# ESD Measurements

Report - no: **08-575-2025**

**Company:** **FunderMax GmbH**
**Wr.Neudorf**
**Industriezentrum NÖ-Süd Straße 3 Objekt 1**
**2355 WIENER NEUDORF**

**Date of measurements:** 2025-08-12 to 2025-08-15

**Task:** **Qualification of material through ANSI/ESD STM4.1-2017, ANSI/ESD STM11.11 and IEC 61340-2-3**

The report contains: 18 pages

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## I. REALIZATION OF MEASUREMENTS

### Measurement parameters

- Surface resistance and resistance to groundable point according to ANSI/ESD STM 4.1-2017, ANSI/ESD STM11.11-2022 and IEC 61340-2-3

### Measurement devices

1. PRS 801 - resistance system for ESD requirements; Resistance to ground and System resistance:

Surface resistance and resistance to ground:

| | | | |
|---|---|---|---|
| Measurement range: | 100 V | | $0 - 10^{14}\ \Omega$ |
| Measurement voltage: | 10 V | below | $1 * 10^{6}\ \Omega$ |
| | 100 V | over | $1 * 10^{6}\ \Omega$ |

### Measurement electrodes

for the resistance to groundable point ($R_{GP}$):

- Cylindrical electrode according to ANSI/ESD STM 4.1, ANSI/ESD STM11.11-2022 and IEC 61340-2-3 with conductive rubber, weight: 2,27 kg

for the surface resistance ($R_{PP}$ and $R_S$):

- Ring electrode according to ANSI/ESD STM 4.1, ANSI/ESD STM11.11-2022 and IEC 61340-2-3 with conductive rubber
- Two cylindrical electrodes according to ANSI/ESD STM 4.1, ANSI/ESD STM11.11-2022 and IEC 61340-2-3 with conductive rubber, weight: 2,27 kg



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## II. Used Measurement Devices

| Measurement devices | S/N | Next calibration |
|---|---|---|
| PRS 801B | 10604 | 12.2025 |
| 2,27 kg electrode (DB) | 0920 16005 | - |
| 2,27 kg electrode (DB) | 0920 16004 | - |
| 2,27 kg electrode (grau) | 591055-1 | - |
| Ring electrode | 0914066 | - |
| Testo 435 + Sensor 0636 9735 | 01152929 + 20076796/512 | 04.2026 |

Tabelle 1: Verwendete Messgeräte und Elektroden



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## III. LIMITS AND DEFINITIONS

**Limits (basic values)**

1. Surface resistance and Resistance to groundable point in accordance to ANSI/ESD S20.20-2021 and IEC 61340-5-1:

| Material Property | Surface Resistance | Notes |
|---|---|---|
| Elektrostatisch leitfähig | < 1 x $10^4$ Ω. | |
| **electrostatic conductive** | | |
| | | |
| Elektrostatisch ableitfähig | ≥ 1 x $10^4$ Ω und < 1 x $10^{11}$ Ω | |
| **elektrostatic dissipative** | | |
| | | |
| Isolierend | ≥ 1 x $10^{11}$ Ω | |
| **insulative** | | |
| | | |
| Elektrostatisch abschirmend | 20 nJ bei einer HBM Entladung von 1 kV | not applicable |
| **electrostatic shielding** | | |
| | | |
| Feld abschirmend | < 1 x $10^3$ Ω | not applicable |
| **field shielding** | | |



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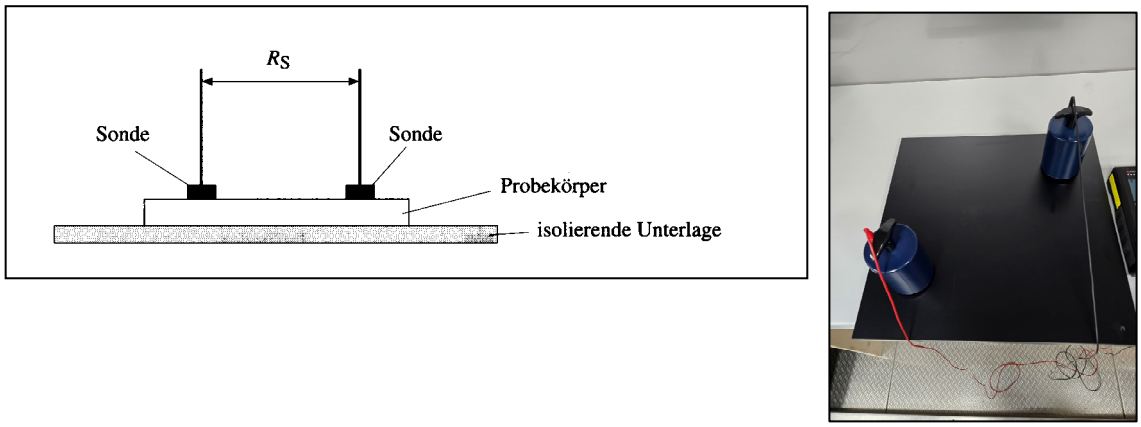
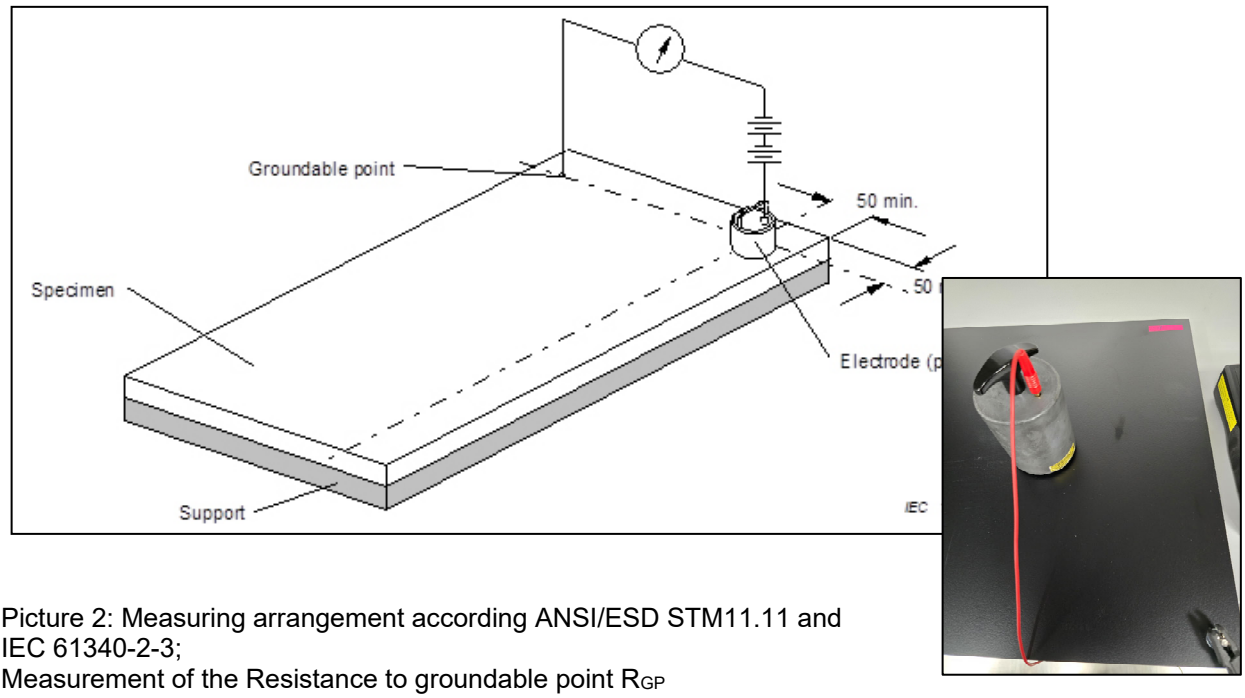
## IV. MESASUREMENT METHODS

### Measurement with different electrodes

The measurements were realized with a measurement voltage of 100 V and for the surface resistance $R_{PP}$ with two 2.27 kg electrodes as well as for the resistance against a groundable point $R_{GP}$ with one 2.27 kg electrode according to ANSI/ESD STM7.1/STM4.1, ANSI/ESD STM11.11 and IEC 61340-2-3 using conductive rubber. A concentric ring electrode according to ANSI/ESD STM11.11 and IEC 61340-2-3 was used for the surface $R_S$.




Picture 1: Measuring arrangement according ANSI/ESD STM11.11 and IEC 61340-2-3;
Measurement with two electrode $R_{PP}$




Picture 2: Measuring arrangement according ANSI/ESD STM11.11 and IEC 61340-2-3;
Measurement of the Resistance to groundable point $R_{GP}$



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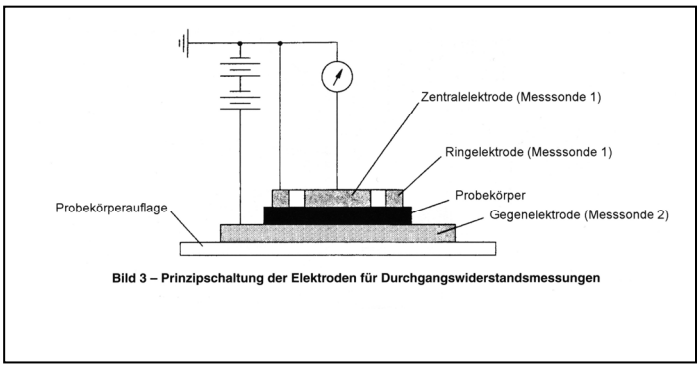
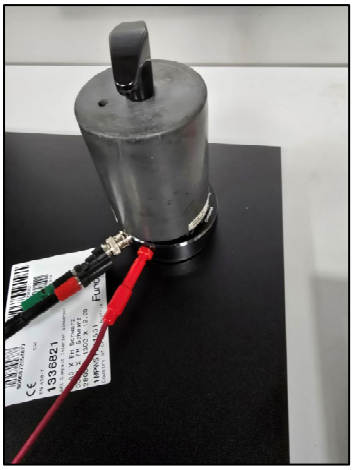



Bild 3 – Prinzipschaltung der Elektroden für Durchgangswiderstandsmessungen



Picture 3: Measuring arrangement according ANSI/ESD STM11.11 and IEC 61340-2-3; Measurement with a concentric ring electrode $R_S$

| | |
|---|---|
| $R_{PP}$ | Surface Resistance Point-to-Point |
| $R_S$ | Surface Resistance with a concentric ring electrode |
| $R_{GP}$ | Resistance to a groundable point |

## V. MATERIAL SAMPLES

| Material Samples | Structure | Dimensions oft he original plates |
|---|---|---|
| | | |
| **1351597**<br>Max (Compact) Resistance with F | | |
| 1MPY02064704 | 0085 X RE White | 3670 x 1630 x 25,0 |
| (7) + (8) | 0085 X RE White | |
| | | |
| **1732821**<br>MAX Compact Interior Plus Black | | |
| 1MPWS1816102 | 0085 X IP White | 2800 x 1300 x 19,0 |
| (11) + (12) | 0085 X IP White | |
| | | |
| **206182**<br>MAX Compact Interior Black Kernel | | |
| 1MPWS1815501 | 0085 X FH White | 2800 x 1300 x 19,0 |
| (9) x (10) | 0085 X FH White | |
| | | |
| **1336821**<br>MAX Compact Interior Black Kernel | | |
| 1MPWS1841501 | 0080 X FH Black | 2800 x 1300 x 19,0 |
| (1) + (2) | 0080 X FH Black | |
| | | |
| **1732823**<br>MAX Compact Interior Plus Black Kernel | | |
| 1MPWS184504 | 0080 X IP Black | 2800 x 1300 x 19,0 |
| (3) + (4) | 0080 X IP Black | |
| | | |
| **1351494**<br>Max (Compact) Resistance with F | | |
| 1MPY02071901 | 0082 X RE Deep Black | 3670 x 1630 x 25,0 |
| (5) + (6) | 0082 X RE Deep Black | |



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## VI. Measurement Results

All measurements were realized in a climate chamber at 12% humidity and 23°C. The samples were stored 48 hours before measurement.

| Sample | Surface Resistance Ω | | Resistance to groundable point Ω | Notes |
|---|---|---|---|---|
| | $R_{PP}$ | $R_S$ | $R_{GP}$ | |
| **Plate 1** | | | | |
| **1336821 Black** | | | | |
| Upper Side | 1,12 x $10^{10}$ | 1,70 x $10^{11}$ | 2,14 x $10^{10}$ | |
| | 1,08 x $10^{10}$ | 2,10 x $10^{11}$ | 2,51 x $10^{10}$ | |
| | 1,11 x $10^{10}$ | | 2,38 x $10^{10}$ | |
| | 1,13 x $10^{10}$ | | | |
| | | | | |
| Lower Side | 9,15 x $10^{9}$ | 2,43 x $10^{11}$ | 2,15 x $10^{10}$ | |
| | 9,02 x $10^{9}$ | 1,75 x $10^{11}$ | 2,45 x $10^{10}$ | |
| | 1,07 x $10^{10}$ | | 2,51 x $10^{10}$ | |
| | 8,89 x $10^{9}$ | | | |
| | | | | |
| **Plate 2** | | | | |
| **1336821 Black** | | | | |
| Upper Side | 8,80 x $10^{9}$ | 1,42 x $10^{11}$ | 4,00 x $10^{10}$ | |
| | 1,11 x $10^{10}$ | 2,01 x $10^{11}$ | 3,75 x $10^{10}$ | |
| | 1,16 x $10^{10}$ | | 4,10 x $10^{10}$ | |
| | 1,18 x $10^{10}$ | | | |
| | | | | |
| Lower Side | 1,05 x $10^{10}$ | 1,98 x $10^{11}$ | 3,26 x $10^{10}$ | |
| | 9,13 x $10^{9}$ | 2,02 x $10^{11}$ | 4,27 x $10^{10}$ | |
| | 9,26 x $10^{9}$ | | 4,29 x $10^{10}$ | |
| | 9,32 x $10^{9}$ | | | |



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| Sample | Surface Resistance Ω | | Resistance to groundable point Ω | Notes |
|---|---|---|---|---|
| | $R_{PP}$ | $R_S$ | $R_{GP}$ | |
| **Plate 3** | | | | |
| **1732823 Black** | | | | |
| Upper Side | 4,58 x $10^{11}$ | 1,13 x $10^{12}$ | 8,23 x $10^{11}$ | |
| | 5,04 x $10^{11}$ | 1,46 x $10^{12}$ | 7,98 x $10^{11}$ | |
| | 4,29 x $10^{11}$ | | 1,18 x $10^{12}$ | |
| | 3,68 x $10^{11}$ | | | |
| | | | | |
| Lower Side | 3,94 x $10^{11}$ | 1,48 x $10^{12}$ | 4,58 x $10^{11}$ | |
| | 6,55 x $10^{11}$ | 1,61 x $10^{12}$ | 6,36 x $10^{11}$ | |
| | 6,05 x $10^{11}$ | | 5,58 x $10^{11}$ | |
| | 6,29 x $10^{11}$ | | | |
| | | | | |
| **Plate 4** | | | | |
| **17328223 Black** | | | | |
| Upper Side | 4,77 x $10^{11}$ | 7,75 x $10^{11}$ | 5,92 x $10^{11}$ | |
| | 1,48 x $10^{12}$ | 1,56 x $10^{12}$ | 4,61 x $10^{11}$ | |
| | 4,63 x $10^{11}$ | | 4,69 x $10^{11}$ | |
| | 4,94 x $10^{11}$ | | | |
| | | | | |
| Lower Side | 3,35 x $10^{11}$ | 2,02 x $10^{12}$ | 6,53 x $10^{11}$ | |
| | 3,84 x $10^{11}$ | 1,57 x $10^{12}$ | 5,33 x $10^{11}$ | |
| | 5,43 x $10^{11}$ | | 4,61 x $10^{11}$ | |
| | 4,32 x $10^{11}$ | | | |



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| Sample | Surface Resistance Ω | | Resistance to groundable point Ω | Notes |
|---|---|---|---|---|
| | $R_{PP}$ | $R_S$ | $R_{GP}$ | |
| **Plate 5** | | | | |
| **1351494 Black** | | | | |
| Upper Side | 5,95 x $10^{11}$ | 1,55 x $10^{12}$ | 4,49 x $10^{11}$ | |
| | 3,60 x $10^{11}$ | 1,18 x $10^{12}$ | 8,22 x $10^{11}$ | |
| | 5,92 x $10^{11}$ | | 2,16 x $10^{12}$ | |
| | 5,66 x $10^{11}$ | | | |
| | | | | |
| Lower Side | 3,62 x $10^{11}$ | 2,20 x $10^{12}$ | 1,51 x $10^{12}$ | |
| | 4,48 x $10^{11}$ | 1,79 x $10^{12}$ | 1,64 x $10^{12}$ | |
| | 5,53 x $10^{11}$ | | 2,70 x $10^{12}$ | |
| | 5,87 x $10^{11}$ | | | |
| | | | | |
| **Plate 6** | | | | |
| **1351494 Black** | | | | |
| Upper Side | 5,56 x $10^{11}$ | 1,04 x $10^{12}$ | 6,35 x $10^{11}$ | |
| | 6,87 x $10^{11}$ | 2,34 x $10^{12}$ | 1,78 x $10^{12}$ | |
| | 5,40 x $10^{11}$ | | 7,30 x $10^{11}$ | |
| | 4,87 x $10^{11}$ | | | |
| | | | | |
| Lower Side | 4,10 x $10^{11}$ | 1,05 x $10^{12}$ | 2,17 x $10^{12}$ | |
| | 5,09 x $10^{11}$ | 5.02 x $10^{12}$ | 4,03 x $10^{11}$ | |
| | 5,04 x $10^{11}$ | | 5,32 x $10^{11}$ | |
| | 4,34 x $10^{11}$ | | | |



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| Sample | Surface Resistance Ω | | Resistance to groundable point Ω | Notes |
|---|---|---|---|---|
| | $R_{PP}$ | $R_S$ | $R_{GP}$ | |
| **Plate 7** | | | | |
| **1351597 White** | | | | |
| Upper Side | 4,47 x $10^{11}$ | 1,33 x $10^{12}$ | 3,06 x $10^{14}$ | |
| | 1,34 x $10^{12}$ | 1,61 x $10^{12}$ | 3,07 x $10^{14}$ | |
| | 6,37 x $10^{11}$ | | > $10^{14}$ | OL |
| | 6,18 x $10^{11}$ | | | |
| | | | | |
| Lower Side | 1,41 x $10^{12}$ | 1,89 x $10^{12}$ | 2,17 x $10^{14}$ | |
| | 1,30 x $10^{12}$ | 2,99 x $10^{12}$ | > $10^{14}$ | OL |
| | 4,83 x $10^{11}$ | | 2,05 x $10^{14}$ | |
| | 6,10 x $10^{11}$ | | | |
| | | | | |
| **Plate 8** | | | | |
| **1351597 White** | | | | |
| Upper Side | 3,58 x $10^{11}$ | 1,49 x $10^{12}$ | 3,75 x $10^{14}$ | |
| | 9,04 x $10^{11}$ | 1,35 x $10^{12}$ | 3,11 x $10^{14}$ | |
| | 5,46 x $10^{11}$ | | > $10^{14}$ | OL |
| | 5,96 x $10^{11}$ | | | |
| | | | | |
| Lower Side | 1,23 x $10^{12}$ | 1,58 x $10^{12}$ | > $10^{14}$ | OL |
| | 6,41 x $10^{11}$ | 2,01 x $10^{12}$ | > $10^{14}$ | OL |
| | 5,36 x $10^{11}$ | | > $10^{14}$ | OL |
| | 1,74 x $10^{12}$ | | | |

OL Over Load (outside of limits)



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| Sample | Surface Resistance Ω | | Resistance to groundable point Ω | Notes |
|---|---|---|---|---|
| | $R_{PP}$ | $R_S$ | $R_{GP}$ | |
| **Plate 9** | | | | |
| **206182 White** | | | | |
| Upper Side | 1,41 x $10^{10}$ | 1,13 x $10^{11}$ | 3,11 x $10^{11}$ | |
| | 1,37 x $10^{10}$ | 1,38 x $10^{11}$ | 3,76 x $10^{11}$ | |
| | 1,43 x $10^{10}$ | | 4,24 x $10^{11}$ | |
| | 1,54 x $10^{10}$ | | | |
| | | | | |
| Lower Side | 1,78 x $10^{10}$ | 1,08 x $10^{11}$ | 3,81 x $10^{11}$ | |
| | 1,74 x $10^{10}$ | 1,68 x $10^{11}$ | 4,57 x $10^{11}$ | |
| | 2,00 x $10^{10}$ | | 4,53 x $10^{11}$ | |
| | 1,89 x $10^{10}$ | | | |
| | | | | |
| **Plate 10** | | | | |
| **206182 White** | | | | |
| Upper Side | 1,52 x $10^{10}$ | 1,44 x $10^{11}$ | 4,32 x $10^{10}$ | |
| | 2,01 x $10^{10}$ | 1,47 x $10^{11}$ | 4,47 x $10^{11}$ | |
| | 1,63 x $10^{10}$ | | 5,00 x $10^{11}$ | |
| | 1,70 x $10^{10}$ | | | |
| | | | | |
| Lower Side | 2,09 x $10^{10}$ | 1,51 x $10^{11}$ | 4,31 x $10^{11}$ | |
| | 2,08 x $10^{10}$ | 1,67 x $10^{11}$ | 5,10 x $10^{11}$ | |
| | 2,18 x $10^{10}$ | | 4,87 x $10^{11}$ | |
| | 2,00 x $10^{10}$ | | | |



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| Sample | Surface Resistance Ω | | Resistance to groundable point Ω | Notes |
|---|---|---|---|---|
| | $R_{PP}$ | $R_S$ | $R_{GP}$ | |
| **Plate 11** | | | | |
| **1732821 White** | | | | |
| Upper Side | 4,97 x $10^{11}$ | 9,30 x $10^{11}$ | 6,39 x $10^{11}$ | |
| | 4,25 x $10^{11}$ | 1,49 x $10^{12}$ | 3,84 x $10^{12}$ | |
| | 3,11 x $10^{11}$ | | 4,26 x $10^{12}$ | |
| | 3,85 x $10^{11}$ | | | |
| | | | | |
| Lower Side | 6,67 x $10^{11}$ | 3,92 x $10^{11}$ | > $10^{14}$ | OL |
| | 4,78 x $10^{11}$ | 1,21 x $10^{12}$ | > $10^{14}$ | OL |
| | 3,29 x $10^{11}$ | | > $10^{14}$ | OL |
| | 2,95 x $10^{11}$ | | | |
| | | | | |
| **Plate 12** | | | | |
| **1732821 White** | | | | |
| Upper Side | 3,88 x $10^{11}$ | 1,80 x $10^{12}$ | > $10^{14}$ | OL |
| | 4,96 x $10^{11}$ | 1,31 x $10^{12}$ | > $10^{14}$ | OL |
| | 4,25 x $10^{11}$ | | > $10^{14}$ | OL |
| | 3,65 x $10^{11}$ | | | |
| | | | | |
| Lower Side | 5,99 x $10^{11}$ | 1,07 x $10^{12}$ | 5,33 x $10^{12}$ | |
| | 3,37 x $10^{11}$ | 1,54 x $10^{12}$ | 5,02 x $10^{11}$ | |
| | 3,66 x $10^{11}$ | | 4,24 x $10^{12}$ | |
| | 3,46 x $10^{11}$ | | | |



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## V. SUMMARY

On August 15, 2025, measurements of all plates were realized after a 48-hour storage of the samples under special climatic conditions.

It was investigated that only plates 1 and 2 (**1336821** black) as well as 9 and 10 (**206182** white) meet the requirements for "electrostatically dissipative" material. All other measurement values of the plates are above the limit value of 1 x $10^{11}$ Ω.

The determining factor was the required surface resistance $R_{PP}$. The measurement values obtained with the concentric ring electrode $R_S$ correspond to the $R_{PP}$ values. Here, the measurement values must be divided by a factor of 10. This factor results from the design of the concentric ring electrode.

All measured values meet the requirements of ANSI/ESD S20.20 and IEC 61340-5-1.

All measurements were realized in a climate chamber with conditions of 12% humidity and 23°C temperature.



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## ANNEX

Limits after ANSI/ESD S20.20-2021 and IEC 61340-5-1 + measurement methods in accordance ANSI/ESD TR 53 and IEC/TS 61340-5-4:

| Technical requirements | ESD item | Measurement methods | Limits |
|---|---|---|---|
| Personal grounding (daily test) | Wrist strap system | ~~IEC 61340-5-1 A.1~~ IEC/TS 61340-5-4 | $< 3.5 * 10^7\ \Omega$ |
| | Systemresistance | ~~IEC 61340-5-1 A.2~~ IEC/TS 61340-5-4 | $< 3.5 * 10^7\ \Omega$<br>$< 1 * 10^8\ \Omega$ |
| EPA requirements | Working surface<br>Storage shelfs<br>Trolleys | ~~IEC 61340-2-3~~ IEC/TS 61340-5-4 | $< 1 * 10^9\ \Omega$ |
| | Floor | ~~IEC 61340-4-1~~ IEC/TS 61340-5-4 | $< 1 * 10^9\ \Omega$ |
| | Ionization | ~~IEC 61340-4-7~~ IEC/TS 61340-5-4 | ± 1000 V auf ± 100 V in weniger als 20 s |
| | Chairs | ~~IEC 61340-2-3~~ IEC/TS 61340-5-4 | $< 1 * 10^9\ \Omega$ |
| | Garments | ~~IEC 61340-4-9~~ IEC/TS 61340-5-4 | $< 1 * 10^{11}\ \Omega$ |
| | Garments (groundable) | | $< 1 * 10^9\ \Omega$ |

Table: limits in accordance to ANSI/ESD S20.20 and IEC 61340-5-1

Notes:

1. The resistance to ground and groundable point of all ESD control measures must be less than $1 * 10^9$. In exceptional cases, when resistance values exceed $1 * 10^9\ \Omega$, the permissible discharge time can be checked. This must be less than 2 s when discharging from 1000 V to 100 V.
2. If ESD items or ESD facilities are connected in series, the limit values must not be exceeded. A series connection of tables and work surfaces should be avoided. A star-shaped grounding is preferred.
3. The lower limit is restricted on one hand by the fact that electrostatic charges must be dissipated in a controlled manner and there must be no sudden discharge. On the other hand, the lower limit is restricted by personnel protection according to VDE 0100. It is defined today that no discharge according to the CDM model may occur.
4. Upward deviations can be explained by the possibility of providing suitable materials and equipment. If the upper limit is exceeded, the discharge time for electrostatic charges (1000 V $\Rightarrow$ 100 V: less than 2 s) must also be maintained. Electrostatic charges must still be able to dissipate sufficiently controllably.
5. The resistance to ground for the floor can be below $7.5 * 10^5\ \Omega$ (according to IEC 61340-5-1), provided that personnel protection is ensured and the individuals are wearing ESD appropriate shoes.



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