

**Comparative measurements  
of two ESD-swivel chairs  
with different castors and glides  
used on different ESD-flooring systems**

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# Background

- In the new IEC 61340-5-1 Edition 2.0 (2016-05) the upper limit value of the resistance to ground for "seating" has been reduced for the "product qualification" and "compliance verification" from  $10^{10}$  ohm to  $10^9$  ohm.
- Because of this change problematic situations during the process of "compliance verification" might occur to pass the new limit value.

This paper shows the test results of two typical ESD-swivel chairs with different castors and glides used on different ESD-flooring systems.

# Aim of the investigation

- „Product qualification“ of different flooring systems, ESD-swivel chairs and smocks in a walk-in climate chamber at a relative humidity of  $12 \pm 3 \%$  and a temperature of  $23 \pm 2 \text{ }^\circ\text{C}$  (conditioning more than 48 hours).
- „Compliance verification“ of ESD-swivel chairs on different flooring systems at a relative humidity of  $12 \pm 3 \%$  and a temperature of  $23 \pm 2 \text{ }^\circ\text{C}$  and at ambient conditions as well (RH:  $50 \pm 3 \%$  ; T:  $23 \pm 2 \text{ }^\circ\text{C}$ ).
- Measurement of the resistance to ground  $R_{g\text{System}}$  and a body voltage test of a seated person in the system „Person / ESD-swivel chair / flooring system“ with different smocks.

# Used instruments and probes

Instrument / Probe	Type / description	Serial-No.
Digital High Resistance Tester	METRISO® 3000	XE1548
T/H Sensor	Z550B	WC3252
Probe	Model 870	15001, 15002
Backrest Probe	Model 900	16001
Hand-held Probe	Model 45	-
Metal Plate	400 x 300 x 2 mm	-
Walking Test Kit	WT5000	01500304

All the mentioned instruments and probes are conform to IEC 61340-2-3 (2000-03) and subject to the control of inspection according to ISO 9001:2008 and were verified before performing the measurements.

# Used flooring systems

Type	Material	Version
FS-1	PVC	Dissipative pigments in the surface and conductive painting on the back side Thickness: 1.9 mm
FS-2	PVC	Two layer flooring: Dissipative top surface and conductive back side. Thickness: 2.0 mm
FS-3	PUR	Volume dissipative integral foam. Thickness: 13 mm
FS-4	Epoxy	Coating with scattered carbon fibres. Thickness: 3.0 mm
FS-5	PUR-paint	Pigmented paint without conductive layer. Thickness: 0.2 mm

# Product qualification – flooring systems

Material	U <sub>m</sub>	TP 1	TP 2	TP 3	TP 4	TP 5
PVC-1	10 V	524 kΩ	362 kΩ	499 kΩ	278 kΩ	368 kΩ
PVC-2	100 V	129 MΩ	122 MΩ	131 MΩ	127 MΩ	121 MΩ
PUR	10 V	392 kΩ	395 kΩ	348 kΩ	306 kΩ	344 kΩ
Epoxy	10 V	18.9 kΩ	32.7 kΩ	74.1 kΩ	117 kΩ	12.8 kΩ
PUR- paint	100 V	7.08 MΩ	7.09 MΩ	6.62 MΩ	5.57 MΩ	5.91 MΩ



## Analysis of the test results:

All the flooring systems are measured according to IEC 61340-4-1 Ed. 2.0 (2003-12) and are according to IEC 61340-5-1 Ed. 2.0 (2016-05) - Table 3 „EPA requirements“ within the specified limit of resistance to groundable point  $R_{gp} < 1 \times 10^9 \Omega$  (1 Gohm).

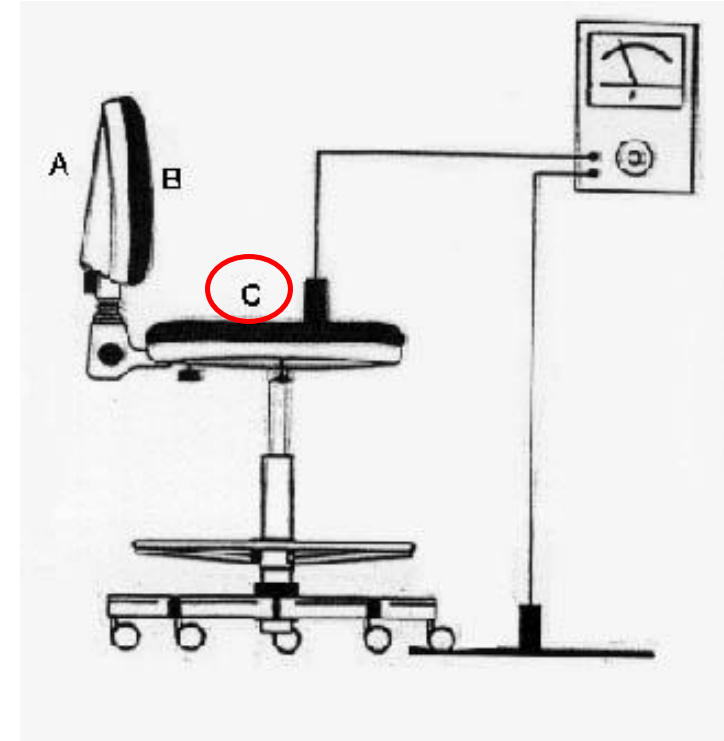
# Product qualification - ESD-swivel chairs



Type „SC-1“



Type „SC-2“



RH:  $12 \pm 3 \%$ ; T:  $23 \pm 2 \text{ }^\circ\text{C}$

Left picture: Measurement resistance to groundable point  $R_{gp}$  at test point „C“ with the probe Model 870 in the walk-in climate chamber.

Right picture: Measurement resistance to groundable point  $R_{gp}$  at test point „B“ with the backrest probe Model 900 in the walk-in climate chamber.

# Product qualification - swivel chair „SC-1“



Test point:  
Castor /  
Glide –  
Seat

+ Castor  
Plastic  
(new)



+ Castor  
Plastic  
(used / dirty)



+ Castor  
Metal  
(new)



+ Glide  
Plastic  
(new)



1-C	1.56 MΩ	<b>3.83 GΩ</b>	2.13 MΩ	2.73 MΩ
2-C	1.79 MΩ	<b>3.73 GΩ</b>	2.15 MΩ	2.31 MΩ
3-C	1.75 MΩ	<b>2.79 GΩ</b>	1.97 MΩ	2.34 MΩ
4-C	1.73 MΩ	<b>2.73 GΩ</b>	2.06 MΩ	2.07 MΩ
5-C	1.79 MΩ	<b>2.31 GΩ</b>	2.01 MΩ	1.86 MΩ

Analysis of the test results: The limit of  $R_{gp} < 1 \times 10^{10} \Omega$  (10 Gohm) is fulfilled. The dirty castors made of plastic exceed the new limit of  $R_{gp} < 1 \times 10^9 \Omega$  (1 Gohm).



# Product qualification - swivel chair „SC-2“



Test point:  
Castor /  
Glide –  
Seat

+ Castor  
Plastic  
(new)



+ Castor  
Plastic  
(used / dirty)



+ Castor  
Metal  
(new)



+ Glide  
Plastic  
(new)



	+ Castor Plastic (new)	+ Castor Plastic <u>(used / dirty)</u>	+ Castor Metal (new)	+ Glide Plastic (new)
1-C	97.5 MΩ	<b>3.95 GΩ</b>	99.5 MΩ	102 MΩ
2-C	96.1 MΩ	<b>3.91 GΩ</b>	98.6 MΩ	100 MΩ
3-C	96.5 MΩ	<b>2.89 GΩ</b>	98.2 MΩ	103 MΩ
4-C	95.7 MΩ	<b>2.80 GΩ</b>	98.1 MΩ	100 MΩ
5-C	95.0 MΩ	<b>2.91 GΩ</b>	97.7 MΩ	101 MΩ

Analysis of the test results: The limit of  $R_{gp} < 1 \times 10^{10} \Omega$  (10 Gohm) is fulfilled. The dirty castors made of plastic exceed the new limit of  $R_{gp} < 1 \times 10^9 \Omega$  (1 Gohm).

# Used smocks

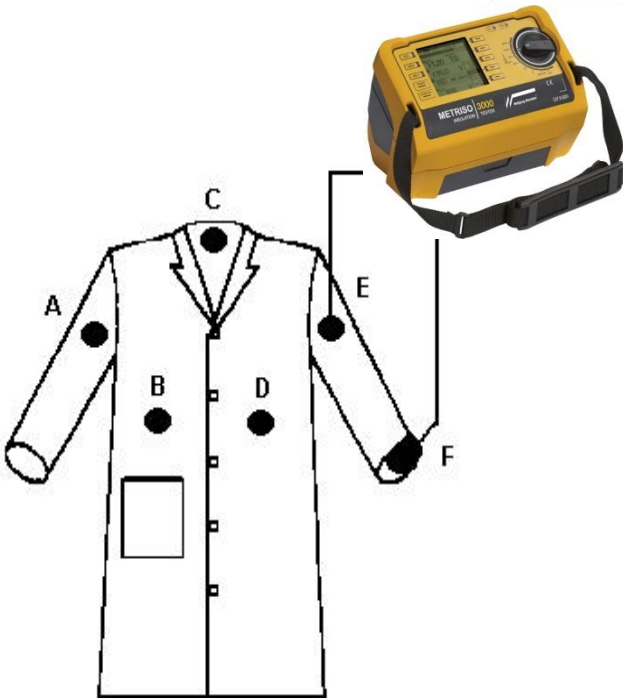
Type	Performance
S-1	<b>Composition:</b> 100 % cotton Weight: 210 g/m <sup>2</sup>
S-2	Electrostatic dissipative fabric <b>Composition:</b> 65 % polyester, 32 % cotton and 3 % carbon coated yarn in a 4 mm grid. Weight: 156 g/m <sup>2</sup>
S-3	Electrostatic dissipative fabric <b>Composition:</b> 65 % polyester, 32 % cotton and 3 % carbon coated yarn in a 4 mm grid with conductive cuffs. Weight: 156 g/m <sup>2</sup>



# Product qualification - smocks

Type	A - E	A - C	C - E	C - F	B - D
S-1	> 1 TΩ	> 1 TΩ	> 1 TΩ	> 1 TΩ	> 1 TΩ
S-2	3.1 MΩ	1.3 MΩ	1.1 MΩ	1.3 MΩ	836 kΩ
S-3	2.3 MΩ	1.3 MΩ	1.2 MΩ	1.0 MΩ	604 kΩ

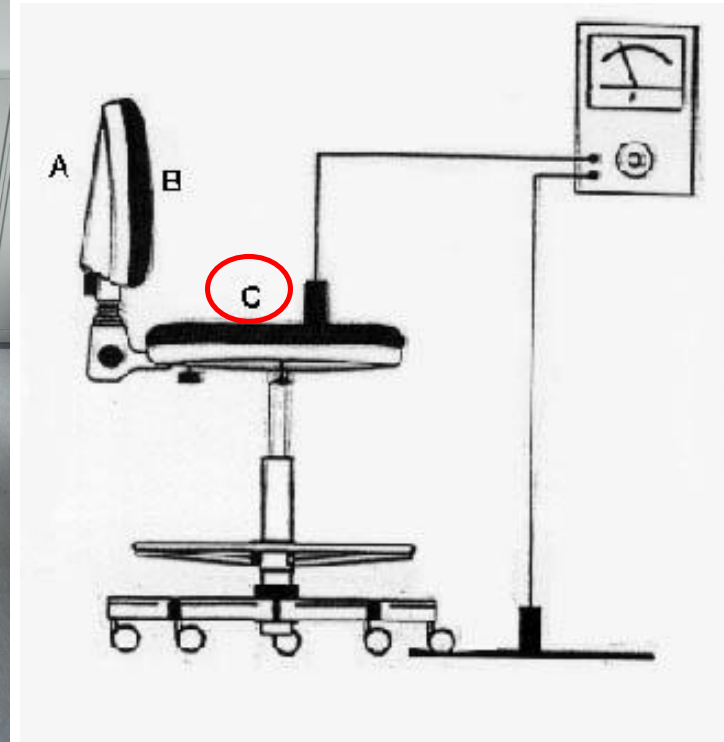
According to IEC 61340-4-9 (2016-04) at RH:  $12 \pm 3 \%$ ; T:  $23 \pm 2 \text{ }^\circ\text{C}$



## Analysis of the test results:

According to IEC 61340-5-1 Edition 2.0 (2016-05) – Table 3 „EPA requirements“ the smock Type „S-1“ (made of 100 % cotton) does not meet the requirement of  $R_{p-p} < 1 \times 10^{11} \text{ } \Omega$  (100 GOhm) and unfortunately such smocks are still used in several EPAs.

# ESD-swivel chairs / flooring systems



Left picture: Measurement resistance to groundable point  $R_{gp}$  of the swivel chair (seat) type „SC-2“ on the flooring „PUR-painting“ in the walk-in climate chamber.

Right picture: Measurement setup in the lab with the swivel chair type „SC-1“ and all flooring systems which were used.



# Swivel chair „SC-1“ / flooring systems

Flooring system

12 % / 23 °C  
(50 % / 23 °C)

+ Castors  
Plastic



+ Castors  
(used / dirty)



+ Castors  
Metal







+ Glides  
Plastic



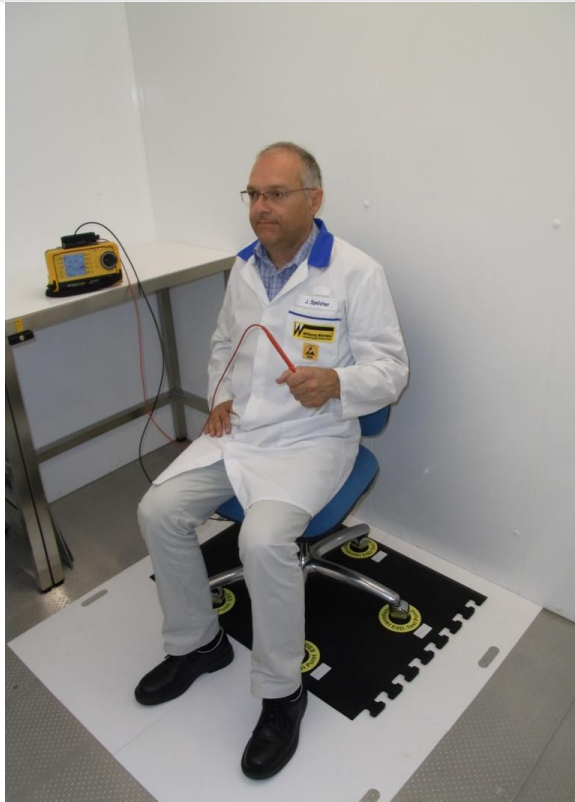
PVC-1	3.91 MΩ	<b>7.14 GΩ</b>	1.69 MΩ	2.86 MΩ
(PVC-1	2.71 MΩ	193 MΩ	716 kΩ	4.05 MΩ)
PVC-2	324 MΩ	773 MΩ	155 MΩ	<b>7.31 GΩ</b>
(PVC-2	74.9 MΩ	131 MΩ	77.3 MΩ	<b>1.61 GΩ)</b>
PUR	1.63 MΩ	3.02 MΩ	1.63 MΩ	1.51 MΩ
(PUR	764 kΩ	826 kΩ	734 kΩ	1.00 MΩ)
Epoxy	<b>432 GΩ</b>	<b>&gt; 1 TΩ</b>	<b>&gt; 1 TΩ</b>	<b>844 GΩ</b>
(Epoxy	<b>88.4 GΩ</b>	<b>128 GΩ</b>	<b>273 GΩ</b>	<b>135 GΩ)</b>
PUR-paint	9.76 MΩ	1.16 MΩ	7.73 MΩ	16.5 MΩ
(PUR-paint	4.27 MΩ	122 MΩ	3.52 MΩ	226 MΩ)



# Swivel chair „SC-2“ / flooring systems

Flooring system 12 % / 23 °C (50 % / 23 °C)	+ Castors Plastic 	+ Castors (used / dirty) 	+ Castors Metal 	+ Glides Plastic 
PVC-1	142 MΩ	<b>10.3 GΩ</b>	139 MΩ	156 MΩ
(PVC-1	69.9 MΩ	324 MΩ	70.9 MΩ	271 MΩ)
PVC-2	380 MΩ	652 MΩ	269 MΩ	<b>8.81 GΩ</b>
(PVC-2	126 MΩ	245 MΩ	158 MΩ	<b>1.22 GΩ)</b>
PUR	138 MΩ	156 MΩ	138 MΩ	151 MΩ
(PUR	62.2 MΩ	69.5 MΩ	70.3 MΩ	65.5 MΩ)
Epoxy	<b>&gt; 1 TΩ</b>	<b>&gt; 1 TΩ</b>	<b>&gt; 1 TΩ</b>	<b>&gt; 1 TΩ</b>
(Epoxy	<b>180 GΩ</b>	<b>263 GΩ</b>	<b>809 GΩ</b>	<b>141 GΩ)</b>
PUR-paint	146 MΩ	439 MΩ	157 MΩ	438 MΩ
(PUR-paint	47.2 MΩ	183 MΩ	80.4 MΩ	87.9 MΩ)

# Person / ESD-chair / flooring system







Measurements of a seated person wearing a smock with conductive cuffs on an ESD-swivel chair over the flooring system in the walk-in climate chamber at RH:  $12 \pm 3 \%$ ; T:  $23 \pm 2 \text{ }^\circ\text{C}$ .

Left picture: Resistance to ground  $R_{g \text{ System}}$  (Next Table: **< 35 M $\Omega$**  )

Right picture: Body voltage U







# Person / „SC-1“ / flooring systems

Flooring system 12 % / 23 °C (50 % / 23 °C)	+ Castors Plastic 	+ Castors (used / dirty) 	+ Castors Metal 	+ Glides Plastic 
PVC-1	4.55 MΩ	1.83 GΩ	3.64 MΩ	5.90 MΩ
(PVC-1	2.14 MΩ	136 MΩ	2.02 MΩ	2.26 MΩ)
PVC-2	96.1 MΩ	197 MΩ	73.9 MΩ	3.31 GΩ
(PVC-2	27.2 MΩ	90.4 MΩ	36.9 MΩ	458 MΩ)
PUR	3.58 MΩ	3.65 MΩ	3.17 MΩ	3.84 MΩ
(PUR	1.05 MΩ	1.35 MΩ	1.13 MΩ	1.35 MΩ)
Epoxy	> 1 TΩ	> 1 TΩ	> 1 TΩ	> 1 TΩ
(Epoxy	159 GΩ	64,7 GΩ	242 GΩ	117 GΩ)
PUR-paint	10.9 MΩ	42.8 MΩ	9.67 MΩ	13.1 MΩ
(PUR-paint	4.50 MΩ	59.8 MΩ	3.92 MΩ	5.68 MΩ)





# Person / „SC-2“ / flooring systems

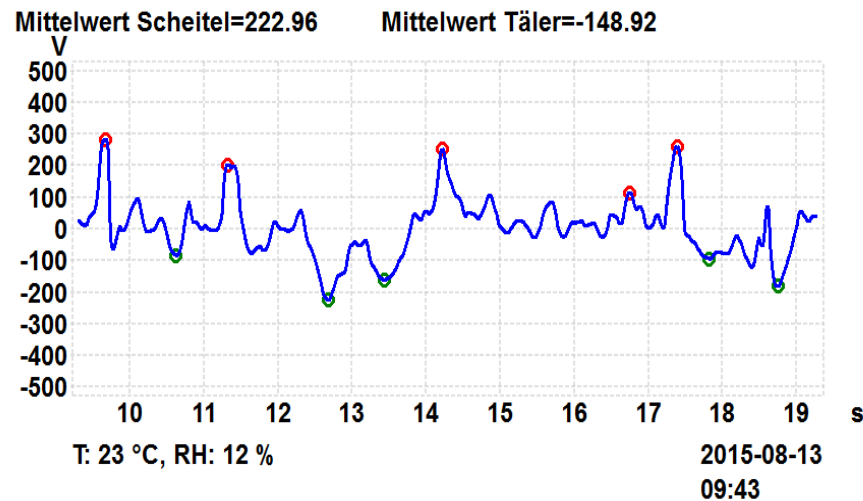
Flooring system 12 % / 23 °C (50 % / 23 °C)	+ Castors Plastic	+ Castors (used / dirty)	+ Castors Metal	+ Glides Plastic
				
PVC-1	39.4 MΩ	3.09 GΩ	27.9 MΩ	29.7 MΩ
(PVC-1	11.6 MΩ	147 MΩ	10.9 MΩ	11.2 MΩ)
PVC-2	106 MΩ	221 MΩ	93.6 MΩ	3.60 GΩ
(PVC-2	34.7 MΩ	106 MΩ	47.6 MΩ	508 MΩ)
PUR	27.8 MΩ	30.9 MΩ	28.9 MΩ	30.5 MΩ
(PUR	8.93 MΩ	9.52 MΩ	10.6 MΩ	8.91 MΩ)
Epoxy	> 1 TΩ	> 1 TΩ	> 1 TΩ	> 1 TΩ
(Epoxy	210 GΩ	94.9 GΩ	304 GΩ	259 GΩ)
PUR-paint	38.7 MΩ	70.6 MΩ	34.8 MΩ	41.6 MΩ
(PUR-paint	13.5 MΩ	86.2 MΩ	15.4 MΩ	14.0 MΩ)

# Person / ESD-chairs / flooring systems

## S-3 / SC-1+glides / PVC-2:

Measured body voltage  $U$  at  
 $R_{gp} \approx 7.3 \text{ G}\Omega$  and  $R_{g \text{ System}} = 3.31 \text{ G}\Omega$

Grafik 2



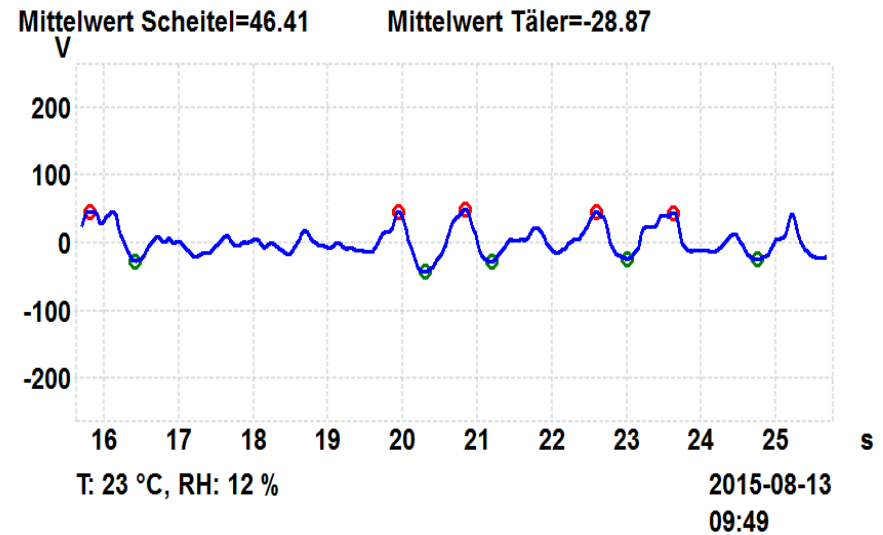
### Analysis of the graph 2:

**Generated body voltage (average of the 5 highest peaks) at seated movements: 222,96 V / - 148,92 V.**

## S-3 / SC-2+dirty castors / PVC-2:

Measured body voltage  $U$  at  
 $R_{gp} \approx 655 \text{ M}\Omega$  and  $R_{g \text{ System}} = 221 \text{ M}\Omega$

Grafik 4



### Analysis of the graph 4:

**Generated body voltage (average of the 5 highest peaks) at seated movements: 46,41 V / - 28,87 V.**

# Summary I

- The ESD-swivel chairs with clean (new) castors or glides fulfill the product qualification and the change of the resistance to a groundable point  $R_{gp}$  to  $< 10^9$  Ohm (1 GOhm) is no problem at all. However both type of the swivel chairs with used and dirty castors made of plastic have exceeded the new resistance limit.
- The measurements of the compliance verification at about 50 % relative humidity shows that the resistance to ground of both ESD-swivel chairs meet the limit of  $10^{10}$   $\Omega$  (10 GOhm) and the new limit of  $10^9$   $\Omega$  (1 GOhm) too. Exception: On the Epoxy flooring all the castor-/glide-combinations are above the limit of  $10^{10}$   $\Omega$  (10 GOhm). Reason: Contact problems of the castors / glides to the conductive components of the very hard Epoxy surface coating.

# Summary II

- The measurement of the resistance to ground  $R_{g \text{ System}}$  of a seated person wearing a smock on ESD-swivel chairs to a ESD-flooring system at a relative humidity of 12 % in a walk-in climate chamber shows that the specified limit of the wrist-band grounding of  $R < 35 \text{ M}\Omega$  can be fulfilled depending on the existing constellation.
- If the resistance to ground in the system  $R_{g \text{ System}}$  „person / ESD-swivel chair / ESD-flooring system“ of the compliance verification is higher than  $10^9 \Omega$  (1 GOhm) a measurement of the body voltage according to IEC 61340-4-5 (2004-07) is recommended.

# Final Conclusion

- The investigation has shown that the change of the limit for the product qualification respectively compliance verification should not be a general problem with exception of the use on particular epoxy flooring systems where the resistance and body voltage test failed as well.
- Finally it has to be mentioned that this measurements have been done at „clean“ lab conditions. Therefore it should be considered the important criteria like dirty floorings, dirty and long used castors or glides while doing the compliance verifications at ambient conditions.