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Test Report

Determination of the cleanroom suitability of the saddle chair »Saddle CLR« manufactured by Score BV

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Index

1 Introduction and objectives

Score BV is a company which manufactures chairs aimed at meeting customer-specific requirements. Their products are of an exceptionally high quality. In order to secure Score BV's position in the market sector of clean manufacturing, it is essential that knowledge be gained of the contamination behavior of their products to ensure that corresponding cleanroom specifications are adhered to.

To test and qualify the saddle chair »Saddle CLR« with regard to its possible use in cleanrooms, a test sample was assessed for cleanroom suitability. To achieve this, particle emission tests were carried out.

The qualification measurements were performed at the Fraunhofer IPA test center in Stuttgart, Germany. The test sample was supplied by Score BV for the duration of the tests.

2 Overview of the measurements

The following table shows the exact breakdown of the test piece:

TP01	
Description of test piece	Saddle chair Saddle CLR
Company name	Score BV
Category **Subcategory**	Working Place and Operator Chairs
Batch number	70663
Manufacturing date	17-04-2014
Colour of the seat	Black

Figure 1 Test piece data TP01

The following table shows the corresponding tests carried out on the test piece:

	Emission measurements (particles)	ESD behavior	Outgassing	Chemical resistance	Cleanability (particles)	Biological cleanability	Ability to resist metabolism	Surface roughness	Expertise
TP01	X	X							

Figure 2 Table of test piece and corresponding tests

3 Airborne particle emission tests

3.1 Cleanroom environment

All tests were carried out in the Fraunhofer IPA test centre for semiconductor devices. The measurements were performed in a cleanroom fulfilling Class 1 specifications (in accordance with ISO 14644-1). A vertical laminar flow prevailed with a flow rate of first air of 0.45 m/s. The highly-clean air is introduced into the cleanroom via the ceiling as a laminar airflow and extracted via a raised floor. Environmental conditions were kept constant with a room temperature of 22 °C ± 0.5 °C and a relative humidity of 45 % ± 5 %.

According to ISO 14644-1, Cleanroom Class 1 means that only ten particles the size of 0.1 µm may be found in a reference volume of one cubic meter in the first air (filtered air introduced into the cleanroom). In practical operation, even fewer particles are found in this cleanroom class.

3.2 Test set-up, parameters and procedure

Test set-up
Score BV supplied the Fraunhofer IPA with the required test piece which could be operated maintenance-free.

On delivery, the test piece was introduced into the cleanroom at the Fraunhofer IPA in Stuttgart. It was then assembled and put into operation (complete with all the functional components required for its assembly and operation) by the Fraunhofer IPA.

Introduction of the test piece into the cleanroom
The test piece was brought into the cleanroom. To do this, the entire surfaces of the system and all other functional components were cleaned with low emission cleanroom cloths soaked in a mixture of isopropanol and DI water and then dried using ionizing, ultra-pure compressed air.

Pre-conditioning of the test piece
To remove particles generated during the running-in phase, the test piece was first operated with an average load for a period of 24 hours in the reference cleanroom while simultaneously subjected to a continuous airflow of ultra-pure first air.

Any modifications to the test piece which were required in order to carry out the tests were then made in mutual agreement with the contractor.

Test parameters / execution
To ascertain the actual state of the test piece, it was tested using the operating parameters specified below.

The saddle chair »Saddle CLR« was tested; in the report it is henceforth known as the **test piece TP01**.

Operating parameters for the test piece were selected in mutual agreement with the customer before commencing the tests:

- Type of stress applied:.. pulsating vertical force
- Location of stress impact:...midpoint of the seat
- Force:.. F = 1200 N
- Cycles:..12 / min

Overview test set-up and test piece

Figure 3 Overview test set-up and test piece

3.3 Measuring technique

The following type of laser particle counter devices was used to determine particle emission during the tests.

Model LasAir II 110 manufactured by PMS with measuring channels of ≥ 0.1 µm, ≥ 0.2 µm, ≥ 0.3 µm, ≥ 0.5 µm, ≥ 1.0 µm and ≥ 5.0 µm

Optical particle counters function according to the principal of scattered light. Using a sampling probe, a defined volume of air of 1 cubic foot (1 cft = 28.3 liters) is sucked in per minute and guided into a measuring chamber via a tube connected to it. The air sucked in is illuminated by a light source, in modern devices either a laser or laser diode. As soon as a particle carried by the airflow is struck by a ray of light, the light is scattered and then recorded by photo-detectors.

The amount of impulses registered equates to the number of particles found in the volume of air; the height of the impulse indicates the particle size.

3.4 Localization measurements

Localization measurements were carried out separately for each setting to determine the location of the Measuring Points for the subsequent qualification tests.

Taking the intended motion sequence and the visual inspection of the surface into consideration, likely sources of contamination (e.g. bearing grooves, surfaces moving against one another, etc.) were systematically investigated for the emission of particles. By comparing the values obtained, areas generating the highest particle concentrations during the motion sequence could be located. These areas were marked and a particle probe positioned at each of them in such a way so as to record particle emission from them as effectively as possible during the qualification tests.

3.5 Qualification measurements

The qualification tests were carried out in accordance with the guideline VDI 2083 Part 9.1.

Measuring Points were set at each of the critical areas identified. Particle emission measurements were recorded at each Measuring Point over a period of 100 minutes with a measuring interval of 1/min. To improve the comparability of results, for each test series particle emission values were recorded in parallel by up to 2 particle counters equating to up to 2 measuring points.

The flow rate of the measurement volume sucked in was 1 cft/min. Particle values are shown cumulatively for each size channel. This means that the value shown for a defined size channel is the number of all particles equating to or exceeding the stated size (≥ 0.1 µm, ≥ 0.2 µm, ≥ 0.3 µm, ≥ 0.5 µm, ≥ 1.0 µm or ≥ 5.0 µm, respectively).

The selected time period of 100 minutes ensured adequate statistical certainty of the test results and safeguarded against faulty measurements. Each measurement value shows the particle size, the number of particles generated and the site of origin of the particulate contamination.

Statistical analysis was carried out in accordance with the procedure laid down in the guideline VDI 2083 Part 9.1 and enabled the suitability of the operating utility to be determined for use in cleanrooms classified in accordance with ISO 14644-1.

3.5.1 Description of measuring sites for the Measuring Points MP01 to MP04

The following photographs show the exact positions selected for the measurement of airborne particles emitted from test piece.

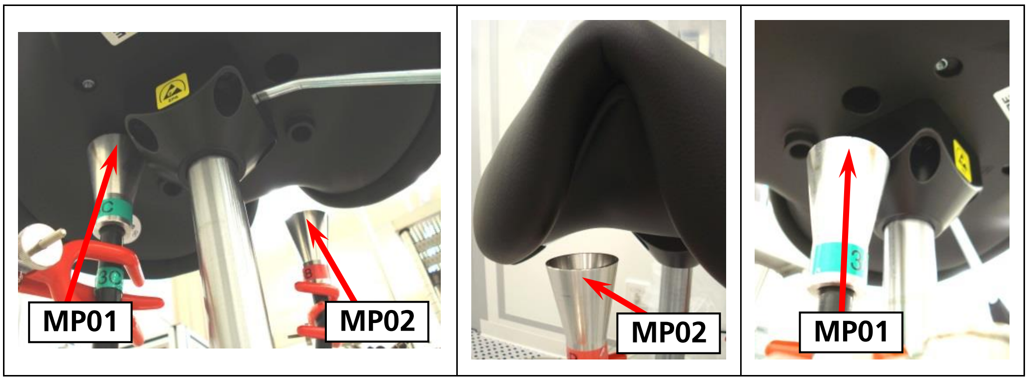

Figure 4 Measuring Points MP01 and MP02 for the measurement of airborne particle emission

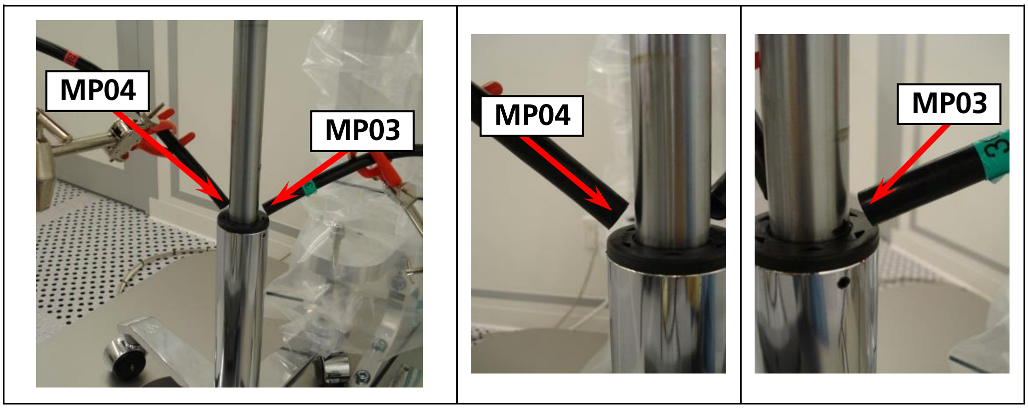

Figure 5 Measuring Points MP03 and MP04 for the measurement of airborne particle emission

3.5.2 Analysis of the results from the airborne particle emission tests

The measurement recording parameters mentioned below applied to all the subsequent measurements taken:

Particle emission values were recorded at each measuring point over a test period of 100 minutes. The flow rate of the measurement volume sucked in was 1 cft/min.

Particle values are shown cumulatively for each of the size channels ≥ 0.1 µm, ≥ 0.2 µm, ≥ 0.3 µm, ≥ 0.5 µm, ≥ 1.0 µm and ≥ 5.0 µm. This means, for example, that the value shown for the size channel ≥ 0.1 µm is the number of all particles equating to or exceeding a diameter of 0.1 µm, therefore also including particles with a diameter ranging between 0.2 µm and > 5.0 µm.

The mean and maximum particle emission values shown are always the maximum values and arithmetical mean values of particle emission recorded at each of the measuring points over the entire test period of 100 minutes.

The chronological progression graphs show the progression of particle emission at each of the measuring points over the entire test period of 100 minutes relevant for the qualification.

3.5.3 Mean and maximum particle emission values

The following tables show the arithmetical mean values and maximum values of particle emission at each Measuring Point (MP) over the entire test time of 100 minutes:

Test series Score BV Saddle CLR Pulsating vertical force F = 1200 N | 12 Cycles / min Overview Measuring Points MP01 to MP04					
Statistical parameters		Measuring Point			
		MP01	MP02	MP03	MP04
Mean values for the detection size [particles / cft]	0.1 µm	0.3	0.0	0.1	0.1
	0.2 µm	0.1	0.0	0.1	0.0
	0.3 µm	0.1	0.0	0.1	0.0
	0.5 µm	0.1	0.0	0.1	0.0
	1.0 µm	0.0	0.0	0.0	0.0
	5.0 µm	0.0	0.0	0.0	0.0
Maximum values for the detection size [particles / cft]	0.1 µm	15	0	11	3
	0.2 µm	13	0	6	2
	0.3 µm	12	0	6	2
	0.5 µm	7	0	5	1
	1.0 µm	4	0	4	1
	5.0 µm	1	0	0	0

Figure 6 Table showing maximum values and arithmetical mean values of the airborne particle emission measurements recorded from the test piece at Measuring Points MP01 to MP04 over the test period of 100 minutes

3.5.4 Chronological progression of particle emission

The following graph shows the progression of particle emissions recorded in the specified size channel at each of the Measuring Points over the test period of 100 minutes relevant for the qualification tests. The measuring interval was always 1 minute, equating to a measuring volume of 1 cubic foot (cft).

Occurrence of contamination in relation to time:

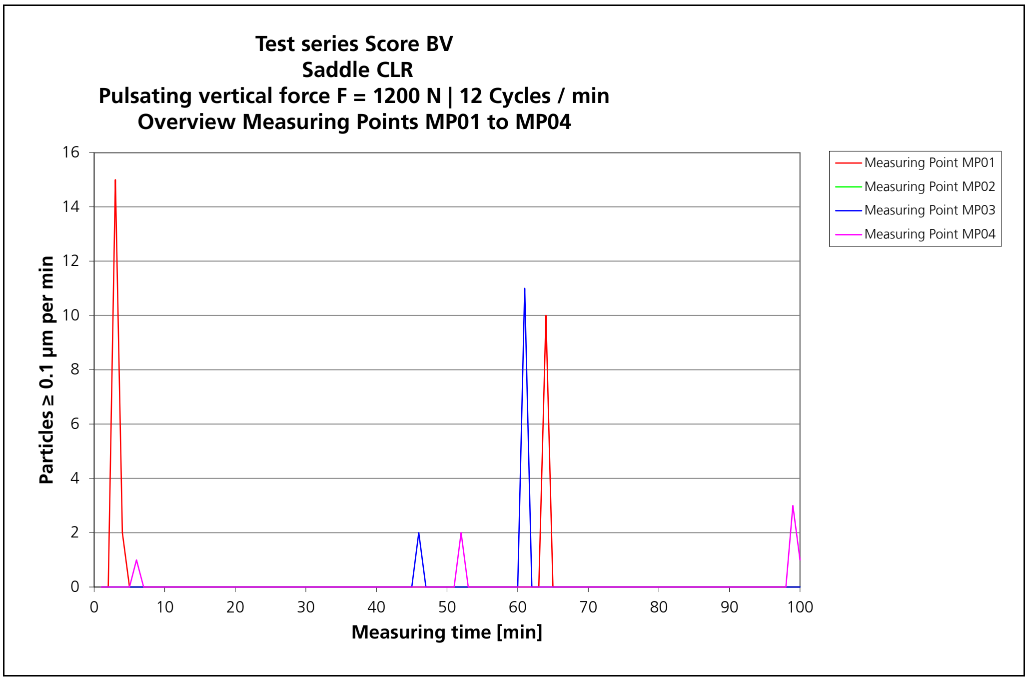

Figure 7 Chronological progression of particles sized ≥ 0.1 µm emitted from the test piece at Measuring Points MP01 to MP04 over the test period of 100 minutes

3.6 Classification

The aim of the tests was to clarify in which clean environments the test piece may be operated as defined in VDI 2083 Part 9.1. The following classifications have been carried out based on ISO 14644-1 and on a statistical analysis of the data obtained. A table has also been included in the annex which compares the classification according to ISO 14644-1 with other current air cleanliness norms.

3.6.1 Statistical verification of the measurement data

International air cleanliness standards, such as ISO 14644-1, state limiting values for each of the Air Cleanliness Classes they define. These limiting values are stipulated for specific particle channels (e.g. ≥ 0.1 µm, ≥ 0.2 µm, ≥ 0.3 µm, ≥ 0.5 µm, ≥ 1.0 µm and ≥ 5.0 µm). On comparing a value obtained empirically (e.g. from a qualification test) with such a limiting value, a degree of certainty is usually required by which the limiting value may not be exceeded. In technology, a statistical degree of certainty of 95 % is generally considered to be adequate.

Poisson and Student distribution are used as a basis for statistical observations in both of the internationally-recognized air cleanliness standards, ISO 14644-1 and VDI Guideline 2083. Poisson distribution is applied if the limiting values considered are < 10 and Student distribution is utilized in all other cases. The basis of the calculations is formed by mean values and standard deviations determined empirically in the test series.

When classifying operating utilities in accordance with the procedure laid down in Guideline VDI 2083 Part 9.1, statistical probabilities of not exceeding limiting values are ascertained for each of the limiting values stipulated for the Air Cleanliness Classes 1 - 9. The relevant class is the one where the statistical certainty of 95 % of keeping within the limiting value is not exceeded (»worst-case assumption«). This means that the corresponding probability of exceeding limiting values is equal to or less than 5 %.

This is ascertained at each Measuring Point for all six particle channels ≥ 0.1 µm to ≥ 5.0 µm recorded and is based on the limiting values specified. If a test series has several Measuring Points, the relevant Measuring Point is the one with the highest (poorest) Air Cleanliness Class where particle counts remain within limiting values. The operating utility is then classified into this Air Cleanliness Class when operated under the same parameters as those used in the test.

Poisson and Student distribution are recognized as significant types of distribution under the following conditions:

- The detected particles are randomly distributed in the gas.
- In order to apply Poisson distribution, limiting values must be less than or equal to 10 particles per measuring cycle.
- In order to apply Student distribution, limiting values must be higher than or equal to 10 particles per measuring cycle.

3.6.2 Calculation of individual probabilities of exceeding limiting values and classify-cation

When performing airborne particle emission measurements, **VDI 2083 Part 9.1** specifies that particle emission values are to be recorded at each Measuring Points over a **test period of 100 minutes**.

The following figures show the air cleanliness classifications attained in accordance with ISO 14644-1 and the corresponding probabilities of exceeding limiting values for each Measuring Point. The Air Cleanliness Class relevant for each test series has been highlighted.

Test series Score BV Saddle CLR Pulsating vertical force F = 1200 N | 12 Cycles / min Overview Measuring Points MP01 to MP04					
Statistical parameters		Measuring Point			
		MP01	MP02	MP03	MP04
Mean values for the detection size [particles / cft]	0.1 µm	0.3	0.0	0.1	0.1
	0.2 µm	0.1	0.0	0.1	0.0
	0.3 µm	0.1	0.0	0.1	0.0
	0.5 µm	0.1	0.0	0.1	0.0
	1.0 µm	0.0	0.0	0.0	0.0
	5.0 µm	0.0	0.0	0.0	0.0
Standard deviation for the detection size [particles / cft]	0.1 µm	1.8	0.0	1.1	0.4
	0.2 µm	1.3	0.0	0.6	0.2
	0.3 µm	1.2	0.0	0.6	0.2
	0.5 µm	0.7	0.0	0.5	0.1
	1.0 µm	0.4	0.0	0.4	0.1
	5.0 µm	0.1	0.0	0.0	0.0
Air Cleanliness Class [ISO 14644-1]		**3**	1	**3**	2
Limiting values of particles in corresponding Air Cleanliness Class for the detection size [particles / cft]	0.1 µm	28	0	28	3
	0.2 µm	7	0	7	1
	0.3 µm	3	0	3	0
	0.5 µm	1	0	1	0
	1.0 µm	0	0	0	0
	5.0 µm	0	0	0	0
Probability of exceeding limiting values for the detection size [%]	0.1 µm	<0.1	<0.1	<0.1	<0.1
	0.2 µm	<0.1	<0.1	<0.1	<0.1
	0.3 µm	<0.1	<0.1	<0.1	2.0
	0.5 µm	0.2	<0.1	0.1	1.0
	1.0 µm	3.9	<0.1	3.9	1.0
	5.0 µm	1.0	<0.1	<0.1	<0.1
Statistical certainty of keeping within the required limiting value for the given Air Cleanliness Class [%]		96.1	>99.9	96.1	98.0

Figure 8 Statistical certainties and probabilities of exceeding limiting values at Measuring Points MP01 to MP04

From the calculations of the probability of exceeding limiting values for the detection sizes ≥ 0.1 µm, ≥ 0.2 µm, ≥ 0.3 µm, ≥ 0.5 µm, ≥ 1.0 µm and ≥ 5.0 µm, it can be derived that the test piece is suitable for use in cleanrooms fulfilling the specifications of **Class 3** in accordance with ISO 14644-1.

3.7 Annex: Comparison of classifications of airborne particulate contamination

Here, the limiting values determining Air Cleanliness Classes according to the international norm **ISO 14644-1** are compared with limiting values as stated in **EU GMP Guideline** Volume 4, Annex 1 and in the American norm **US Federal Standard 209E** (since retracted). The comparison is made using the particle size channels as explicitly stipulated in ISO 14644-1; limiting values are stated for the reference volumes of 1 m³ and 1 cft (1 cubic foot = 0.0283 m³). The comparison is based on these values.

Regulatory				Limiting values of each air cleanliness class for differing particle sizes and reference volumes (acc. to ISO 14644-1)											
DIN EN ISO 14644-1	EU-GMP "at rest"	EU-GMP "in operation"	US Fed. Standard 209E*	0.1 µm		0.2 µm		0.3 µm		0.5 µm		1.0 µm		5.0 µm	
				per m³	per cbf	per m³	per cbf	per m³	per cbf	per m³	per cbf	per m³	per cbf	per m³	per cbf
1				10	0.3	2	0.1								
2				100	3	24	1	10	0.3	4	0.1				
3				1,000	30	237	7	102	3	35	1	8	0.2		
			1	1,240	35	265	8	106	3	35	1				
4				10,000	300	2,370	67	1,020	29	352	9.9	83	2		
			10	12,000	340	2,650	75	1,060	29	353	10				
5				100,000	2,833	23,700	671	10,200	289	3,520	100	832	24	29	0.8
	A	A								3,520	100			20	0.6
	B									3,520	100			29	0.8
			100			26,500	750	10,600	300	3,530	100				
6				1,000,000	28,329	237,000	6,710	102,000	2,890	35,200	997	8,320	235	293	8
			1,000							35,300	1,000			247	7
7										352,000	9,972	83,200	2,357	2,930	83
	C									352,000	9,972			2,900	82
		B								352,000	9,972			2,900	82
			10,000							353,000	10,000			2,470	70
8										3,520,000	99,716	832,000	23,569	29,300	830
	D									3,520,000	99,716			29,000	821
		C								3,520,000	99,716			29,000	821
			100,000							3,530,000	100,000			24,700	700
9										35,200,000	997,167	8,320,000	235,694	293,000	8,300

Figure 9 Overview of limiting values for airborne particles per m³ or cft for the norms ISO 14644-1, EU GMP Guideline Volume 4, Annex 1 and US Federal Standard 209E (since retracted).

Biotic airborne particle levels, for which limiting values are stipulated in the EU GMP Guideline Volume 4, Annex 1, were not investigated at the Fraunhofer IPA as part of these qualification tests. As each manufacturing environment possesses its own individual spectrum of microorganisms, it is not possible to carry out such tests in a reference laboratory. Rather, they can only be performed directly in the actual manufacturing environment concerned. The individual spectrum of microorganisms present is primarily influenced by production sequences, the prevailing environment and by the operating staff working in each specific manufacturing area.

Fraunhofer IPA

4 Determination of ESD characteristics

4.1 Test / cleanroom environment

The tests were performed in the test center for semiconductor devices at the Fraunhofer IPA. They were carried out under the same environmental conditions as those mentioned in Chapter 3.1.

4.2 Test set-up and procedure

The aim was to clarify the suitability of the test piece for use in clean environments. To do this, it was tested to assess its electrostatic behavior (surface resistivity, discharge resistance and volume resistivity).

Before commencing the tests in the cleanroom, the test piece was first wiped clean with a mixture of isopropanol and deionized water and dried using ionized ultra-pure compressed air. It was then placed on insulating mats in a vertical laminar air flow.

Before determining surface resistivity, discharge resistance and volume resistivity, the highly-insulating mounted base mats with the test piece placed on them were first electrically discharged / neutralized. To achieve this, a mass potential was applied to the base mats with the test piece placed on them. The surfaces of the materials to be tested were then neutralized immediately afterwards using an air ionization device.

4.3 Test equipment

The following devices were utilized for the tests described:

- Data capture:
  Tera Ohm meter Model 6206, manufactured by Eltex (Weil am Rhein)
- Measuring probes (2):
  ets Model 850 (2.5 kg), manufactured by Electro-Tech Systems Inc. (Glenside, USA)
- Counter electrode:
  Stainless steel plate
  Dimensions: 1000 mm x 500 mm (± 2 mm), 1.2 ± 0.1 mm thick
- Insulating mounts:
  Planar PTFE-sheet with R > 10^{14} Ohm
  Dimensions: 1210 mm x 1200 mm (± 5 mm), 5 mm (± 1 mm) thick.

The tests were carried out in compliance with DIN EN 61340-5-1 and DIN EN 61340-4-1 (August 2001).

The following generally applies:
"For resistances below 1.0 x 10^6 Ω, the measuring device must have an operating voltage of 10 V +/- 0.5 V,
for resistances ranging between 1.0 x 10^6 Ω and 1.0 x 10^9 Ω, an operating voltage of 100 V +/- 5 V and
for resistances above 1.0 x 10^9 Ω, an operating voltage of 500 V +/- 25 V."
(Freely translated from DIN EN 61340-4-1 (Dec. 2004) Page 4).
Therefore, not all possible resistance values were determined in the tables from Figure 11, Figure 13 and Figure 15, rather only those relevant to the norm.

In accordance with the criteria laid down in **DIN EN 61340-5-1:2008-07** for seats (see Table DIN EN ISO 61344-5-1 table 3), surface resistivity, discharge resistance and volume resistivity needs to be ascertained. The test piece must fulfill the following specifications:

- surface resistivity **R ≤ 1 x 10^{10} Ω**
- discharge resistance **R ≤ 1 x 10^{10} Ω**
- volume resistivity **R ≤ 1 x 10^{10} Ω**

4.4 Surface resistivity tests

The following figures show the test set-up used to determine surface resistivity.

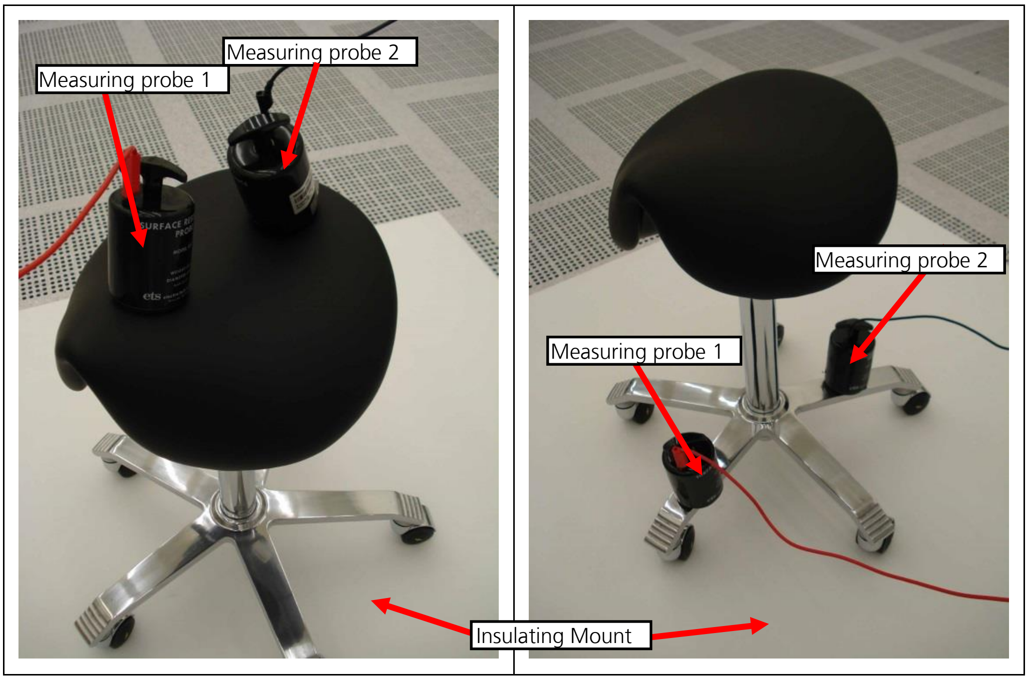

Figure 10 Test set-up to determine surface resistivity

Surface resistivity (point-to-point resistance) expresses the conductivity of the component surfaces.

To measure surface resistivity, (if geometrically possible) the measuring probes described in Chapter 4.3 are placed on the test piece with a distance of 300 mm ± 10 mm (distance each from center to center under 3 geometrical orientations). The test piece was placed on an insulating mount (see Chapter 4.3) and did not touch any other surfaces in the test environment during the tests. A mean value was then calculated from the values obtained at the three different Measuring Points.

The following overview shows the test results obtained from the test materials.

	Operating voltage [V]	Surface resistivity [Ω]	Rating:
Seat 1	**10**	**2.0E+05**	**»electrostatically discharging«**
Seat 2	**10**	**3.6E+05**	**»electrostatically discharging«**
Seat 3	**10**	**3.7E+05**	**»electrostatically discharging«**
Foot 1-3	**10**	**2.2E+03**	**»electrostatically discharging«**
Foot 2-5	**10**	**2.0E+03**	**»electrostatically discharging«**
Foot 1-4	**10**	**2.0E+03**	**»electrostatically discharging«**

Figure 11 Measurement values of electrical surface resistivity of test piece TP01 in accordance with DIN EN 61340-5-1 with a relative humidity of 45 % ± 5 %

The electrical surface resistivity values obtained from the test piece lie below the limiting value of $\mathbf{1 \times 10^{10}\ \Omega}$ required for protective ESD elements.

4.5 Volume resistivity tests

The following figures show the test set-up used to determine volume resistivity.

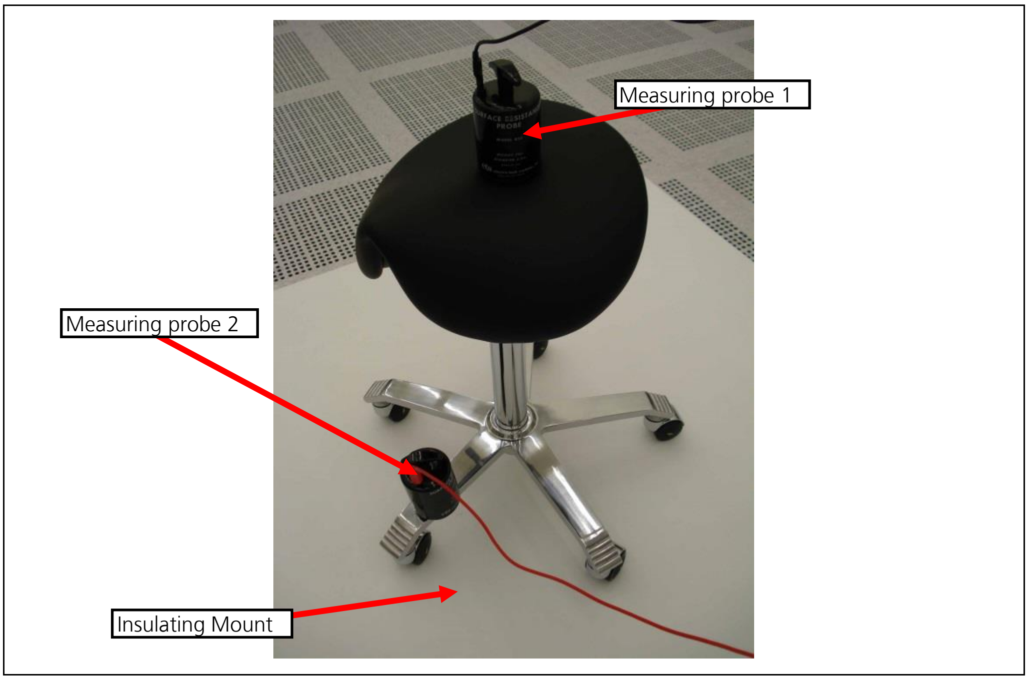

Figure 12 Test set-up to determine volume resistivity

Volume resistivity (end-to-end resistance) expresses the ability of a test piece to discharge an electrical charge either via its surface or through its body. Both the conductivity of connections between separate components and the conductivity of the surface are relevant for this.

In order to measure volume resistivity, the measuring probes described in Chapter 4.3 were placed on two different materials/components of the test piece whose center was at least 100 mm away from the edge of the test piece (where geometrically possible). The test piece was located on an insulating mount (see Chapter 4.3) and did not touch any other surfaces in the test environment during the measurements. A mean value was then calculated from the values obtained at the three different Measuring Points.

The following overview shows the test results obtained from the test materials.

	Operating voltage [V]	Volume resistivity [Ω]	Rating:
Seat -> Foot 1	**10**	**3.4E+06**	**»electrostatically discharging«**
Seat -> Foot 3	**10**	**3.0E+06**	**»electrostatically discharging«**
Seat -> Foot 4	**10**	**1.6E+06**	**»electrostatically discharging«**

Figure 13 Measurement values of the electrical volume resistivity of test piece TP01 in accordance with DIN EN 61340-5-1 with a prevailing relative humidity of 45 % ± 5 %

The electrical volume resistivity values obtained from the test piece lie below the limiting value of **1×10^{10} Ω** required for protective ESD elements.

4.6 Discharge resistance tests

The following figures show the test set-up used to determine discharge resistance.

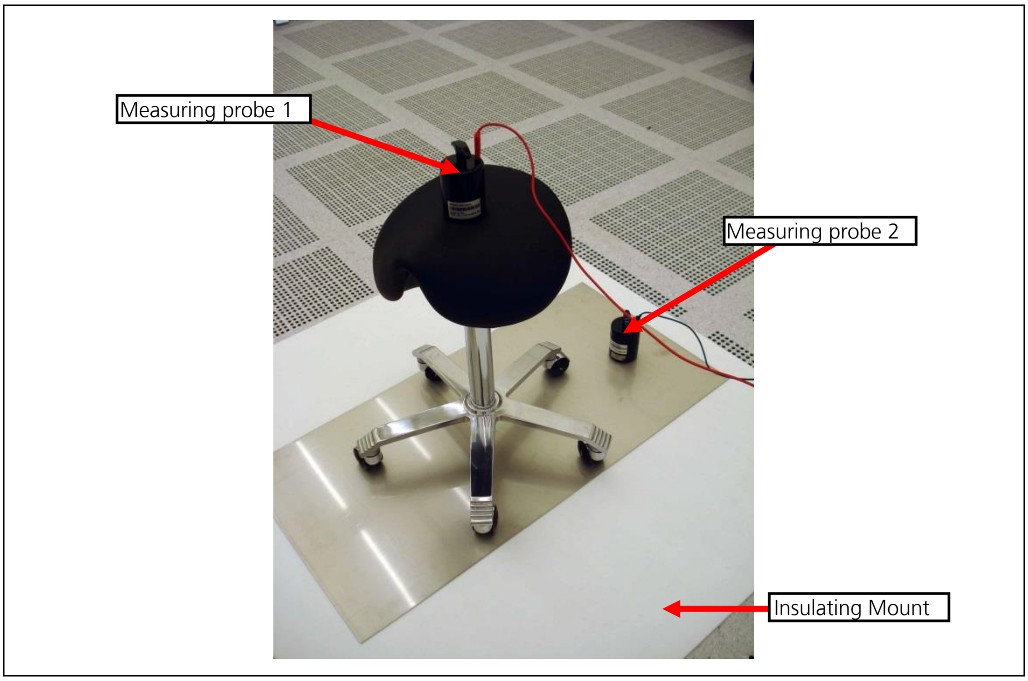

Figure 14 Test set-up to determine discharge resistance

Discharge resistance (resistance to earth) expresses the ability of a test piece to discharge an electrical charge via its surface or through its body to an earthing point or earthed surface (e.g. floor covering in an **e**lectrostatically **p**rotected **a**rea (EPA)). The conductive connection of the separate components is especially relevant here.

By determining the electrical discharge resistance, the suitability of the materials used to discharge electrical charges could be ascertained.

In order to measure discharge resistance, the test piece was placed on a conductive metal plate with an insulating mount (see Chapter 4.3) and did not touch any other surfaces in the test environment during the measurements. The first measuring probe described in Chapter 4.3 was placed on the test piece. The second electrode was connected to the earthing of the system (where available) and placed on the conductive metal plate between the insulating mount and the test piece. Measurements were taken in 3 geometrical orientations and a mean value then calculated from the values obtained.

The following overview shows the results obtained from the test materials.

	Operating voltage [V]	Discharge resistance [Ω]	Rating:
Measuring 1	**10**	**1,8E+05**	**»electrostatically discharging«**
Measuring 2	**10**	**1,9E+05**	**»electrostatically discharging«**
Measuring 3	**10**	**2,1E+05**	**»electrostatically discharging«**

Figure 15 Measurement values of electrical discharge resistances of test piece TP01 in accordance with DIN EN 61340-5-1 with a relative humidity of 45 % ± 5 % prevailing

The electrical discharge resistance values obtained from the test piece lie below the limiting value of **1 x 10^{10} Ω** required for protective ESD elements.

4.7 Overview ESD characteristics

The following overview shows the mean value and the rating of the ESD characteristics:

	Operating voltage [V]	Resistance [Ω]	Rating:
Surface resistivity	10	1.6E+05	»electrostatically discharging«
Volume resistivity	10	2.7E+06	»electrostatically discharging«
Discharge resistance	10	1.9E+05	»electrostatically discharging«

Figure 16 Mean value and rating of the ESD characteristics of test piece TP01 in accordance with DIN EN 61340-5-1 with a relative humidity of 45 % ± 5 % prevailing

The saddle chair »Saddle CLR« fulfills the ESD requirements for EPAs (ESD-protectet areas) of surface resistivity, volume resistivity and discharge resistance according DIN EN 61340-5-1 and DIN EN 61340-4-1.

4.8 Annex: ESD classification

4.8.1 Definition of resistance values as stated in DIN EN 61340-5-1

Electrostatic material properties	Resistance [Ω]				
Insulating	1×10^{11}	$\leq$	$R_{surface}$		
Electrostatically discharging	1×10^{5}	$\leq$	$R_{surface}$	$<$	1×10^{11}
Electrostatically cunductive	1×10^{2}	$\leq$	$R_{surface}$	$<$	1×10^{5}

4.8.2 Requirements of ESD protective elements as laid down in DIN EN 61340-5-1 (with regard to seatings)

Type of resistance	Resistance [Ω]		
Resistance to EPA earth or to an earthing point	$R_{Measuring\ points}$	$\leq$	1×10^{10}