# Important of ESD floor

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Title: Head of Regional Technical Support & Training (SEA) – CRS & Flooring

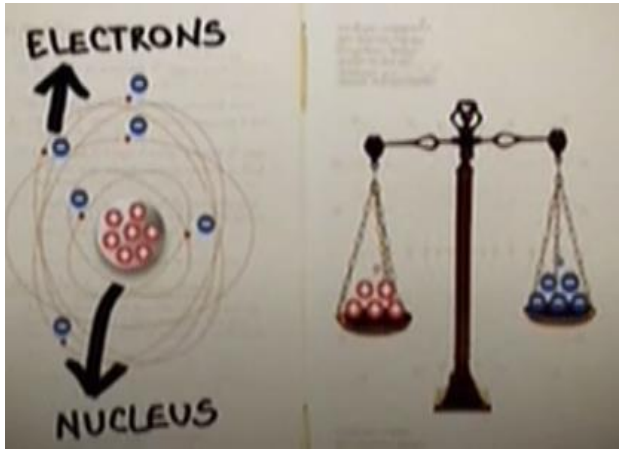
# Outline

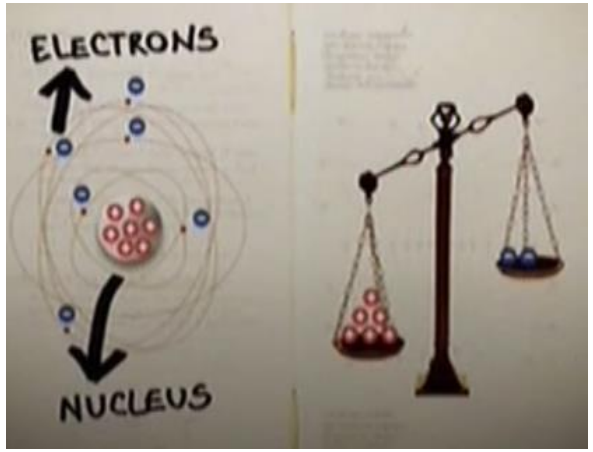
- What is static electricity
- Consequences of ElectroStatic Discharge (ESD)
- Preventive measures for the consequences
- Build up system for conductive floors
- ESD Standards & Guidelines
- Demonstration

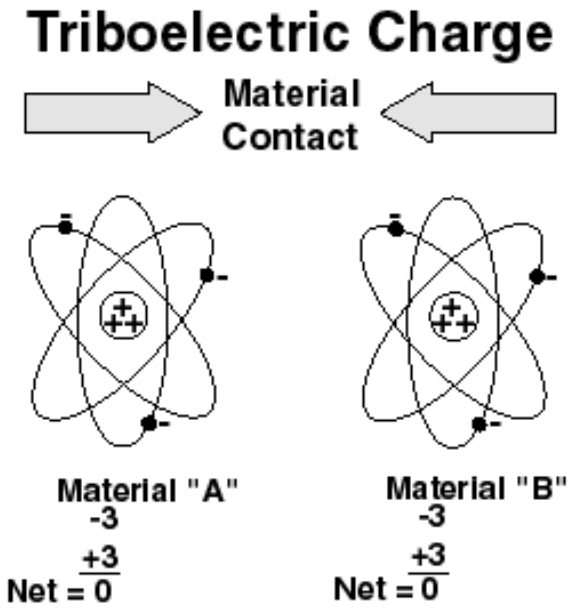
# What is static electricity

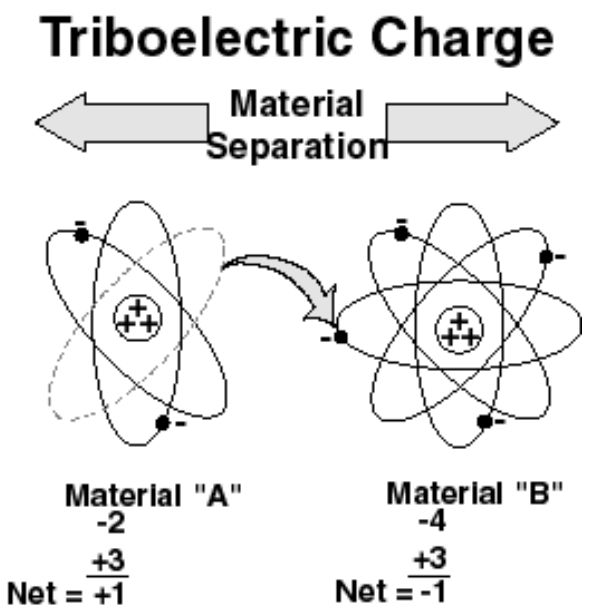

NATIONAL
GEOGRAPHIC

# Electrostatic charge



# Electrostatic charge

Definition:
An electric charge, accumulated on an object, usually by friction between two objects or by transfer from another object.

Charged objects may be discharged spontaneously through a spark, when getting in contact with another object at different electrostatic potential.

# ESD and humidity

| Examples of static generation in relationship to the relative humidity. | | |
|---|---|---|
| **Type of discharge** | **10-25 % rel. hum.** | **65-90 % rel. hum** |
| Walking across carpet | 35000 V | 1500 V |
| Walking across vinyl tile | 12000 V | 250 V |
| Worker at bench | 6000 V | 100 V |
| Lifting a plastic bag from a work bench | 20000 V | 1200 V |
| Chair with polyurethane foam | 18000 V | 1500 V |

# ESD

**Terms and definitions:**

- ESD: **E**lectro**S**tatic **D**ischarge
- ESDS: **E**lectrostatic **S**ensitive **D**evice**s**
- EPA: **E**SD **P**rotected **A**rea

# Consequences of ElectroStatic Discharge (ESD)

# Consequences of electrostatic charges and discharges for the industry

- Electrostatic potentials attract small particles (e.g. dust)

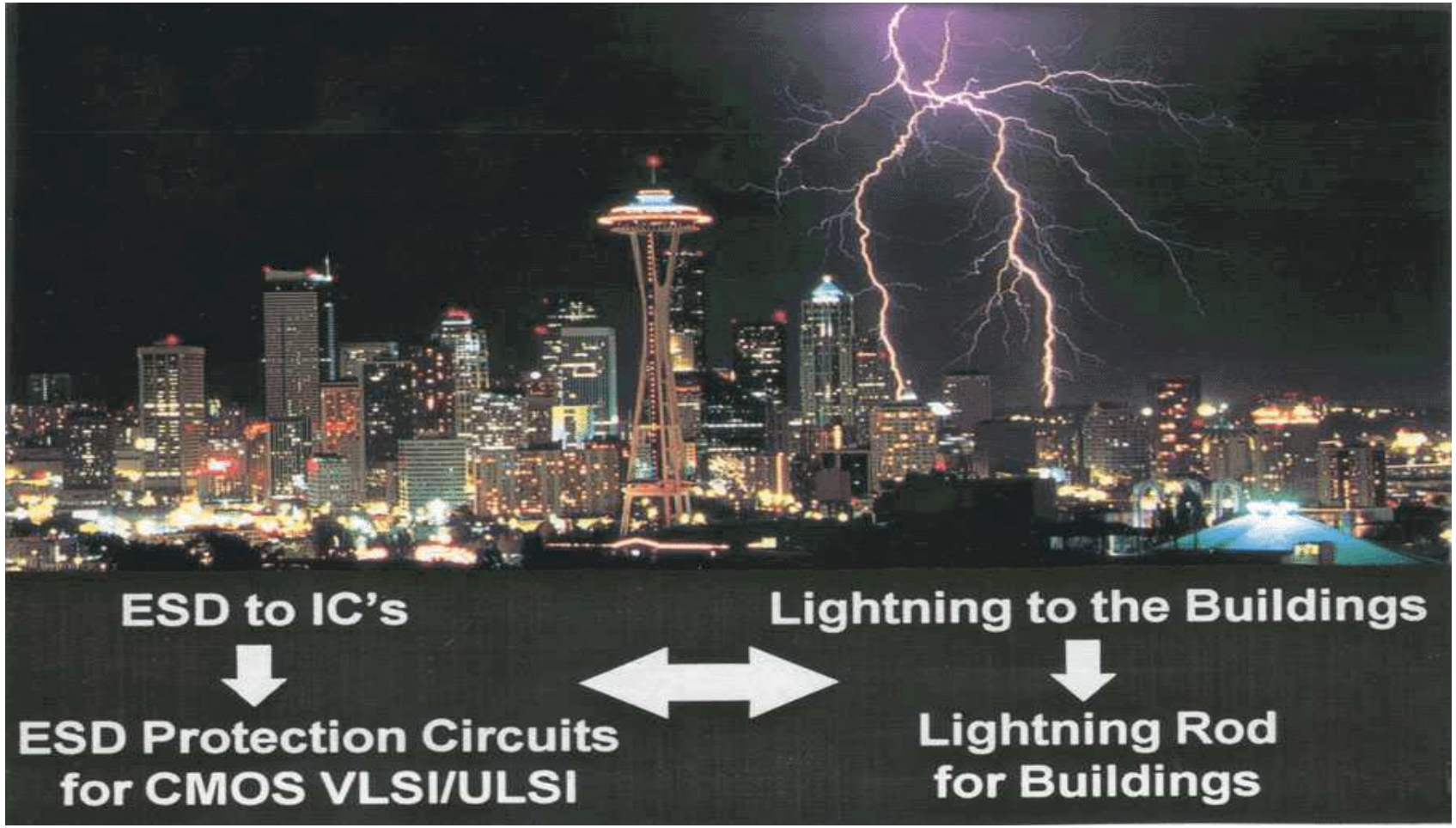
  ➔ Problems in clean rooms

- Electrostatic potentials can discharge themselves by means of a spark

  ➔ Danger of explosion in areas where solvents or ▷ flammable dusts are in the atmosphere (solvent-, fertilizer storages, mills etc.)

  ➔ "Welding", burn-through of sensitive components (microchips, integrated circuits)

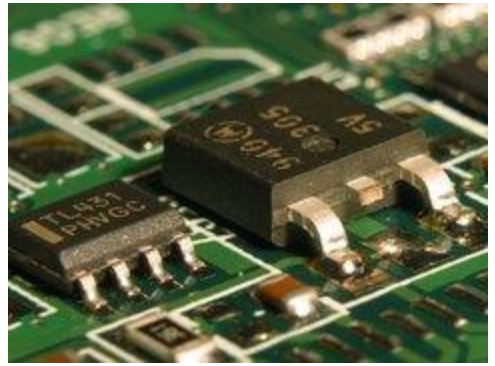
# ESD

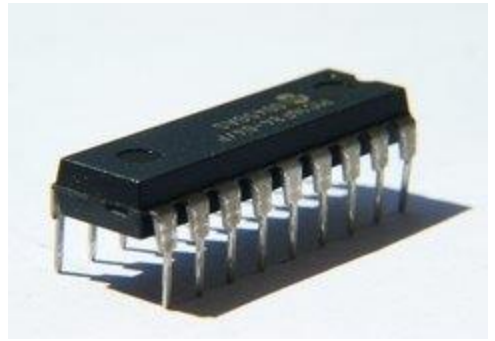

ESD to IC's
Lightning to the Buildings
ESD Protection Circuits
for CMOS VLSI/ULSI
Lightning Rod
for Buildings

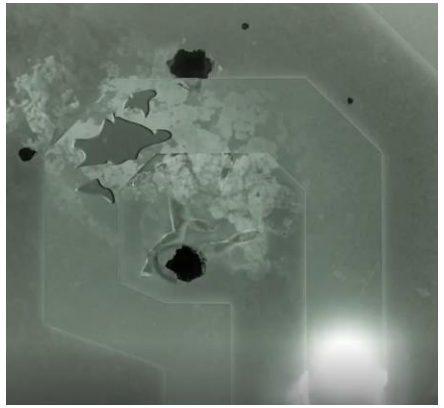
# ESD Failure Modes

- **Catastrophic failures or direct failure (10 – 30%)**: The device is physically damaged and non-operational. These failures occur immediately after an ESD event. They are the easiest to detect and fix.

- **Latent failures (70 – 90%)**: Latent failures occur when a device is subject to an ESD event and non-catastrophic damage occurs. The product is compliant with all factory test conditions but after a period of time, degradation of performance occurs. Effects may include unstable operation, increased leakage current, or complete failure. Latent damage is the most difficult to detect and may incur large costs to repair.



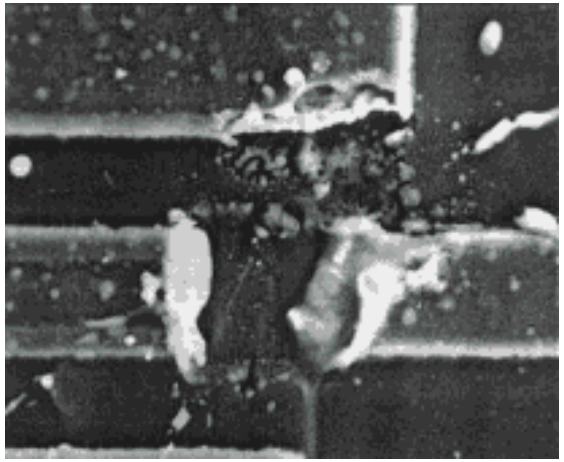




# Electrostatic Potentials

- Electrostatic charging: up to 35000 V (on a person)
- Human sensitivity: > ca. 3000 V

  (regarding ESD-events)
- Minimum ignition energy of gasoline : 0.24 mJ (equals ca. 1500 V on human bodies)
- damage thresholds of very sensitive devices: > ca. 1 - 10 V



➔ **ESD-sensitivity of electronic devices will rise steadily within the following years!!**

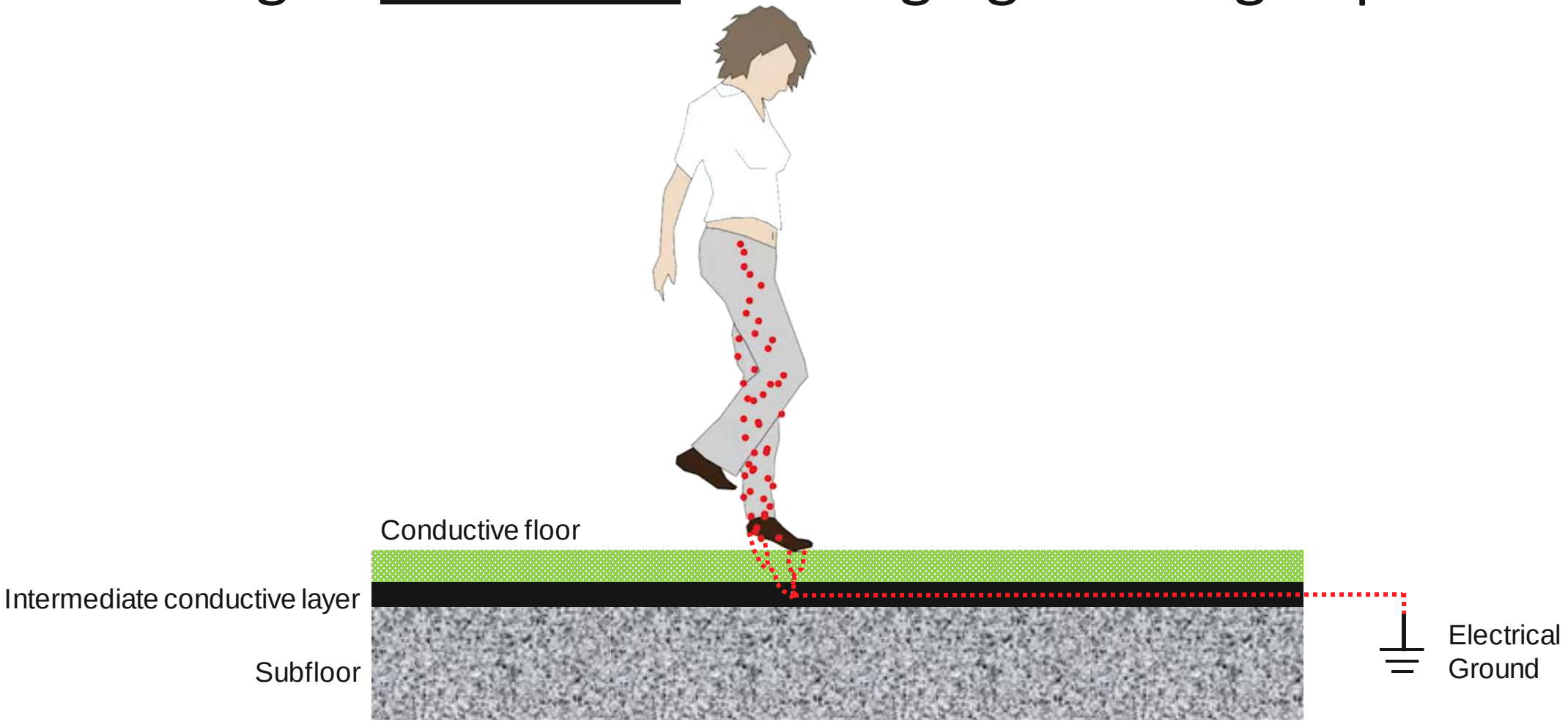
➔ **ESD-protection measures, that function today, won´t be sufficient in the future!**

# Preventive measures for the consequences

# Preventive measures

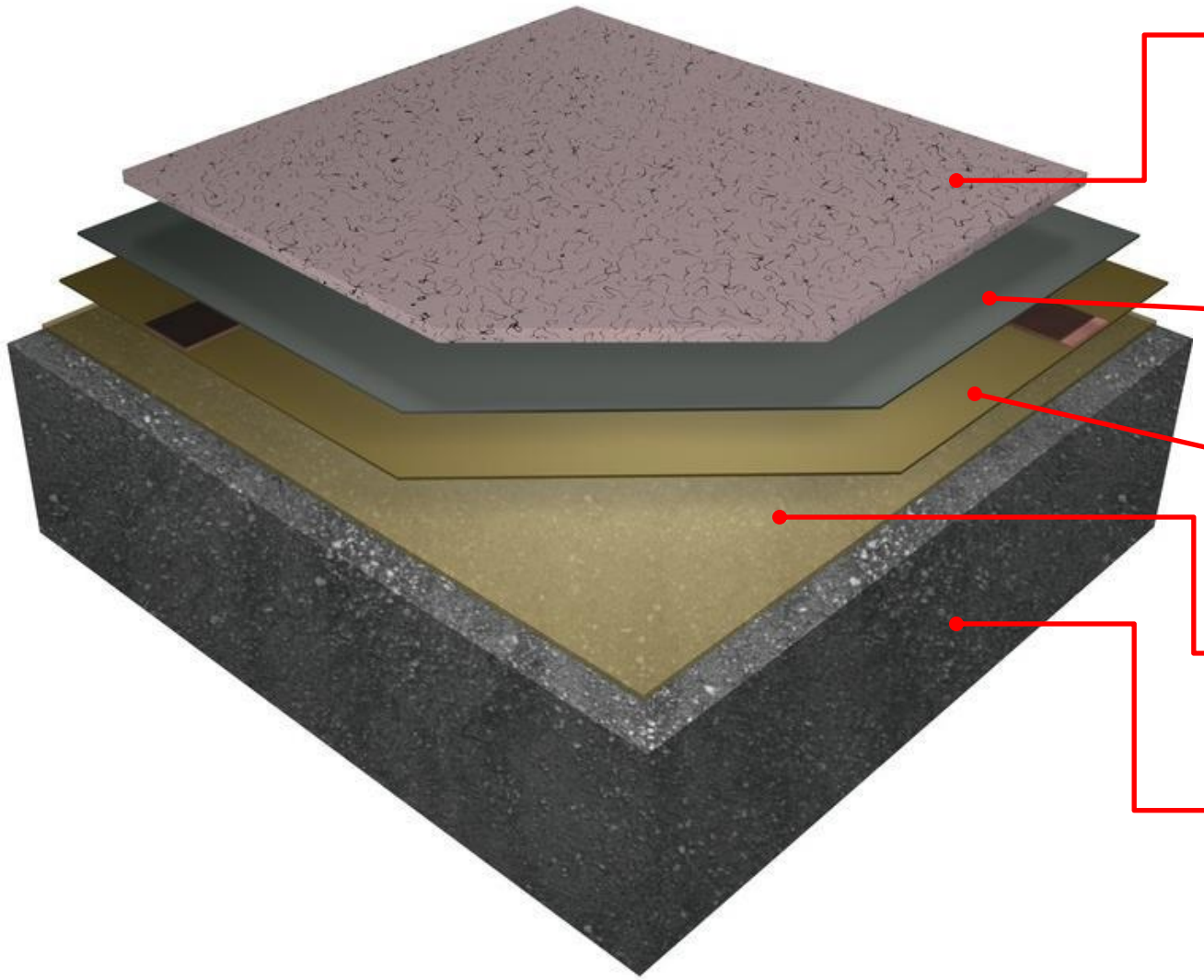
## Conductive floor

- Prevention of charging of persons.
- Enabling of **controlled** discharging of charged persons.



# Build-up system for conductive floors

# System build-up



Topcoat
loaded with carbon fibers or conductive fillers

Conductive intermediate

Levelling layer

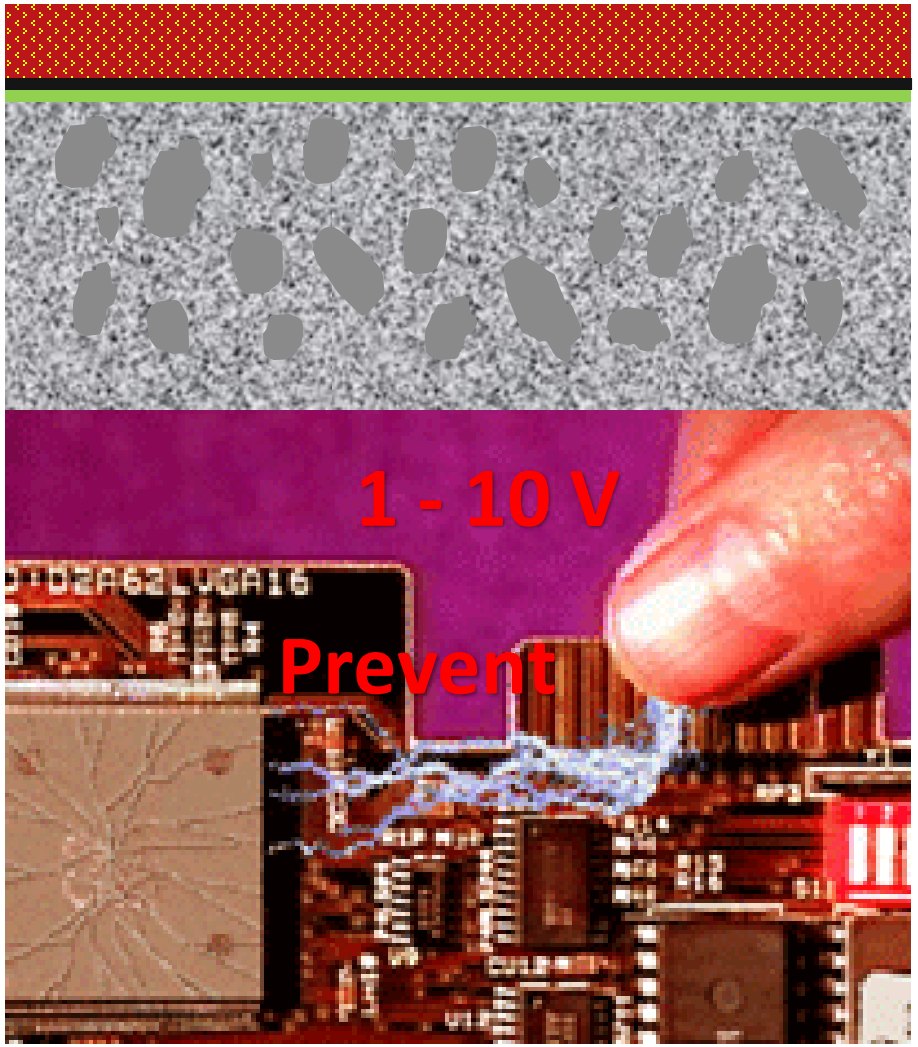
Primer

Subfloor,
e.g. concrete

# Conductive floors

## Conventional carbon-fibers loaded

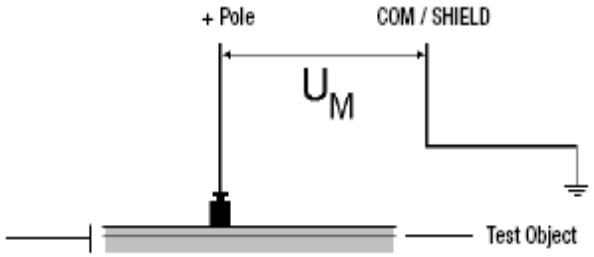

## Volume conductive fillers loaded



# Field of application of electrically conductive floor coatings (Market segments)

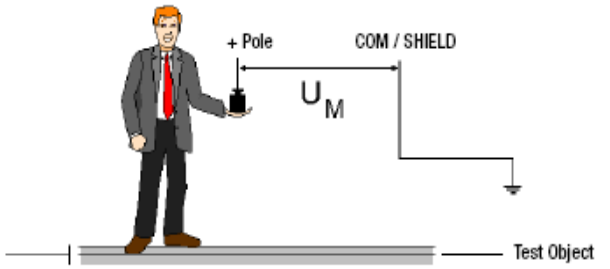
## Explosion protection

- Solvent storages
- Ordnance factories
- Fertilizer storages
- Food industry
- Pharmaceutical Industry




## Protection of electrostatically sensitive devices (esds)

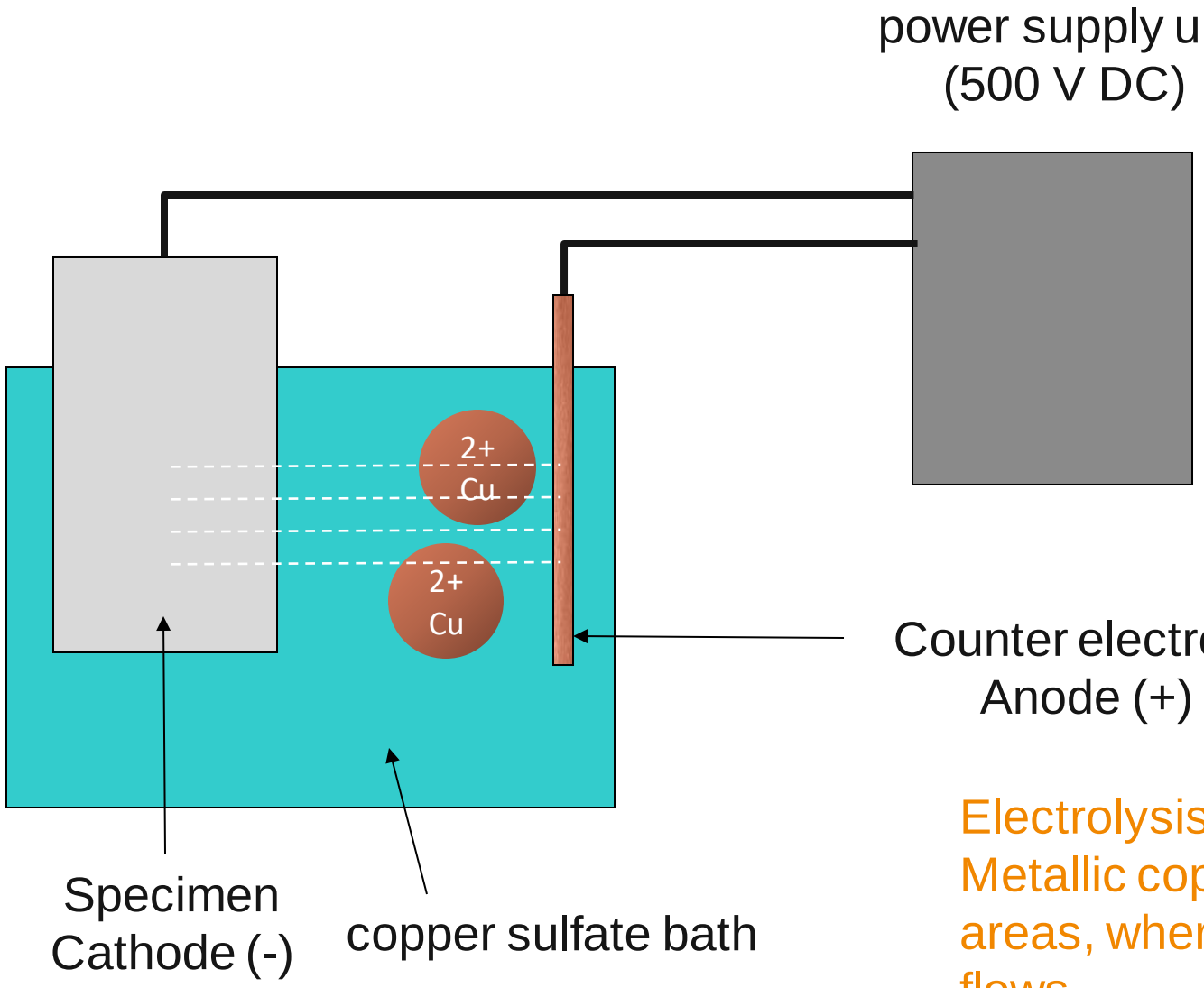
- Electronic Industry
- Precision Engineering
- Aerospace Industry
- Automotive Industry
- Clean rooms
- Hospitals (e.g. surgery)
- Military




Die Personenaufladung wird direkt während der Messung am Computer angezeigt und kann gespeichert werden.

# Volume conductive vs conventional fibers loaded flooring system

# Case study

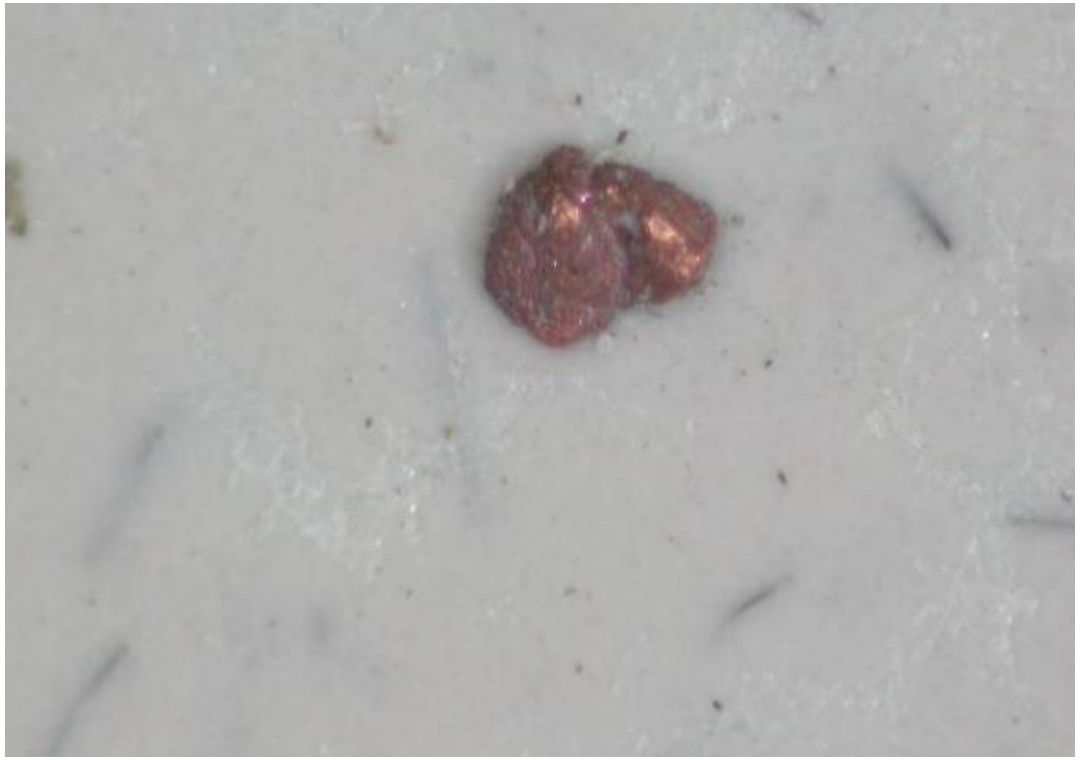



ESD Association's Symposium 2012 (Singapore), 2013 (Penang), 2017 (Singapore) and 2019 (Penang)

Electrolysis:
Metallic copper deposits in areas, where electric current flows

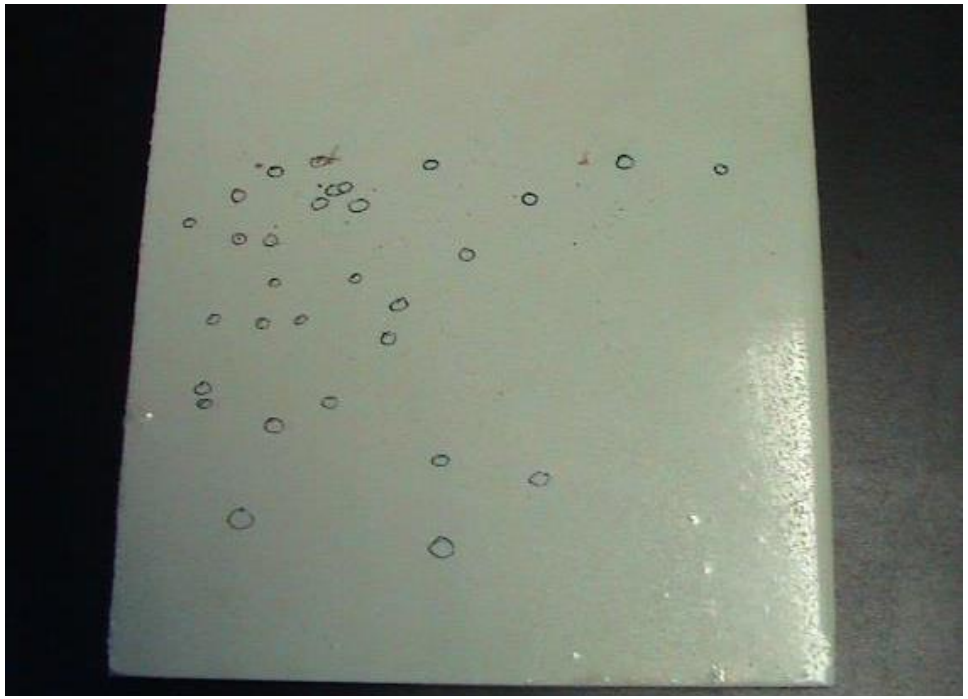
# Case study

Metallic copper has deposited over carbon fibers with contact to conductive intermediate



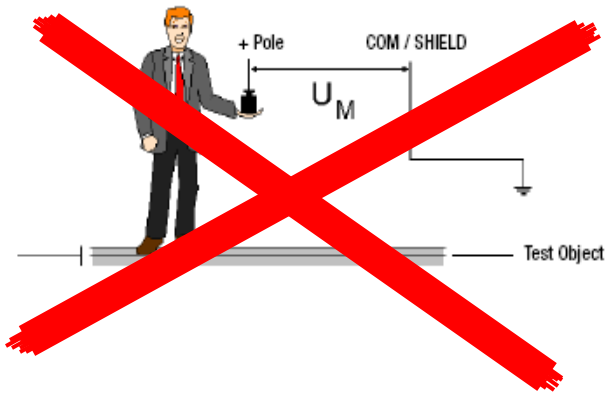
# Case study - results

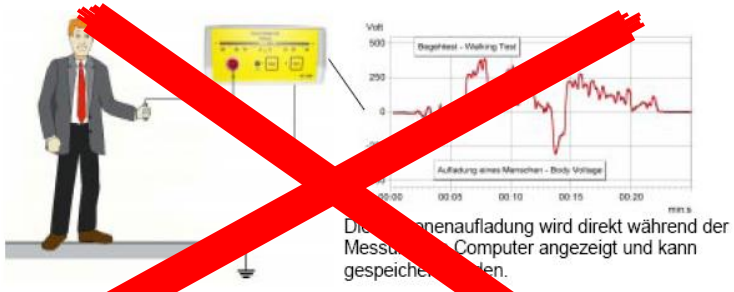
## Fibers loaded conductive coating

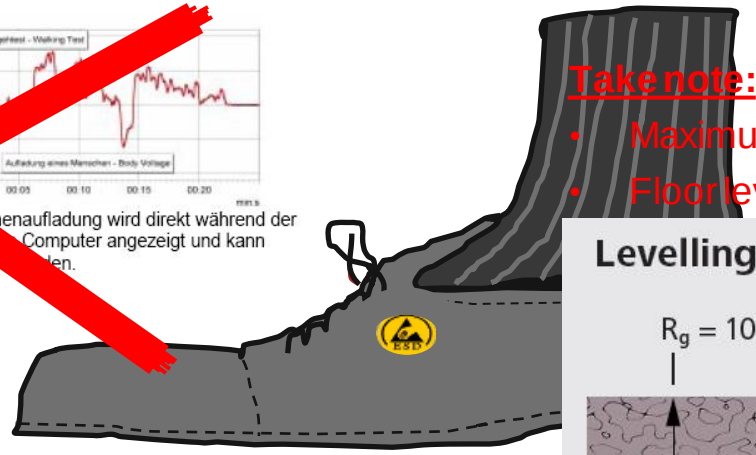


## Volume conductive fillers loaded coating

# Conventional fibers loaded ESD floor

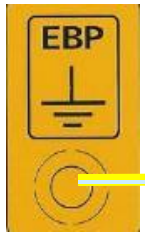


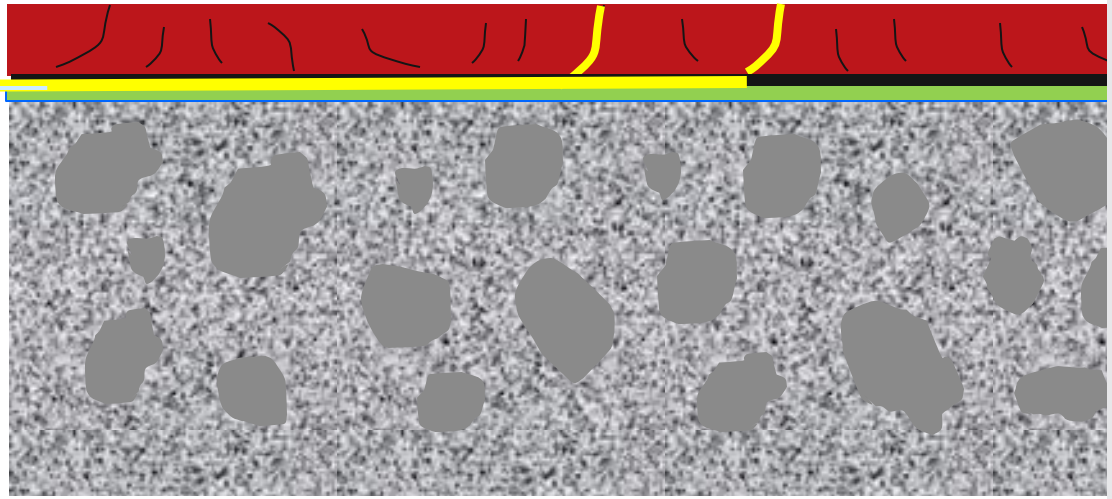



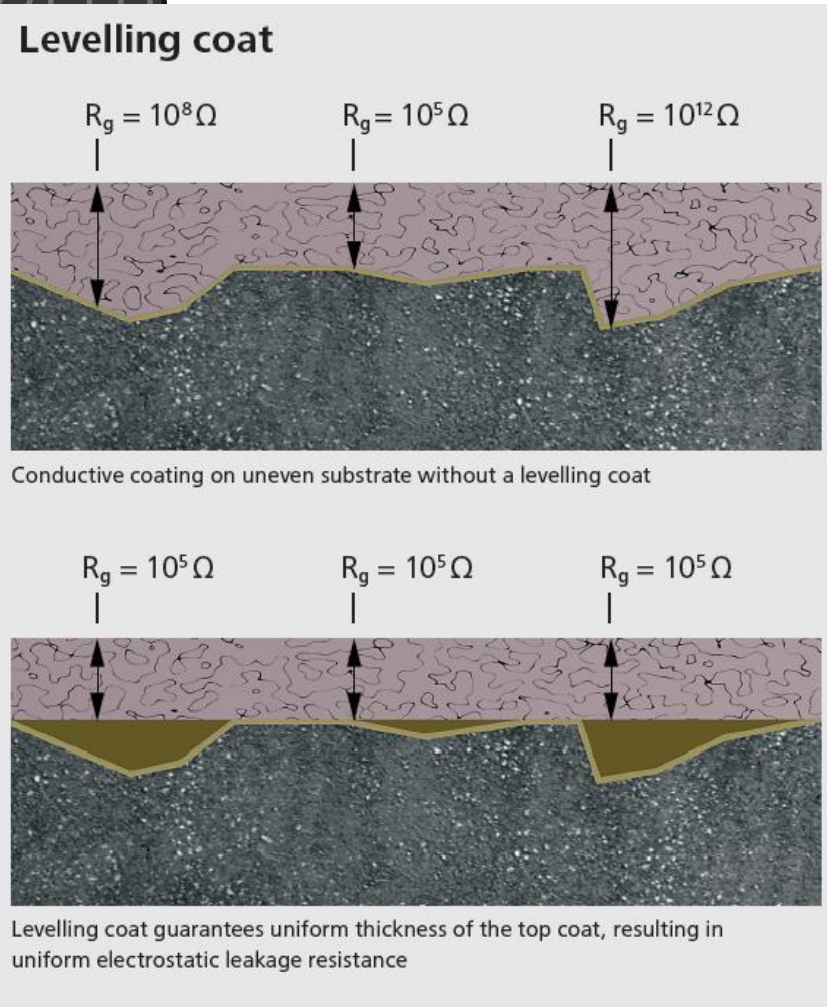



**Take note:**

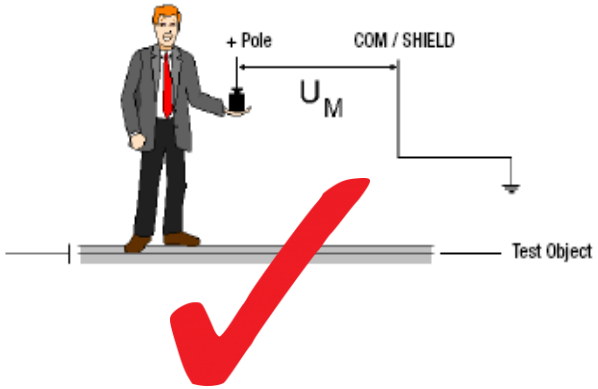
- Maximum coating thickness
- Floor levelness





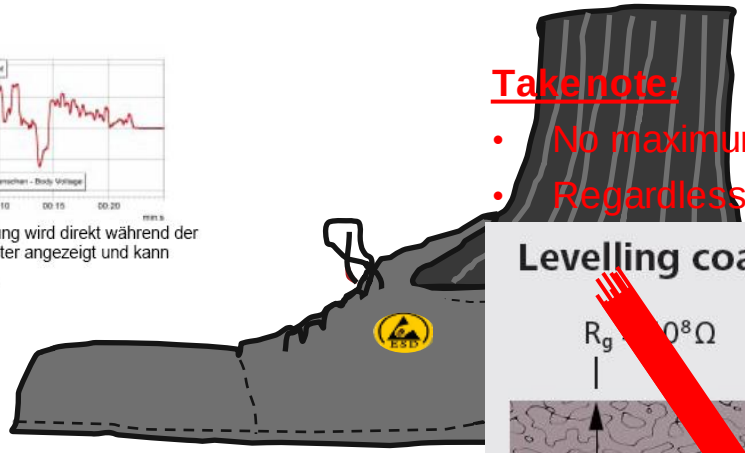
# Volume conductive ESD floor

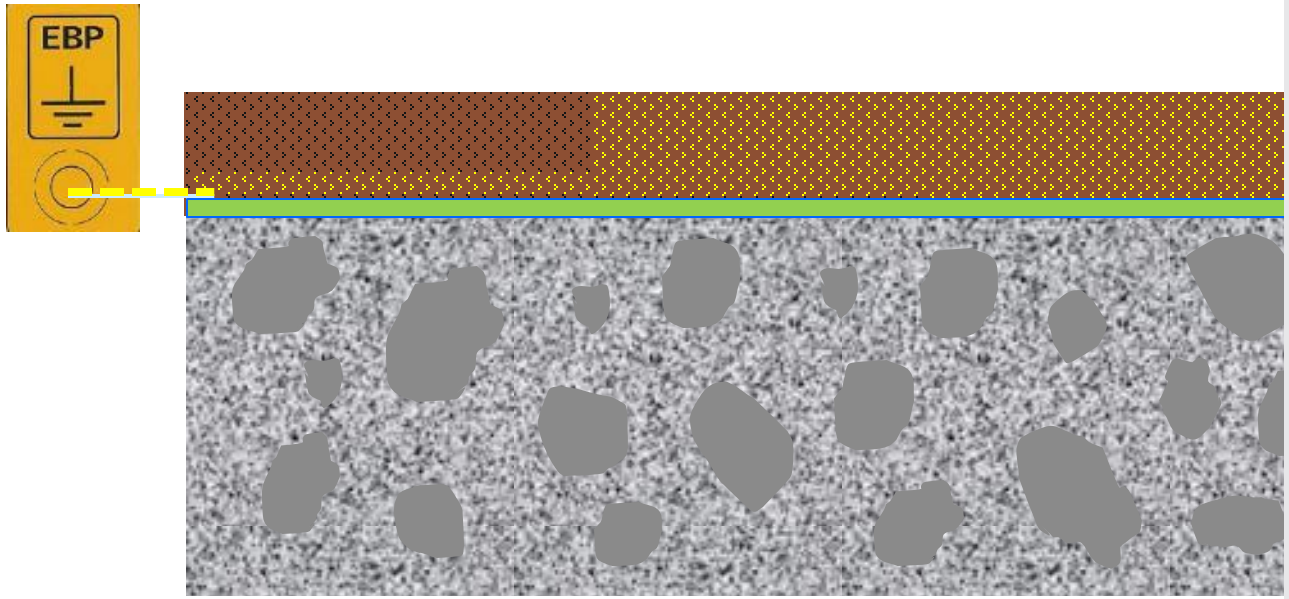


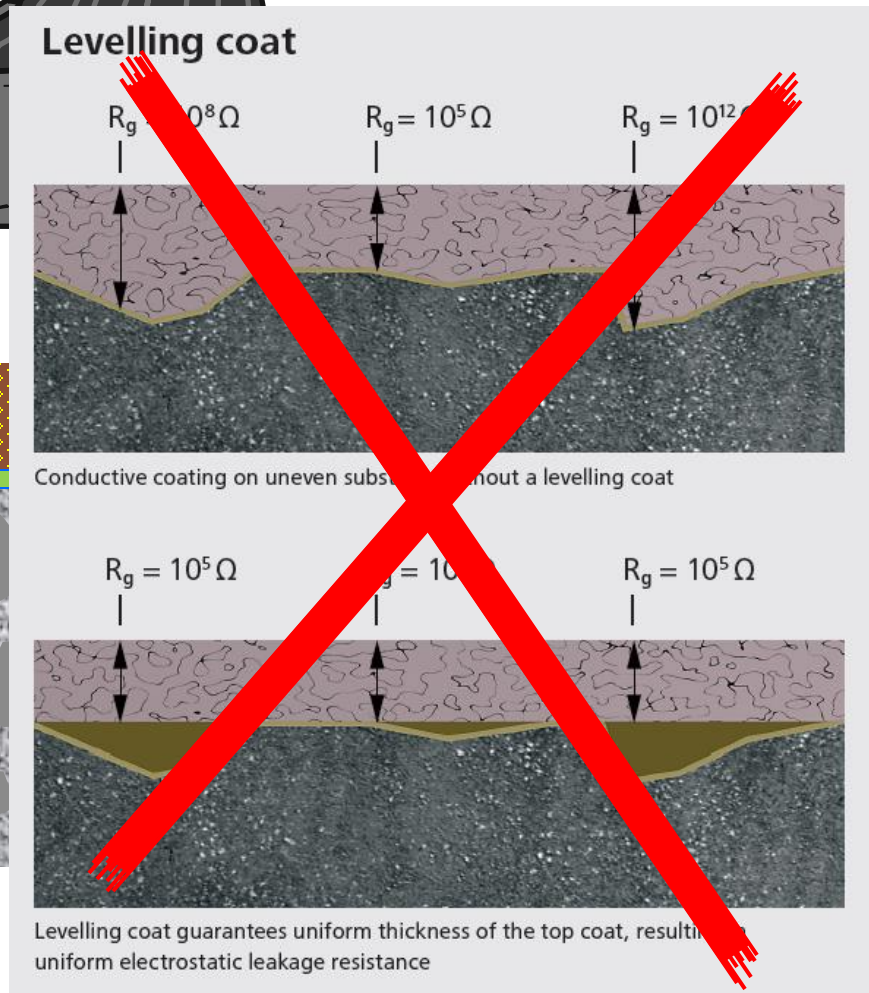


**Take note:**

- No maximum coating thickness
- Regardless of floor levelness





# “Volume conductive coating”

- Advantages
  - All current standards are met without extra sealing
  - Very long-lasting due to high layer thickness
  - ESD performance independent of layer thickness and humidity
  - Many colour shades available
  - Nice appearance of floor
  - Available as ECF (<$10^6$ Ω) and DIF floor ($10^6$ to $10^9$ Ω, human protection)

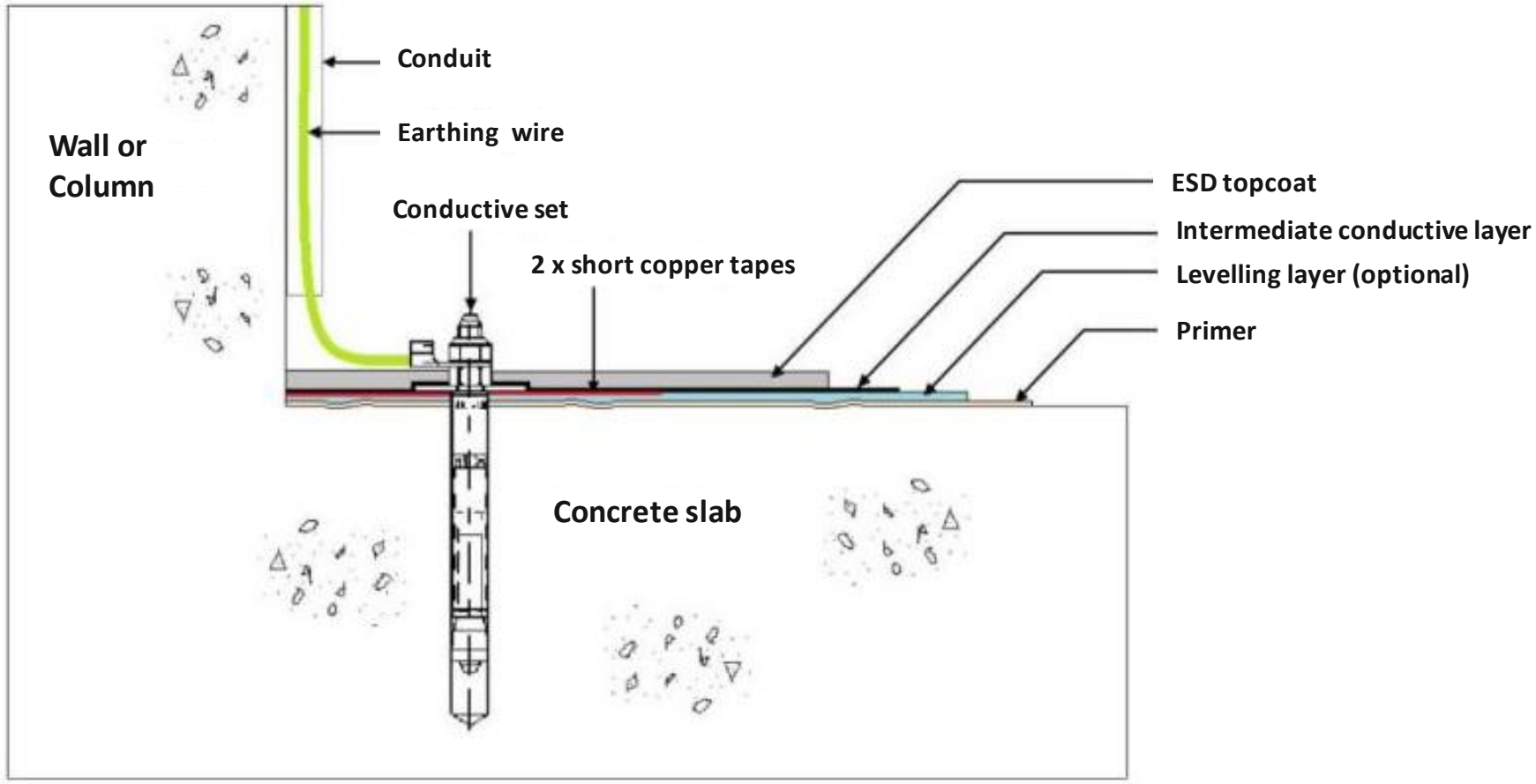
# Grounding – Earthing Point

Conventional grounding via
"Conductive copper tape"

Innovative Grounding via
Conductor set

# Grounding – Earthing Point

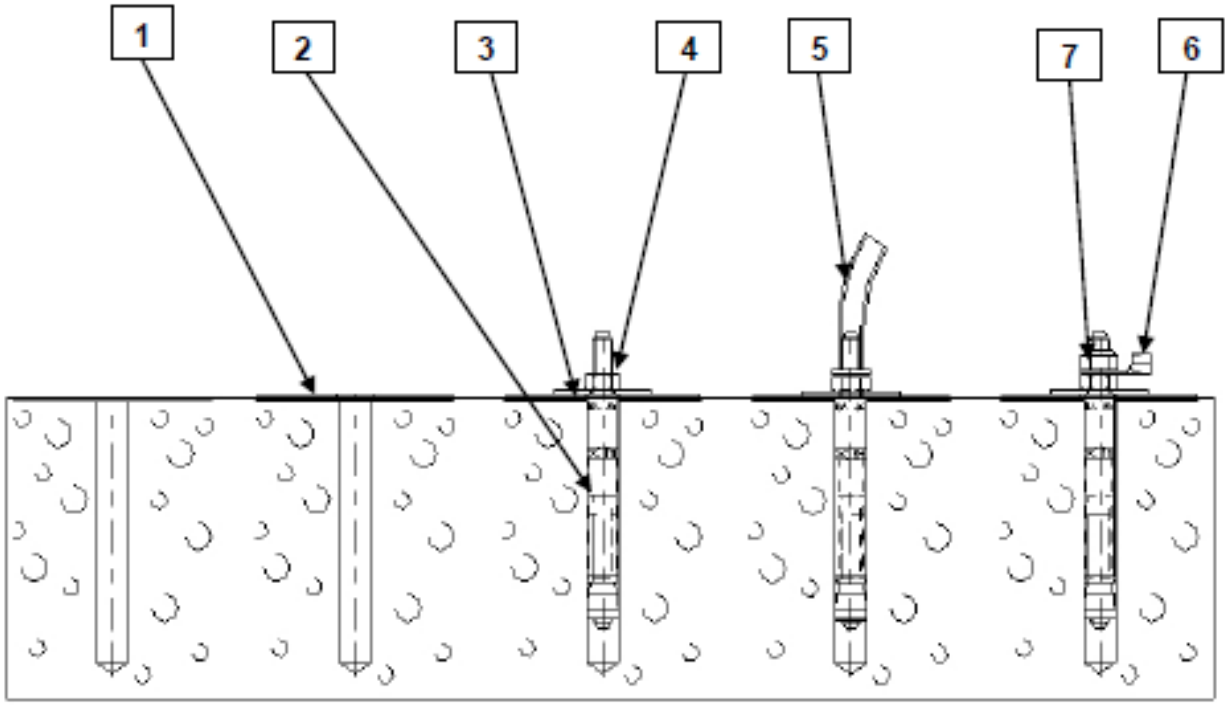
## Conductor set




TYPICAL DETAIL – EARTHING POINT

# Grounding – Earthing Point

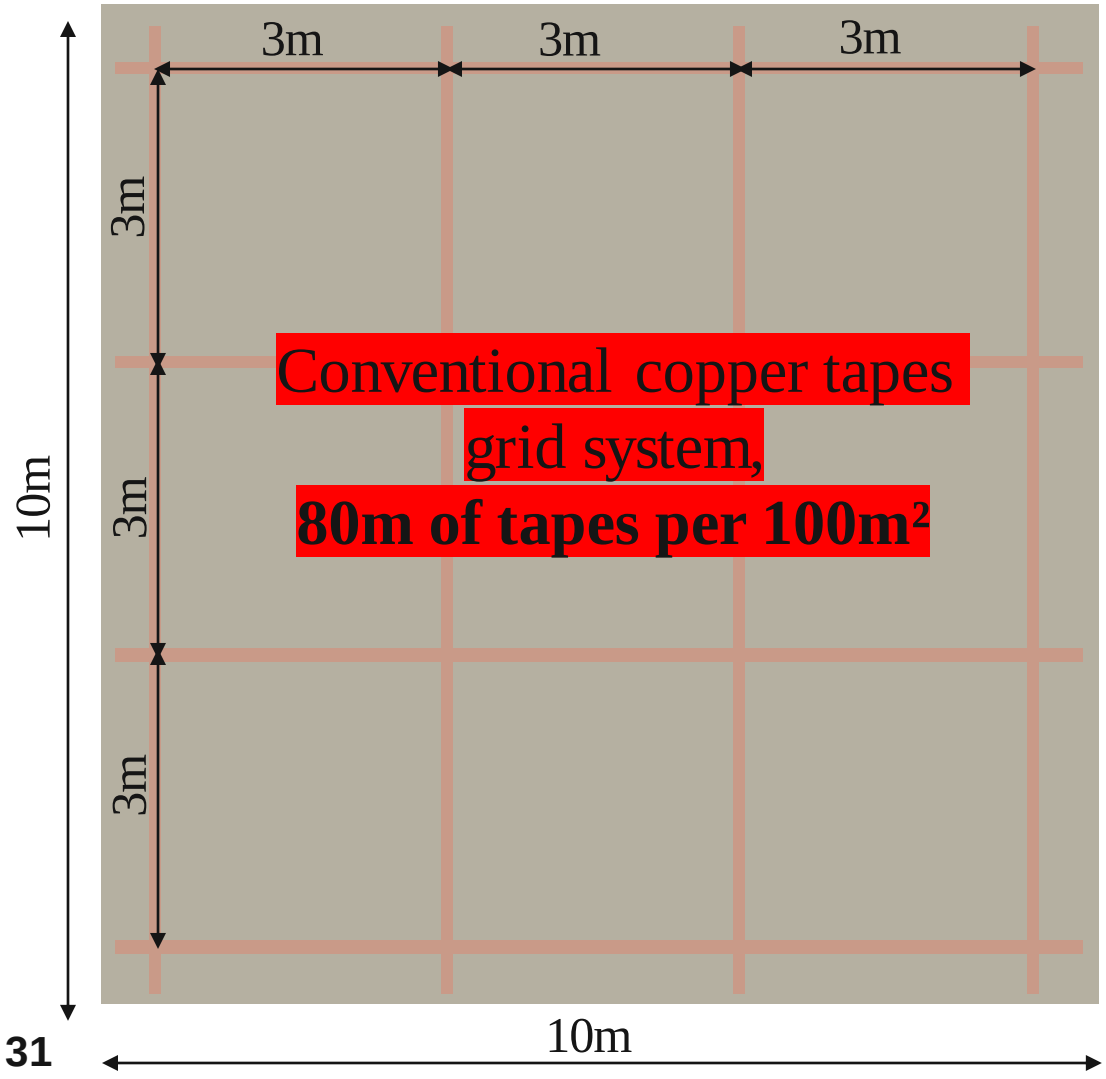
## Conductor set

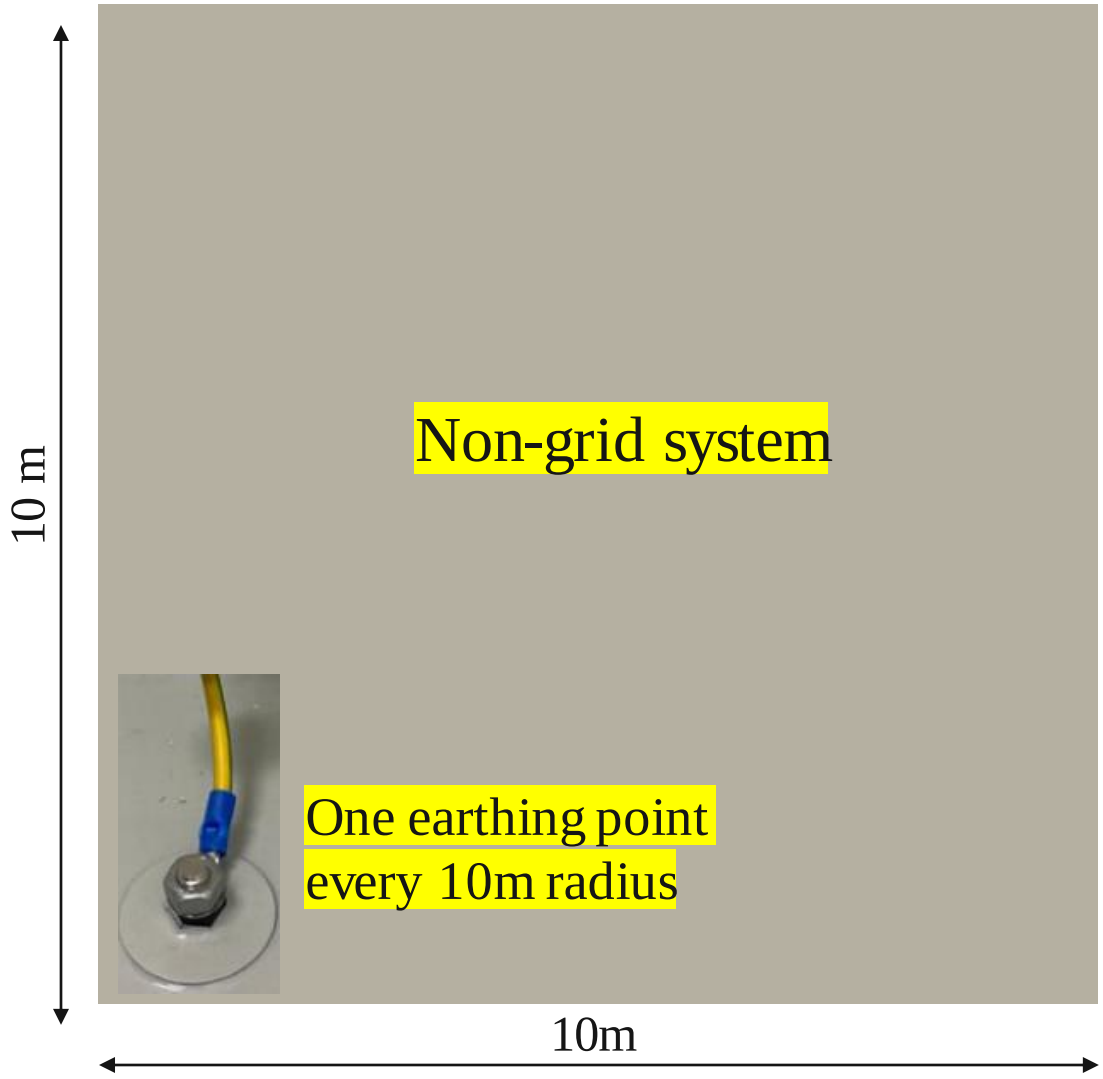



**Contents:**

| | |
|---|---|
| 10 pcs. | Pre-drilled board 50 x 50 x 0.8 mm (pos. 1) |
| 10 pcs. | High performance anchor (pos. 2) |
| 10 pcs. | Washer 6.4 x 30 x 1.5 mm (pos. 3) |
| 10 pcs. | 6kt. nut M 6 (pos. 4) |
| 10 pcs. | Plastic tube (pos. 5) |
| 10 pcs. | Cable foot for M 6 (pos. 6) |
| 10 pcs. | 6kt. nut with clip part (pos. 7) |
| 10 pcs. | Washer A 6.4 |
| 20 pcs. | Copper connector ribbon |

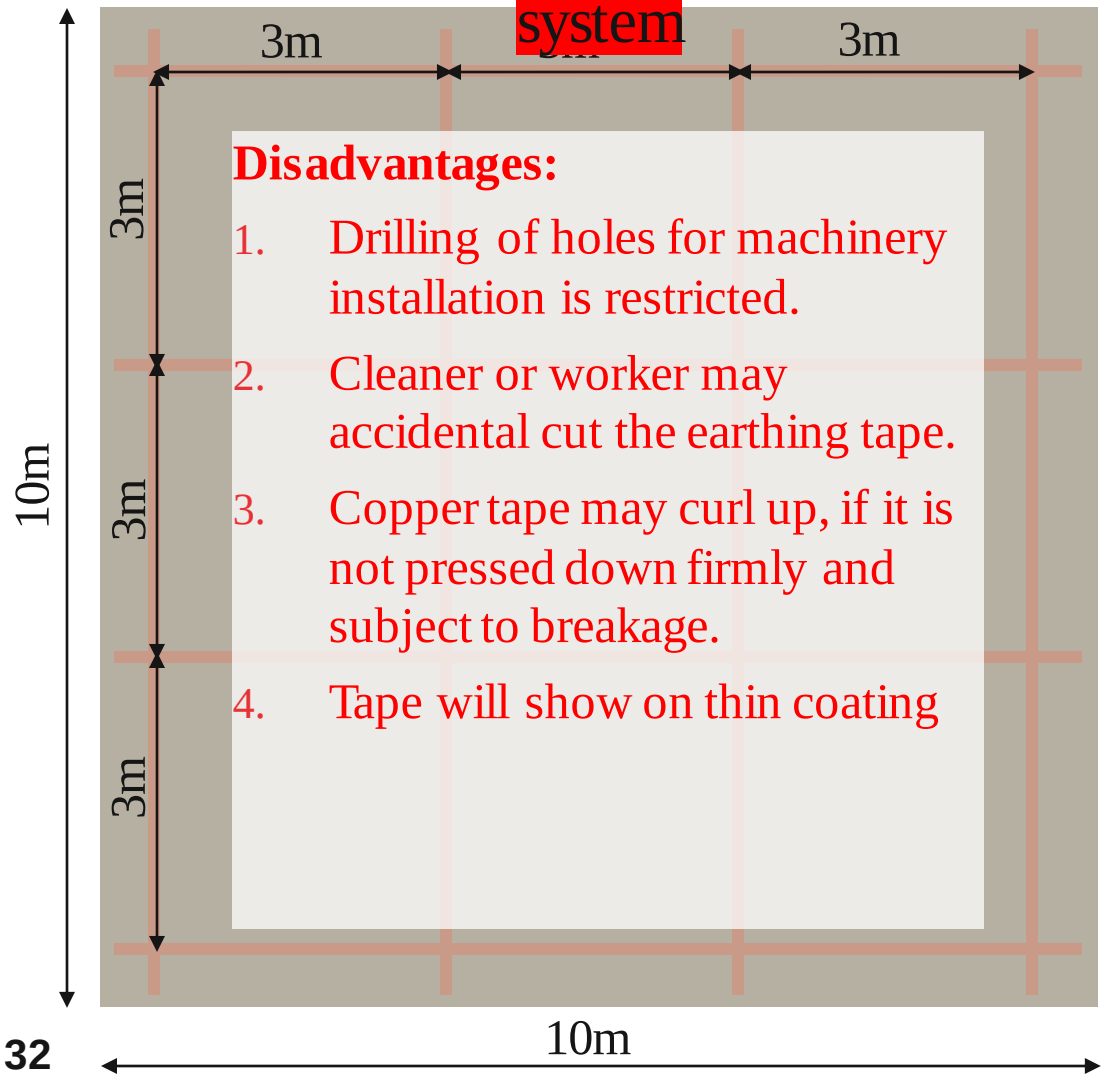
# Grounding – Copper tapes grid system vs non-grid system



# Grounding – Copper tapes grid system vs non-grid system

## Conventional copper tapes grid system

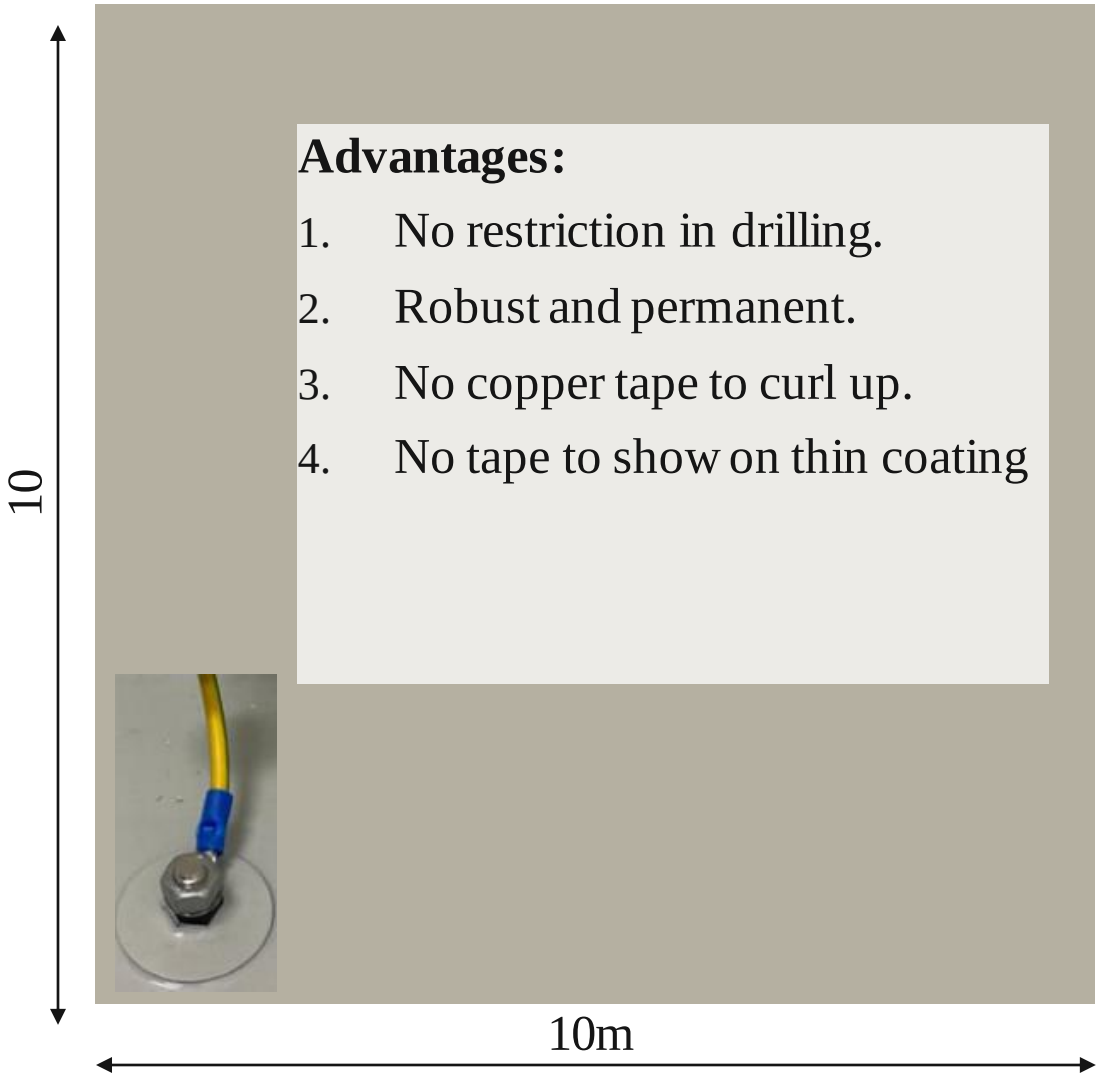



**Disadvantages:**

1. Drilling of holes for machinery installation is restricted.
2. Cleaner or worker may accidental cut the earthing tape.
3. Copper tape may curl up, if it is not pressed down firmly and subject to breakage.
4. Tape will show on thin coating

vs

## Non-grid system




**Advantages:**

1. No restriction in drilling.
2. Robust and permanent.
3. No copper tape to curl up.
4. No tape to show on thin coating

**Conductive floor, < $10^6$ Ω**

**vs**

**Dissipative floor, $10^6$ to $10^9$ Ω**

# ESD-standards

## ECF and DIF

The predecessor standard of EN 61340-4-1 (2004), called IEC 1340-4-1 (1995) described two different kinds of floors:

- ECF floors (Electrically conductive floors)
- DIF floor (Dissipative floors)

ECF floors are characterised by a resistance to ground, which is less than $10^6\ \Omega$.

DIF floors are characterised by a resistance to ground from $10^6$ to $10^9\ \Omega$.

These terms are not described any more in the current standard but are still useful for the distinction of high and low conductive coatings.

**What is the purpose of having a dissipative (low conductive) floor?**

**- human protection against electric shocks.**

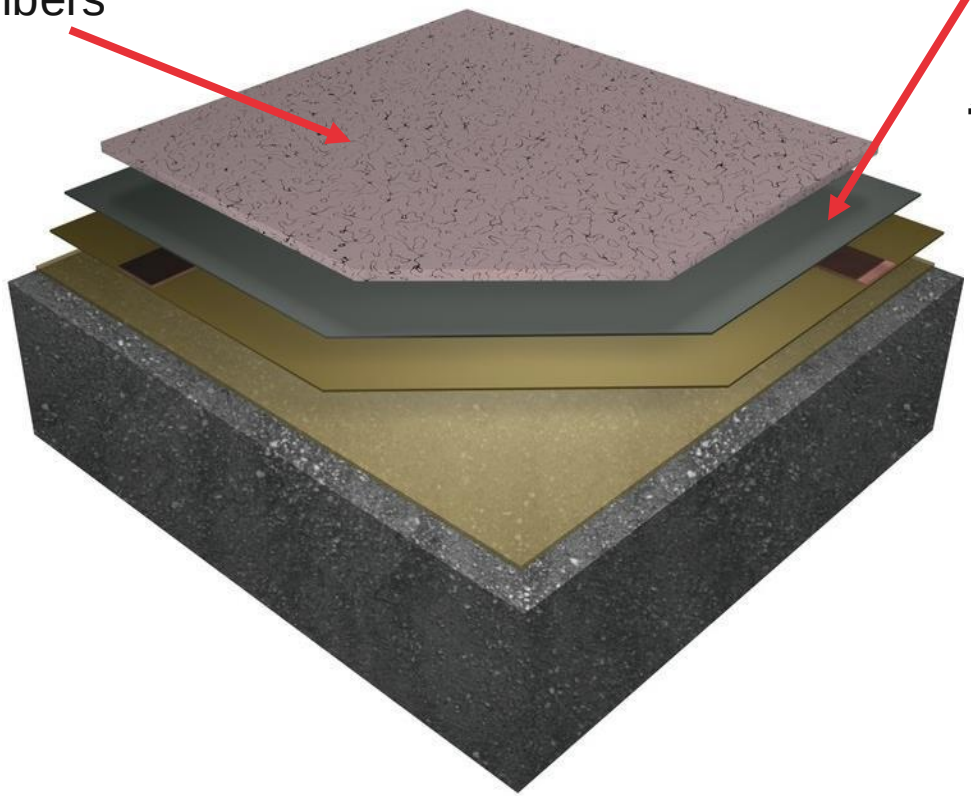
# How to make a dissipative floor?

**Conventional method**

- By reducing the conductivity of the topcoat usually with less carbon fibers

**Disadvantages**

- Conductivity is not consistence
- Limited choices



**Innovative method**

- By using a special dissipative intermediate conductive layer

**Advantages**

- Conductivity is consistence
- Unlimited choices

# Human protection against electric shock

Relationship between voltages, current and resistance

**Ohm's Law**

$$I = \frac{V}{R}$$

Electric current = Voltage / Resistance

German physicist Georg Ohm

# Human protection against electric shock

Relationship between voltages, current and resistance

calculated example:

assume: R = 10 kΩ (lower than requirement)
V = 500 V

searched: electrical current in amperage

result: I = V/R
I = 500 V/ 10 kΩ
I = 50 mA

V = voltage in volts (V)
I = current in milliamps (mA)
R = resistance in kilohms (kΩ)

**DIN VDE 0100-410 (2007)**

Insulation resistance
**≥ 5 x $10^4$Ω or 50kΩ**
(Installation voltage < 500V)

Insulation resistance
**≥ 10 x $10^4$Ω or 100kΩ**
(Installation voltage > 500V)

# Human protection against electric shock

Amperage

**Effects of electric current onto the human body :**

The crucial factors on the effect of electric current onto the human body are the amperage I and the residence time.

- 0.05 mA: prickle, noticeable with the tongue
- 1 mA: prickle, noticeable with the finger
- 1 - 15 mA: increasing prickle, finally starting muscle cramp
- 15 - 20 mA: unhanding barrier (hand can not be detached from embraced conductor )
- 50 mA: heart fibrillation, death within a few seconds possible; (fibrillation barrier)
- over 50 mA: heart fibrillation within (fractions of a) second(s) death
- over 3 A: strong flash burns

# Human protection against electric shock

Relationship between voltages, current and resistance

**DIN VDE 0100-410 (2007)**

Insulation resistance
**≥ 5 x $10^4$Ω or 50kΩ**
(Installation voltage < 500V)

Insulation resistance
**≥ 10 x $10^4$Ω or 100kΩ**
(Installation voltage > 500V)

calculated example:

assume: R = 10 kΩ (lower than requirement)
V = 500 V

searched: amperage

result:

I = V/R
I = 500 V/ 10 kΩ
I = 50 mA

I = V/R
I = 500 V / **50 kΩ**
I = 10 mA

V = voltage in volts (V)
I = current in milliamps (mA)
R = resistance in kilohms (kΩ)

# Human protection against electric shock

Amperage

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- over 3 A: strong flash burns

# Dissipative intermediate conductive layer

Combine with conductive floorings

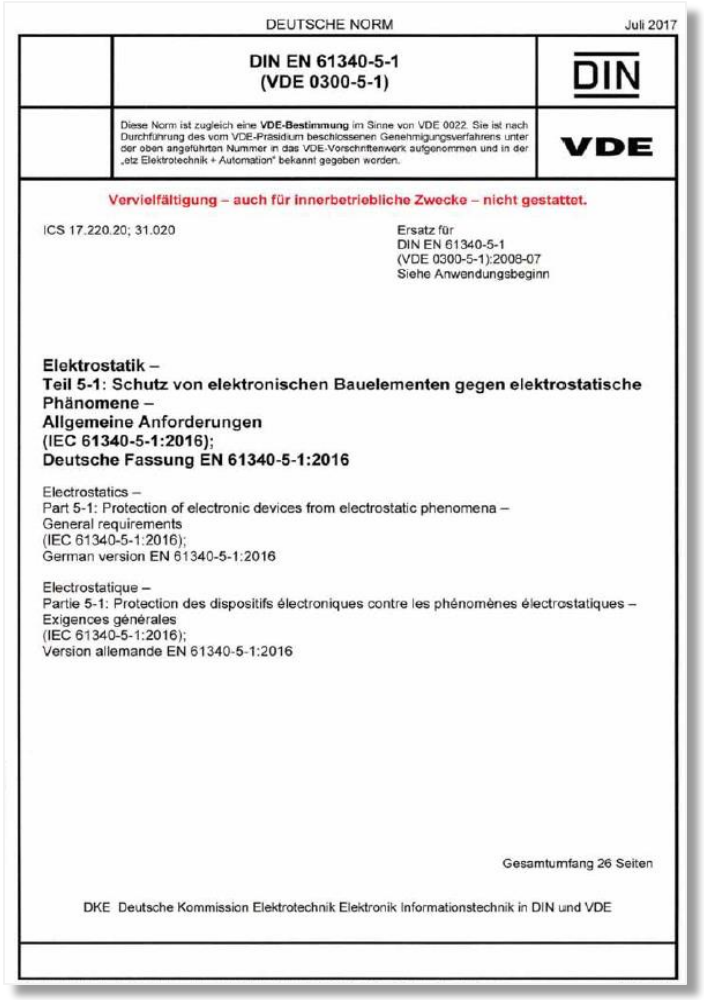
➔Resistance to ground acc. to EN 61340-4-1 in the **range of approx. 500kΩ – 100MΩ**

➔Resistance acc. to DIN VDE 0100-410 in the **range of approx. 100kΩ – 3MΩ**

# ESD Standards & Guidelines

# Standards and guidelines

## Requirements of the current standards



DEUTSCHE NORM Juli 2017

**DIN EN 61340-5-1**
**(VDE 0300-5-1)**

DIN

Diese Norm ist zugleich eine **VDE-Bestimmung** im Sinne von VDE 0022. Sie ist nach Durchführung des vom VDE-Präsidium beschlossenen Genehmigungsverfahrens unter der oben angeführten Nummer in das VDE-Vorschriftenwerk aufgenommen und in der „etz Elektrotechnik + Automation" bekannt gegeben worden.

VDE

Vervielfältigung – auch für innerbetriebliche Zwecke – nicht gestattet.

ICS 17.220.20; 31.020

Ersatz für
DIN EN 61340-5-1
(VDE 0300-5-1):2008-07
Siehe Anwendungsbeginn

**Elektrostatik –**
**Teil 5-1: Schutz von elektronischen Bauelementen gegen elektrostatische Phänomene –**
**Allgemeine Anforderungen**
**(IEC 61340-5-1:2016);**
**Deutsche Fassung EN 61340-5-1:2016**

Electrostatics –
Part 5-1: Protection of electronic devices from electrostatic phenomena –
General requirements
(IEC 61340-5-1:2016);
German version EN 61340-5-1:2016

Electrostatique –
Partie 5-1: Protection des dispositifs électroniques contre les phénomènes électrostatiques –
Exigences générales
(IEC 61340-5-1:2016);
Version allemande EN 61340-5-1:2016

Gesamtumfang 26 Seiten

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE

*EN 61340-5-1 (S 20.20)*

Protection of electronic sensitive devices

Product protection

*DIN VDE 0100-410*

Protection from electric shock

Human protection

*TRGS 727*

Avoidance of ignition danger

Explosion protection

*DIN EN IEC 62485-2*

Stationary batteries

Battery rooms

# EN 61340-5-1 (ANSI/ESD S20.20) „ESD-Main standard“

Protection of electronic devices from electrostatic phenomena - General requirements

*EN 61340-5-1*

„Product protection“

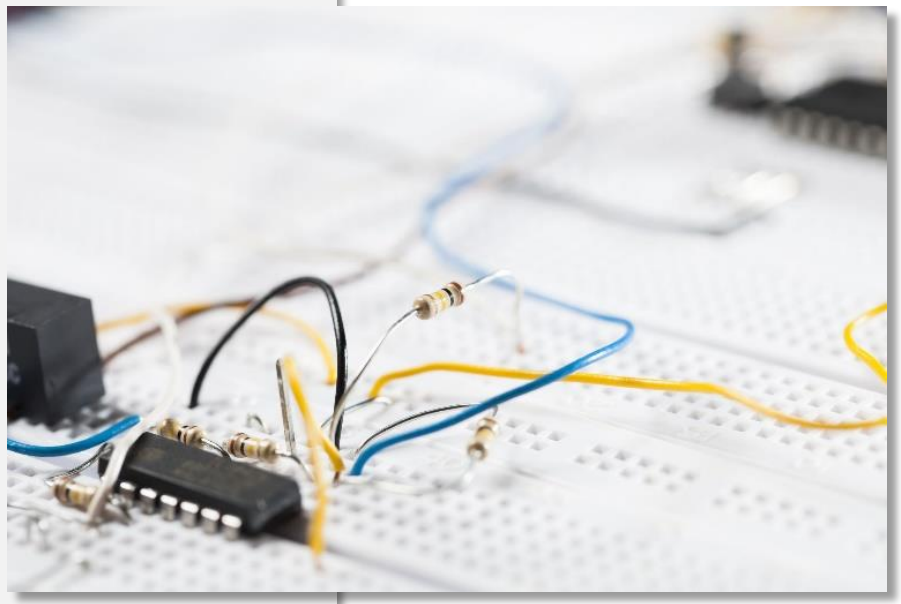
Protection of electronic devices

Current issue: 2017-07

Measurement standards: DIN EN 61340-4-1
DIN EN 61340-4-5

Requirements floor: Resistance (floor & system) $<10^9\ \Omega$

Body voltage <100V



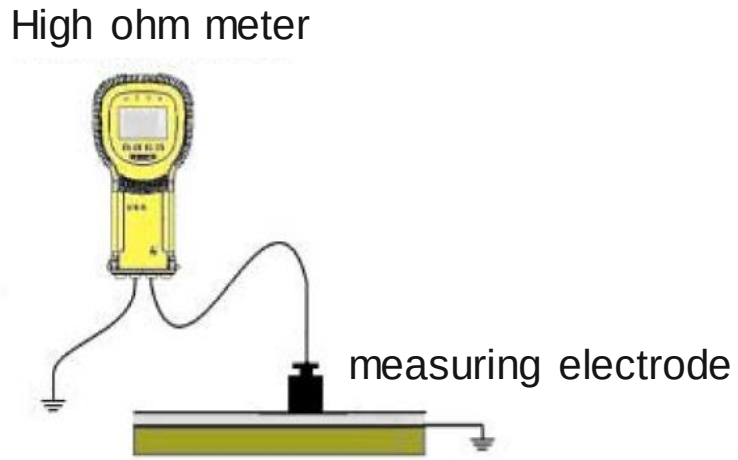
# EN 61340-4-1 (04.2016) / ANSI/ESD-S7.1-2013 (03.2013)

Electrical resistance of floor coverings and installed floors

This standard is first measurement standard for EN 61340-5-1

The standard describes the measurement of the floor only.

There are no threshold values defined in this standard.




source: Warmbier

Number of measurements

- one per 100 m²
- Minimum 6

# EN 61340-4-5 (04.2019) / ESD STM 97.1 - 2015 / 97.2 - 2016

Methods for characterising the electrostatic protection of  footwear and flooring in combination with a person

This is the second measurement standard for EN 61340-5-1 and ANSI/ESD S 20.20.

The standard doesn´t consider the floor as isolated unit, but as part of the system human body, shoes and floor.

Measuring units are:

- The resistance to ground in ohm [Ω] and
- The charge on a person in volt [V]

The threshold values are also defined in EN 61340-5-1 and ANSI/ESD S 20.20.

Number of measurements

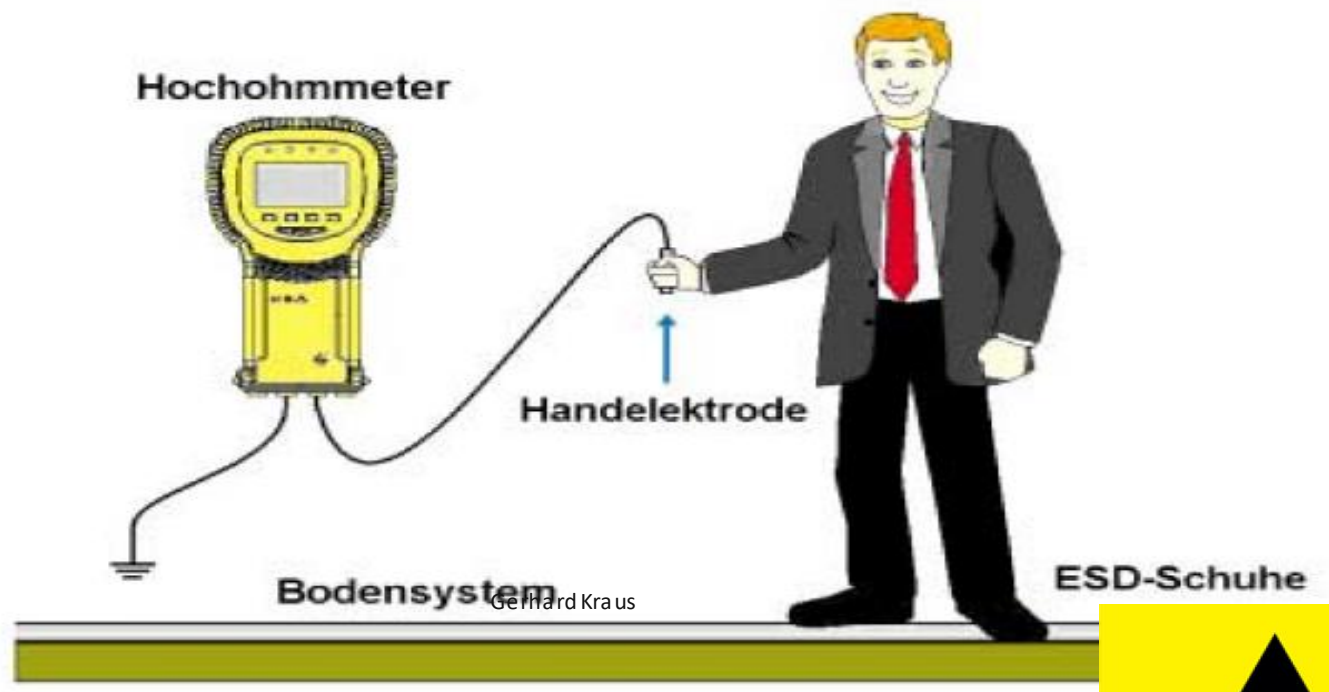
- Minimum 5
- 5 per 500 m²

# EN 61340-4-5 (04.2019) / ESD STM 97.1 - 2015

Methods for characterising the electrostatic protection of  footwear and flooring in combination with a person

System-test

Measurement of the combination resistance Human/Shoe/Floor



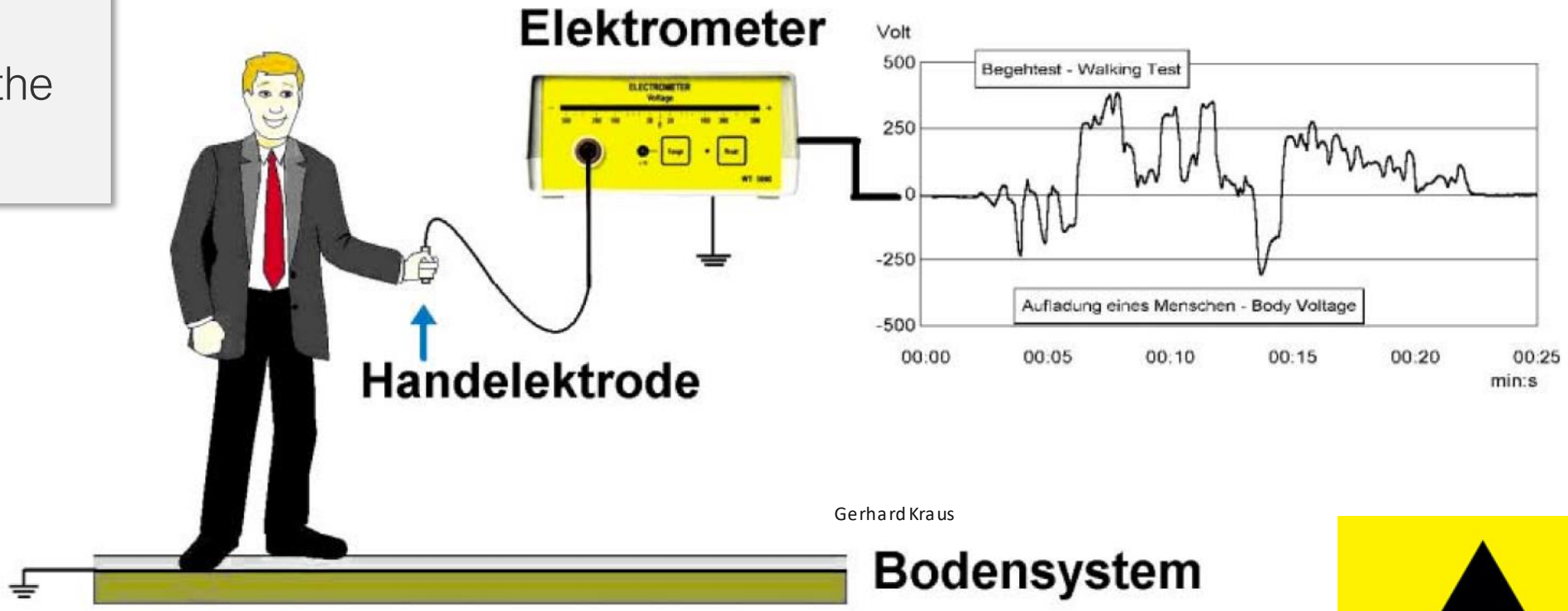

Quelle: Warmbier

# EN 61340-4-5 (04.2019) / ESD STM 97.2 - 2016

Methods for characterising the electrostatic protection of  footwear and flooring in combination with a person

Walking Test

Measurement of the body voltage




Quelle: Warmbier

# DIN VDE 0100-410

VDE: Association of Electrical Engineering - Electronics - Information Technology e.V.

*DIN VDE 0100-410* (Anhang C.1.4 / C.1.5 / C.1.6)
„Human protection“

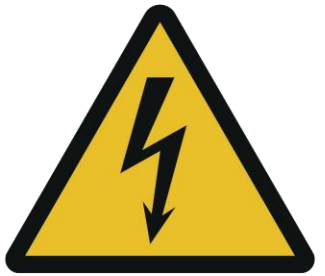
Protection against electric shock

Current issue: 2018-10

Measurement standard: DIN VDE 0100-600

Requirement floor: Resistance > 5 x $10^4$ Ω or 50 kΩ
Nominal voltage < 500 V

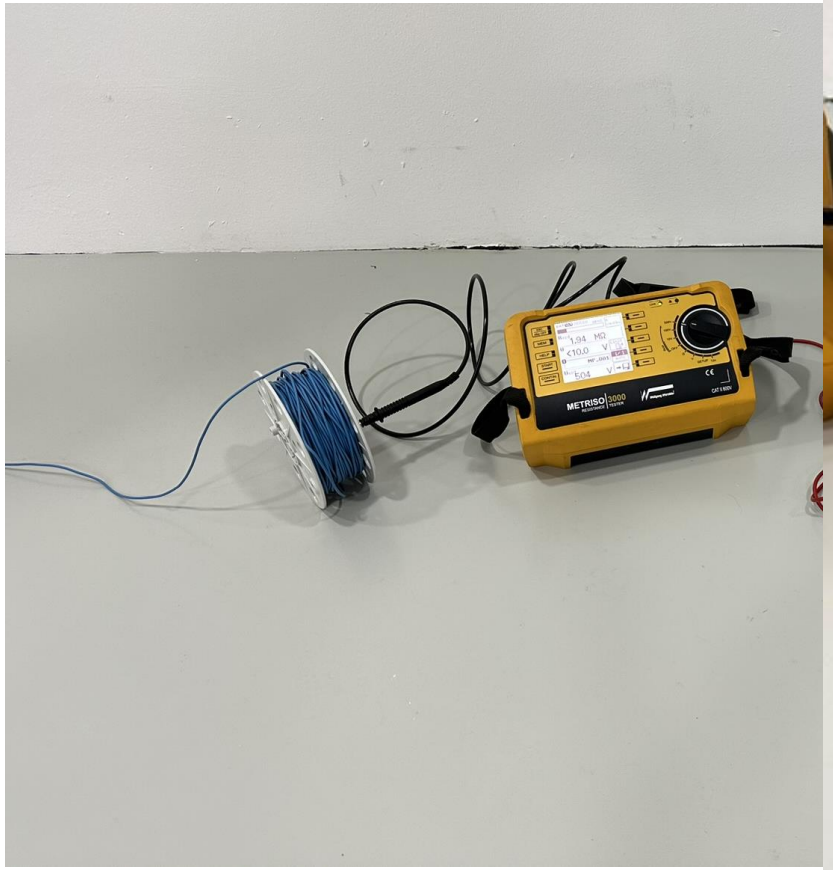
Resistance > $10^5$ Ω or 100 kΩ
Nominal voltage > 500 V

# DIN VDE 0100-410

VDE: Association of Electrical Engineering - Electronics - Information Technology e.V.

Test electrode 1:




# DIN VDE 0100-410

VDE: Association of Electrical Engineering - Electronics - Information Technology e.V.

Test electrode 2:

# TRGS 727

Technical rules for hazardous goods; avoidance of ignition danger caused by electrostatic charges

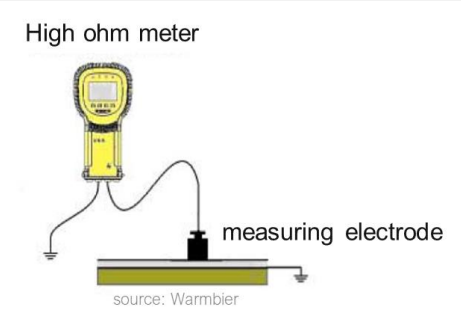
*TRGS 727*

„Explosion protection“

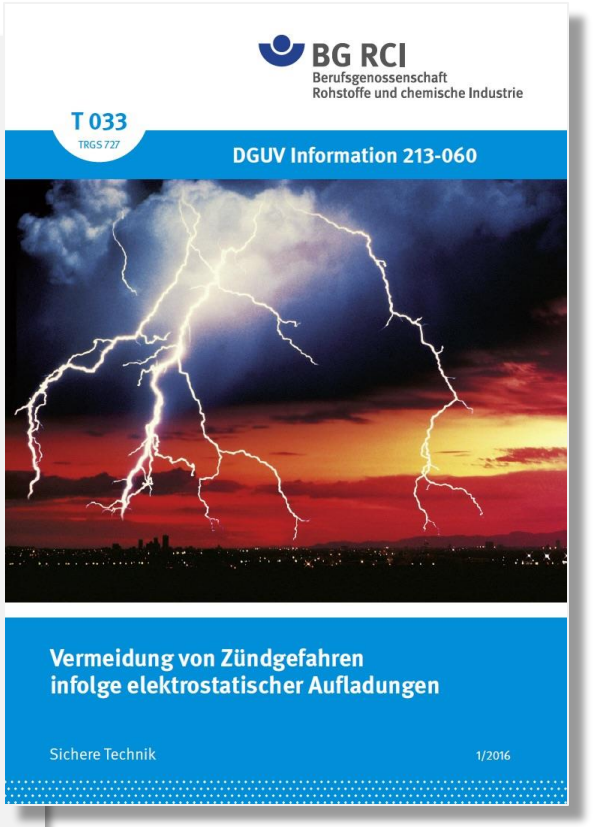
Avoidance of ignition danger caused by electrostatic charges

Current issue: 29.07.2016

Measurement standards: EN 1081 or
EN 61340-4-1




Requirements floor: Resistance to ground $<10^8\ \Omega$




# EN IEC 62485-2

Safety requirements for secondary batteries and battery installations

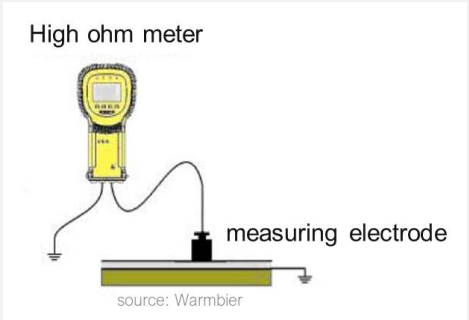
*DIN EN IEC 62485-2*

„Safety requirements for stationary batteries“

Prevention of charges on persons by means of electrically conductive floor

Current issue: 2019-04

Measurement standard: EN 61340-4-1




Requirements floor: Resistance to ground $5x10^4$ - $10^7$ Ω

Nominal voltage ≤ 500 V

Resistance to ground $10^5$ - $10^7$ Ω

Nominal voltage > 500 V

# Summary of Standards and guidelines

## Testing requirements of the current standards

**Requirement:**
EN 61340-5-1 (S 20.20)
*Protection of Electronic sensitive devices*

**Product Protection**

**Method:**
EN 61340-4-1 [5 lbs Probe @ 100V or 10V)
- Rtg < $10^9$ Ω

EN 61340-4-5
*Human/Shoe/Floor & Walking Test*
- Rtg < $10^9$ Ω Or Rtg < 3.5 x $10^7$ Ω (Old requirement)
- Body Voltage < 100V

**Requirement:**
DIN VDE 0100-410
*Protection from electric shock*

**Human Protection**

**Method:**
DIN VDE 0100-600 [5 lbs Probe @ 100V or 10V)
- Rtg > 5 x $10^4$ Ω (When nominal voltage is < 500V)
- Rtg > $10^5$ Ω(When nominal voltage is > 500V)

**Requirement:**
TRGS 727
*Avoidance of ignition danger*

**Explosion Protection**

**Method:**
EN 61340-4-1 [5 lbs Probe @ 100V or 10V)
- Rtg < $10^8$ Ω
- Rtg < $10^6$ Ω ( For Ordnance, Explosive, TNT, Gun Powder, Fireworks etc.)

**Requirement:**
DIN EN IEC 62485-2
*Stationary batteries*

**Battery rooms**

**Method:**
EN 61340-4-1 [5 lbs Probe @ 100V or 10V)
- Rtg: 5 x $10^4$ – $10^7$ Ω (When nominal voltage is ≤ 500V)
- Rtg: $10^5$ - $10^7$ Ω (When nominal voltage is > 500V)

# Example Projects using volume conductive system

**Requirement:**
EN 61340-5-1 (S 20.20)
*Protection of Electronic sensitive devices*

**Product Protection**

**Method:**
EN 61340-4-1 [5 lbs Probe @ 100V or 10V)

- Rtg < $10^9$ Ω

EN 61340-4-5
*Human/Shoe/Floor & Walking Test*

- Rtg < $10^9$ Ω Or Rtg < 3.5 x $10^7$ Ω (Old requirement)
- Body Voltage < 100V

# Electronic Industry – Hard Drives Production Plant

## ESD Water-Based Epoxy System

**System : Volume conductive system**

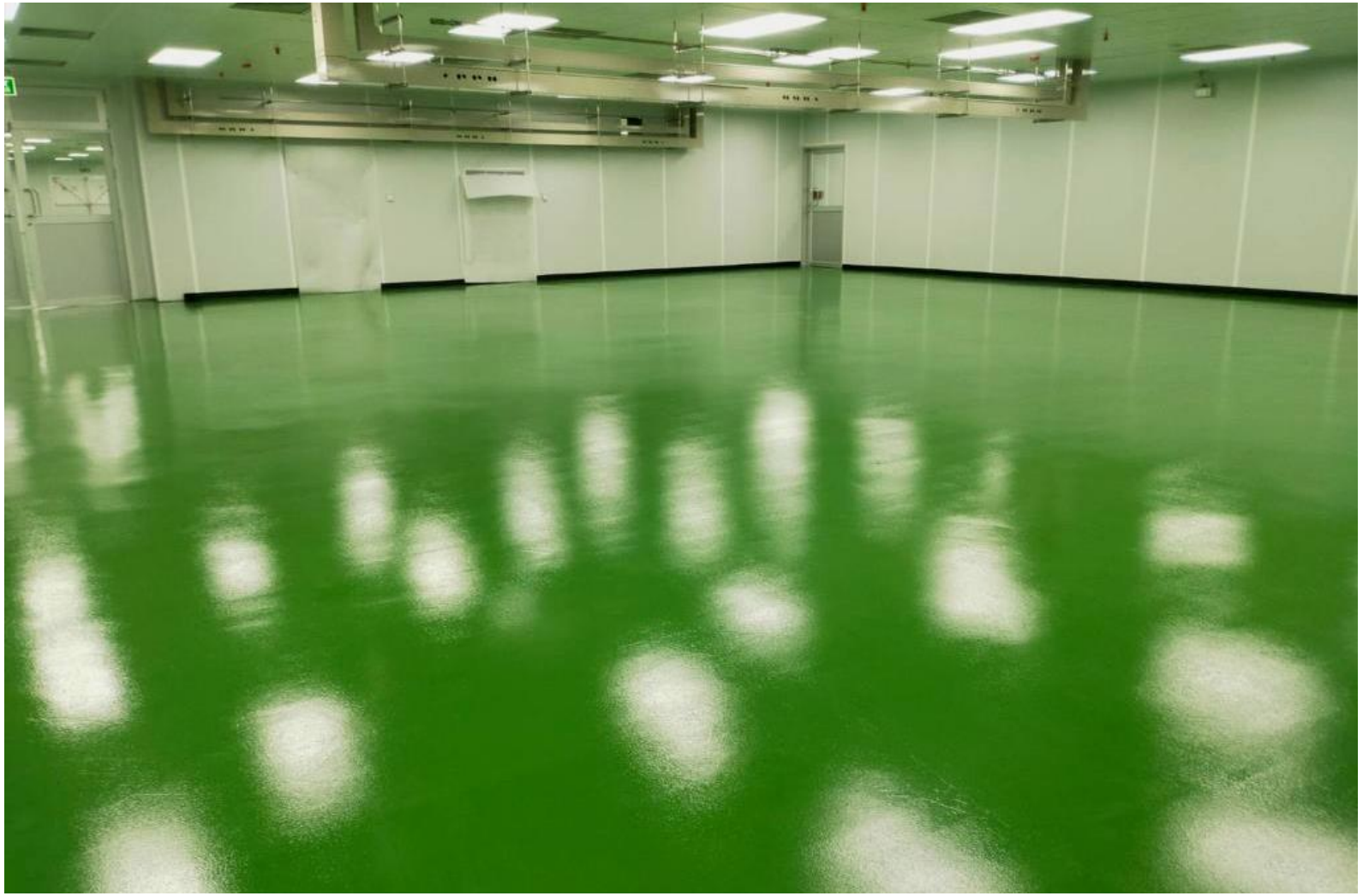
**Location : Ayutthaya, Thailand**

**Requirement: Rtg $10^4$ – $10^6$ Ω**

*EN 61340-5-1 (S 20.20)*

Protection of electronic sensitive devices

Product protection



# Electronic Industry - Color Inkjet Printer Plant

## ESD Water-Based Epoxy System

**System : Volume conductive system**

**Location : Samutsakorn, Thailand**

**Requirement: Rtg $10^4$ – $10^6$ Ω**

*EN 61340-5-1 (S 20.20)*

Protection of electronic sensitive devices

Product protection

# Automotive Industry - EV Battery Plant

## ESD Water-Based Epoxy System

**System : Volume conductive system**

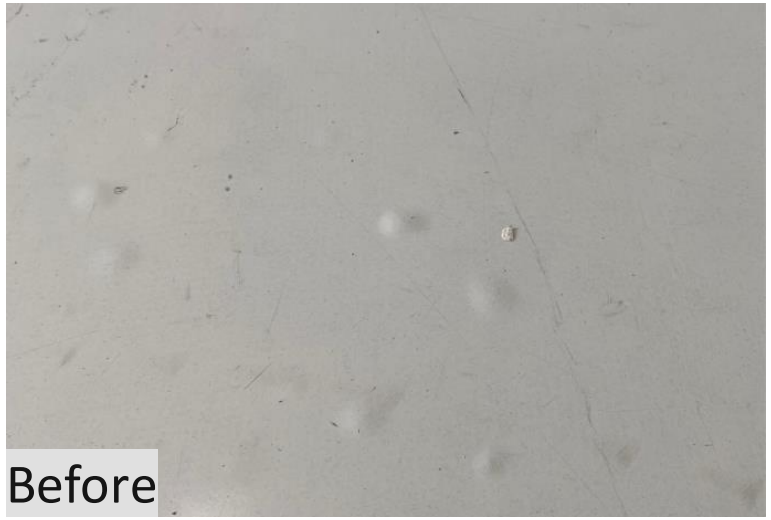
**Location : Samutprakarn, Thailand**

**Requirement: Rtg $10^4$ – $10^6$ Ω**

*EN 61340-5-1 (S 20.20)*

Protection of electronic sensitive devices

Product protection



Before

# Precision Engineering – Electronic Sensors Production Plant

## ESD Epoxy Self-Levelling System

**System : Volume conductive system**

**Location : Johor, Malaysia**

**Requirement: Human/shoe/floor < $10^9$ Ω**

**Walking test < 100 V**

*EN 61340-5-1 (S 20.20)*

Protection of electronic sensitive devices

Product protection

# Electronic Industry – Electro-mechanical Assemblies

## ESD Epoxy Self-Levelling System

**System : Volume conductive system**
**Location : Singapore**
**Requirement: Human/shoe/floor < $10^9$ Ω**
**Walking test < 100 V**
**Human protection > 50 kΩ**

| *EN 61340-5-1 (S 20.20)* | *DIN VDE 0100-410* |
|---|---|
| Protection of electronic sensitive devices | Protection from electric shock |
| Product protection | Human protection |

# Electronic Industry - Bosch GmbH EVI Audio

## ESD Self-Levelling Coating

**Build-Up** : **Volume conductive system**

**Area of Use** : **Production Area**

**Location** : **Germany**

*EN 61340-5-1 (S 20.20)*

Protection of electronic sensitive devices

Product protection

STRICTLY INTERNAL USE ONLY

# Electronic Industry - Systronik GmbH

## ESD Epoxy Self-levelling System

**Build-Up** : **Volume conductive system**

**Location** : **Germany**

*EN 61340-5-1 (S 20.20)*

Protection of electronic sensitive devices

Product protection

# Example Projects using fibers loaded system

**Requirement:**
TRGS 727
*Avoidance of ignition danger*

**Explosion Protection**

**Method:**
EN 61340-4-1 [5 lbs Probe @ 100V or 10V)

- Rtg < $10^8$ Ω
- Rtg < $10^6$ Ω ( For Ordnance, Explosive, TNT, Gun Powder, Fireworks etc.)

# Pharmaceutical Industry - Warehouse

## ESD Epoxy Self-Levelling Coating

**System : Fibers loaded system**

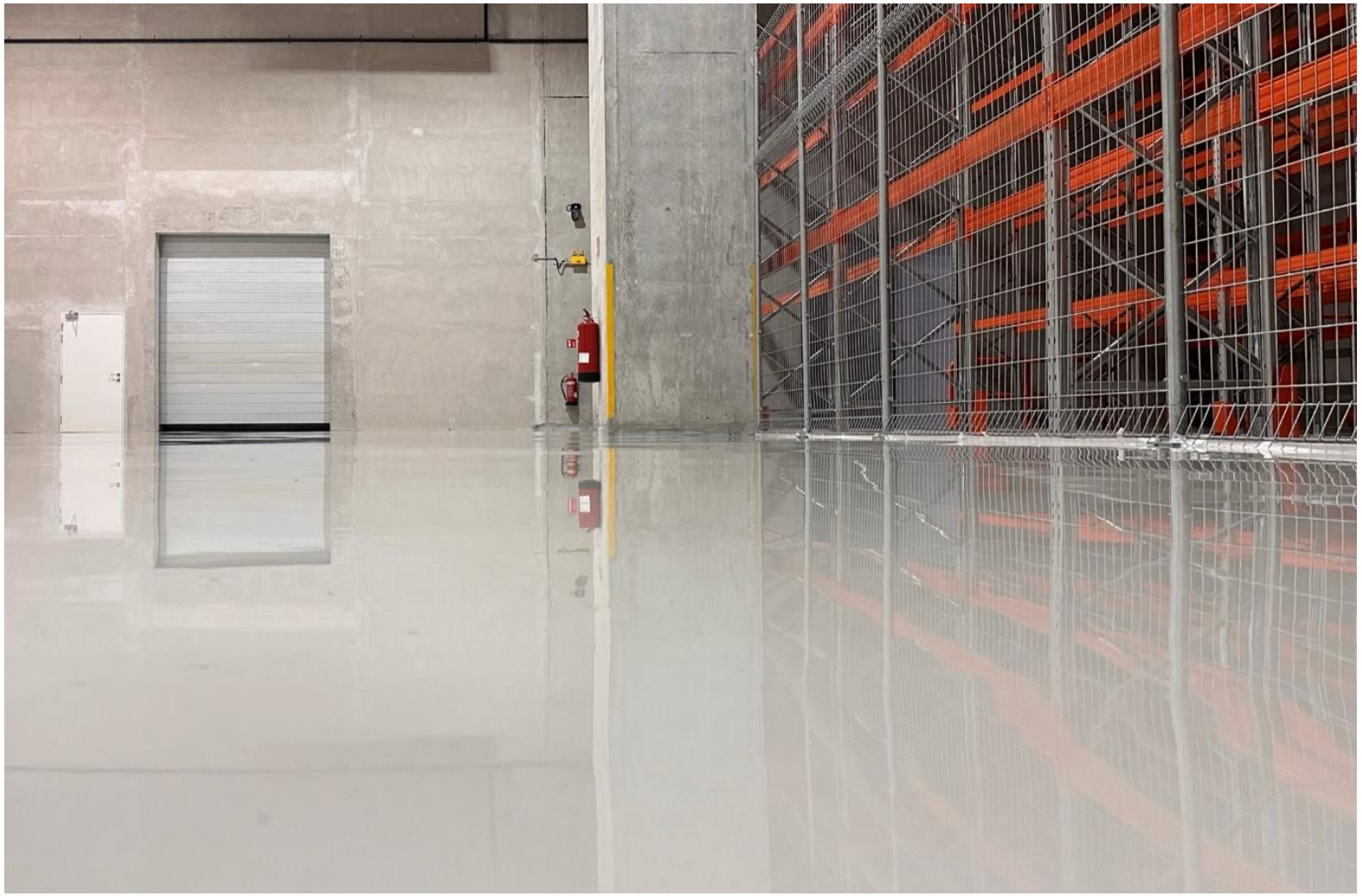
**Location : Singapore**

**Requirement: Rtg < $10^8$ Ω**

*TRGS 727*

Avoidance of
ignition danger

Explosion protection



# Food industry - Flavours and Fragrances Production Plant

## ESD Epoxy Self-Levelling Coating

**System** : **Fibers loaded system**

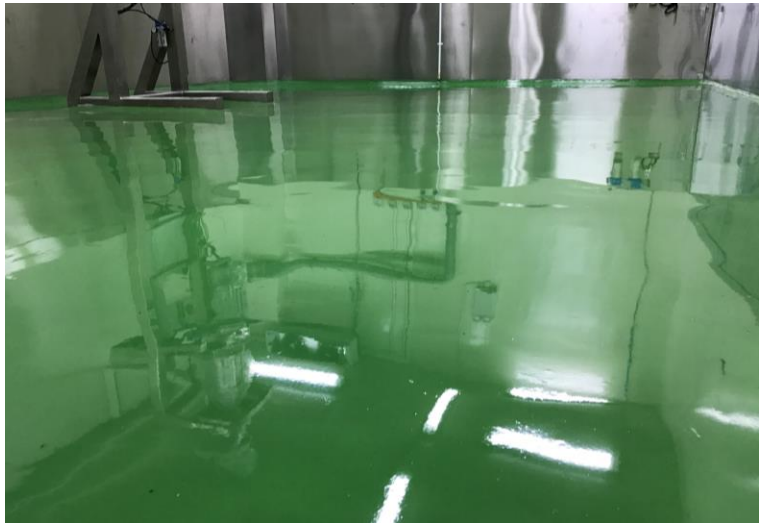
**Location** : **Singapore**

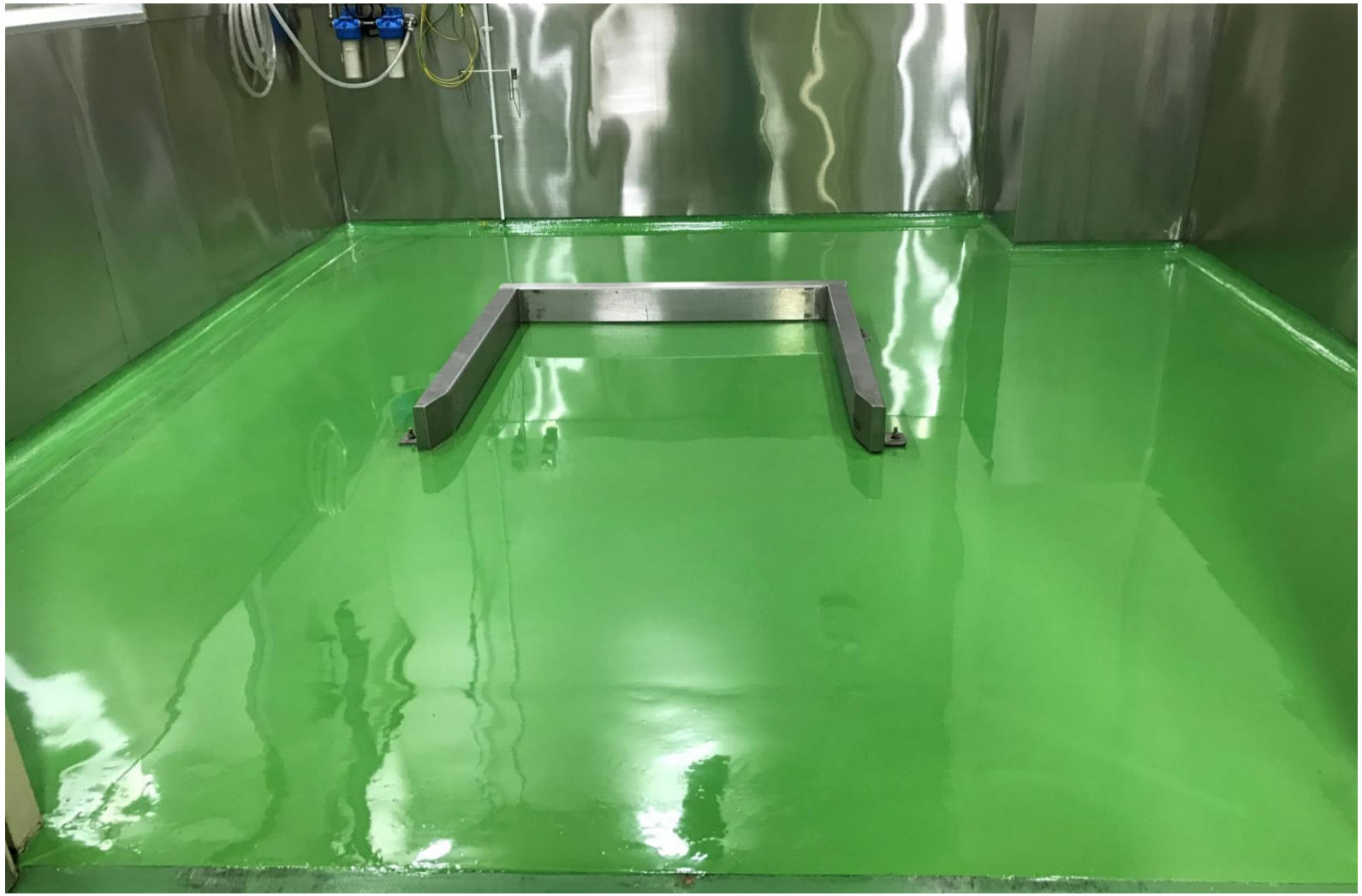
**Requirement: Rtg < $10^8$ Ω**

*TRGS 727*

Avoidance of
ignition danger

Explosion protection





# Pharmaceutical Industry - Sanacorp Pharmahandel GmbH

## ESD Water-Based Epoxy Self-levelling Coating

**Build-Up** : Fibers loaded system

**Area of Use** : Production Area

**Location** : Germany

*TRGS 727*

Avoidance of
ignition danger

Explosion protection

# Conclusion

1. When working on project with ESD floor, the first thing you should do, is to identify the type of protections:
   1. Product protection
   2. Explosion protection

   Additionally required

   1.1. Human protection

   2.1. Battery room protection

2. Thereafter, select a suitable system that meets the type of protection.

3. Lastly, always work with expert that has high knowledge in the field of ESD.

ESD ASSOCIATION

ESD FORUM e.V.

# Demonstration

ESD FORUM e.V.

# THANK YOU!

# ขอบคุณ!