ESD

Clean rooms

The requirements depend on the type of industry and use of the clean room.

Typical requirements are the given ones specified for ATEX areas or EPA (ESD Protected Areas).

All areas – Protection against electric shocks

Where it is important to determine of the insulation resistance of the flooring system, IEC 60364-6:2006 should be used.

The resistance to ground R_g should be:

- > 50 kΩ, for a nominal voltage of the site < 500 V.
- > 100 kΩ, for a nominal voltage of the site > 500 V.

Further Reading

To learn more about Ucrete and MasterTop protective flooring solutions, please visit our websites:

- More about Ucrete: www.ucrete.com
- More about MasterTop: https://www.master-builders-solutions.com/en-gb/products/mastertop

Appendix

GLOSSARY OF TERMS

Ohm (Ω): unit of electrical resistance named after the German physicist, Georg Simon Ohm (1789 to 1854):

Leakage resistance: The leakage resistance of an object is the electrical resistance that is measured between an electrode placed on the object and earth.

Astatic: Materials are astatic or antistatic if they disperse or inhibit electrostatic charge through friction or surface contact separation towards other materials (triboelectric charging).

Electrostatic charges: Electrostatic charges are electric charges that accumulate through mechanical separation of the same or different materials at the separated surfaces or occur on other conductive objects or persons caused by electrostatic induction.

The lifting of feet (footwear) from a surface is a separation process which, when walking, can cause a person to become charged. The charging capacity of a person is approx. 100 pF (Pikofarad).

Resistance to earth: The resistance to earth of an object is the electrical resistance that is measured between an electrode placed on an object and earth.

Earth potential: Reference earth (neutral earth) according to DIN VDE 0141 is that part of the surface of the earth in which no measurable voltage occurs between two points from earth current.

ESD: Electro Static Discharge is the discharge of static electricity. It leads to the equalization of electric charges between two bodies with different potentials and is affected by the discharge of a spark or direct galvanic contact when an electrostatic field is discharged.

ESDS: Electrostatic Discharge Sensitive device: a component or device that may be damaged by electrostatic discharges.

EPA: ESD protected area: an area in which components or devices are protected from damage caused by electrostatic discharges by practical means.

ATEX: ATmosphere Explosive: ATEX regulations cover the prevention of dust and gas explosions in industry.

Hazard classes: Combustible liquids within the meaning of (German) regulations governing facilities for storing, filling and transporting combustible liquids on land (VbF §3) are materials with a flash point which at 35°C are neither solid or unctuous and have a vapor pressure of 3 bar or less at 50°C and belong to one of the following hazard classes:
Hazard class A **I**: flash point below 21°C
Hazard class A **II**: flash point from 21°C to 55°C
Hazard class A **III**: flash point over 55°C to 100°C
Hazard class B: flash point below 21°C; however, as opposed to Hazard class A **I**, it is soluble at 15°C

Charge: An (electric) charge designates a certain quantity of electricity on a body or object.

Conductive layer: A layer connected to earth which bleeds off charges.

Surface resistance: Surface resistance is the electrical resistance between two electrodes placed on the surface of a coating.

Potential difference: Potential difference is the difference between the potentials of two points in an electric field.

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MBS-03-2021-PF-0129-EN