CIT Energy Management AB
A Chalmers Industriteknik Company

Test report

Evaluation of particle generation from a chair for use in cleanrooms

RH Activ 200/220

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Göteborg 2010-11-30

Summary

A chair of model RH Activ 200/220 from Scandinavian Business Seating AB, was tested in a clean zone of ISO Class 4 (US Federal Standard class 10). The tests were conducted for the three particle sizes intervals >0.3µm, >0.5µm and >1µm. The air cleanliness class of the zone was verified before the test of the chair.

The class of the working area remained unchanged when the tested chair was used. Thus, it is concluded that the tested chair can be used in a cleanroom of ISO Class 4, without deterioration of the air cleanliness class.

The gas-stem for adjustment of the seat height was found to release particles when operated. This particle generation is of similar strength as the particle generation from the person using the chair (rising and sitting sown).

The generation of particles from a human dressed in clean room clothes is roughly in the range 1000 till 10 000 particles per second depending on the quality of the clothes and the type of activity. The sum of particles generated by the laboratory personnel and the chair should be prevented from reaching sensitive processes and equipment. This shall be achieved by proper arrangement of the ventilation of the clean zone and by proper location of particle generating sources in relation to the area of clean work. The air cleanliness class ISO 4 (FedStd 10) typically requires the air flow in the cleanroom to be unidirectional, which was the case at the location for the present test.

Background

Today, there are no standards for cleanroom classification of products used in clean rooms. Instead, standards related to cleanroom classification are those defining air cleanliness classes and methods for verification of the cleanness of the air in a clean room (e.g. the old US Federal Standard 209E which has been superseded by the ISO 14644 standard).

In order to verify whether an object can be used in a clean room, considering its particle generation, there are two principally different ways to go. One approach is to measure the particle generation rate of the object itself (e.g. isolating the chair and excluding the influence of the person operating the chair), and compare it to other sources of pollution in the clean room. This approach can be deemed dubious, since such comparison data rarely are available. In the present case, that of testing a chair, this approach may also miss the suspected particle generation due to wear (friction) between the clothes and the seat covering.

The other approach is to measure the particle concentration in a clean zone when the object is used in its normal function. The particle concentrations measured when the test object is in use shall then be compared to the concentrations measured during the use of a reference object, known to have a negligible particle generation. The present test was carried out according to the latter approach.

In the present investigation the object was a chair studied in action with a person dressed in good clean room clothes. A plastic chair, without any padding or moving parts, was used as reference chair. It is reasonable to expect that the main contributors of particle generation are partly the wear (friction) between the clothes and the covering of the chair, and partly the

wear (friction) of surfaces in the mechanisms of the chair. Both these particle generating processes are considered in the approach selected.

The results shown in the present report are valid for the tested object only (described below). However, chairs of other models, but with an equivalent seat cover material and with an equal mechanism can be expected to show similar results, as regards particle generation.

Measurement location and personnel

The measurements were carried out on 8 November 2010 by Lars Ekberg and Tommy Sundström, CIT Energy Management AB.

The tests were performed in an ISO Class 4 zone in the micro-technology laboratory, MC2, at Chalmers University of Technology, Gothenburg, Sweden.

The airflow in the zone was unidirectional with a downward air velocity of 0.4 m/s at a height of 1 m above floor level.

The tested object

The tested object was a chair manufactured by RH – Scandinavian Business Seating AB. Prior to testing, the surfaces of the chair were rinsed using a cloth with alcohol. The tested chair was not labeled. However, the manufacturer has submitted the following information for identification of the chair:

RH Activ 200, ESD cleanroom (low back rest)
RH Activ 220, ESD cleanroom (high back rest)
Armrest: 8E ESD (pair)
Carton combi (0,24)
Gas stem 4B chrome
Castor 7FM (Metal/Soft floor)
Fabric Anti Static VINYL PG5
Base 5J Polished incl caps

The chair is equipped with a filter fabric, covering the entire back sides of both the back-rest and the seat.

Measurement instruments

An optical particle counter, *CLIMET CI-450t-02* serial number 081287, was used for measurement of the number concentration of airborne particles. The measurements were made using the following particle size thresholds: 0.3, 0.5, 1 and 5µm. Results for particles larger than or equal to 0.3, 0.5 and 1 µm are reported in the appendices. The instrument was calibrated 12 April, 2010.

A sensor of the type Swema, SWA 31, was used for air velocity measurements. The sensor has the serial number 382989 and it was calibrated 29 January, 2010.

Documentation of the instrument calibration is found in Appendix 3.

Method

Prior to the tests it was verified that the selected zone was of ISO Class 4 according to the ISO 14644-1 standard (class 10 according to US Federal Standard 209E). The chair was placed in front of a stainless steel table, as shown in Figure 2. The air velocity of the downward parallel airflow was measured to 0.4 m/s at a height of 1 m over the floor. The temperature was 20.1 °C and the relative humidity was 45.7 %RH.

The test-personnel were dressed in high quality cleanroom clothes during the tests, see Figure 2. Data for the cleanroom clothes are:

Brand and model: FRISTADS XT36-8R003
Material: 100% Polyester with carbon threads
Fabric: Cellgard 4
Filtration efficiency for particles >0.3µm: 85%
Filtration efficiency for particles >0.5µm: 88%
Suitable for clean room class 10 (US Federal Standard)

Test-cases

Particle concentrations were measured for the following cases:

- An empty chair
- A chair with a non-moving person
- A chair with a person rising from the chair and sitting down. This was done with a tempo of 1 cycle per 4 seconds.
- A chair with a person changing angel of backrest. This was done with a tempo of 1 cycle per 4 second.
- A chair with a person changing angle of seat and backrest. This was done with a tempo of 1 cycle per 4 second.
- A chair with a person changing height of seat. This was done with a tempo of 1 cycle per 4 second.

Each of the cases described above was investigated by at least three separate particle counting periods. Each period comprised one minute sampling of one cubic foot of air.

In addition to the tested chair, a sub-set of measurements were carried out using a reference chair. The reference chair was made of plastic, without padding or any moving parts.

The particle measurements were made at two locations (as indicated by Figure 1 and Figure 2):

1) In the working-zone at the top of the table, see figure 2. This location represents the working zone, where the air cleanliness requirement of the class must be fulfilled.

2) In addition measurements were made under the chair, near the center of the chair at a height of 0.25 m above the floor.

***Figure 1**. Chair in clean room (high back-rest and low back-rest).*

***Figure 2**. Chair with seated person.*

Results

The results from measurements in the working zone (at the table) are shown in Appendix 1, while results from measurement below the chair are summarized in Appendix 2.

Measurements in the working zone
All measurements in the working zone, at the top of the table, showed particle concentrations that met the requirement according to ISO Class 4, at >0.3µm, >0.5µm and 1 µm.

Slightly increased concentrations were observed for the case when the test person moved, by rising and sitting down, repeatedly. However, the requirement for ISO Class 4 was still met.

Measurements under the seat
The measurements under the seat showed concentrations that met the requirement for ISO Class 4 in all cases, except the following:

- When the test person moved by rising and sitting down, repeatedly
  - Most likely, the particles originated from the person moving – not from the chair. This is supported by the observation that the measurement when using the reference chair showed even higher concentrations.
- When the test person changed the height of the seat (activating the gas-stem)
  - This is an indication that particles are released from the gas-stem. However, it is judged that the contribution to the particle concentration in the room is small, partly because the particle release takes place only when the gas-stem is operated, and partly because the particle release takes place rather close to the floor.
  - The particle concentration measured when operating the gas-stem were of the same magnitude as measured when the test person moved about the reference chair (rising and sitting down). This is an indication that the particle generation from the gas stem is of similar strength as that from a moving person.

Note that the classification of a cleanroom normally is made considering the particle concentration where sensitive products are exposed, e.g. typically in the working zone. The concentration close to the floor is normally not considered at all. In this report, concentrations below the chair (0.25 m above the floor) has been reported in order to provide additional information about the potential particle generation from the tested chair.

Conclusion

The cleanroom class of the working area remained unchanged when the tested chair was used. Thus, it is concluded that the tested chair can be used in a cleanroom of ISO Class 4, without deterioration of the air cleanliness class.

The gas-stem for adjustment of the seat height was found to release particles when operated. This particle generation is of similar strength as the particle generation from the person using the chair (rising and sitting sown).

Appendix 1 Results – Measurements in the working zone

Table 1.1 summarizes the air cleanliness requirements according to the ISO Class 4, for three particle size intervals. In addition, the requirements according to the old US Federal Standard 209E are presented for comparison. In order to facilitate the comparison, all concentrations are presented using the unit *particle number per cubic foot*. However, the basic unit according to the ISO standard is per cubic meter. The concentration values in the tables can be translated to *particle number per cubic meter* by multiplying with 35.3.

Table 1.1. Requirements FedStd 209E Class 10 and ISO Class 4

Particle size [µm]	Federal Standard 209E [number/cuft]	ISO Class 4 [number/cuft]
≥0.3	30	29
≥0.5	10	10
≥1.0	2	2

In the following tables, the results from measurements in the working zone (at the top of the table) are summarized, test case by test case. Cases where the requirement for ISO Class 4 is not met are marked with bold borders of the table cell.

Note that according to the ISO standard, the criterion is set for the average concentration measured at each location. The maximum recorded concentration is given as supplemental information.

Unless otherwise specified, the data are obtained using the high back-rest mounted on the chair.

Table 1.2. RH chair with no person, measured in working zone

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	0	0
≥0.5	0	0
≥1	0	0

Table 1.3. RH chair with a non-moving person, measured in working zone

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	0	0
≥0.5	0	0
≥1	0	0

Table 1.4. RH chair with a moving person (rise and sit down), measured in working zone

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	5	5
≥0.5	2	4
≥1	<1	1

Table 1.5. RH chair with a person changing angle of back rest, measured in working zone

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	0	0
≥0.5	0	0
≥1	0	0

Table 1.6. RH chair with a person changing angle of seat and back rest, measured in working zone

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	0	0
≥0.5	0	0
≥1	0	0

Table 1.7. RH chair with a person changing height of seat, measured in working zone

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	0	0
≥0.5	0	0
≥1	0	0

Table 1.8. Reference chair, with a moving person (rise and sit down), measured in working zone

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	1	4
≥0.5	0	0
≥1	0	0

Table 1.9. RH chair with a person changing angle of seat and back rest, measured in working zone. The chair was equipped with the low back-rest.

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	0	0
≥0.5	0	0
≥1	0	0

Appendix 2 Results – Measurements under seat

In the following tables the results from measurements below the chair (0.25 m above the floor) are summarized, test case by test case. Cases where the requirement for ISO Class 4 is not met are marked with bold borders of the table cell.

Note that according to the ISO standard, the criterion is set for the average concentration measured in each location. The maximum recorded concentration is given as supplemental information.

Note also that the classification of a cleanroom normally is made considering the particle concentration where sensitive products are exposed, e.g. typically in the working zone. The concentration at floor level is normally not considered at all. In this report, concentrations at floor level are reported in order to provide additional information about the potential particle generation from the tested chair.

Unless otherwise specified, the data are obtained using the high back-rest mounted on the chair.

Table 2.1. RH chair with no person, measured under seat

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	0	0
≥0.5	0	0
≥1	0	0

Table 2.2. RH chair with a non-moving person, measured under seat

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	4	6
≥0.5	2	3
≥1	<1	1

Table 2.3. RH chair with a moving person (rise and sit down), measured under seat

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	62	76
≥0.5	46	57
≥1	27	36

Table 2.4. RH chair with a person changing angle of back rest, measured under seat

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	9	14
≥0.5	6	10
≥1	2	5

Table 2.5. RH chair with a person changing angle of seat and back rest, measured under seat

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	6	8
≥0.5	4	5
≥1	1	3

Table 2.6. RH chair with a person changing height of seat, measured under seat

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	216	292
≥0.5	155	236
≥1	63	101

Table 2.7. Reference chair, with a non-moving person, measured under seat

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	3	6
≥0.5	1	1
≥1	0	0

Table 2.8. Reference chair, with a moving person (rise and sit down), measured under seat

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	305	353
≥0.5	204	242
≥1	104	120

Table 2.9. RH chair with a person changing angle of back rest, measured under seat. The chair was equipped with the low back-rest.

Particle size [µm]	Average [number/cuft]	Max [number/cuft]
≥0.3	18	26
≥0.5	8	10
≥1	2	3

Appendix 3 – Documentation of instrument calibration

Figure A1. *Calibration label of the particle counter, CI-450t-02, serial number 081287.*

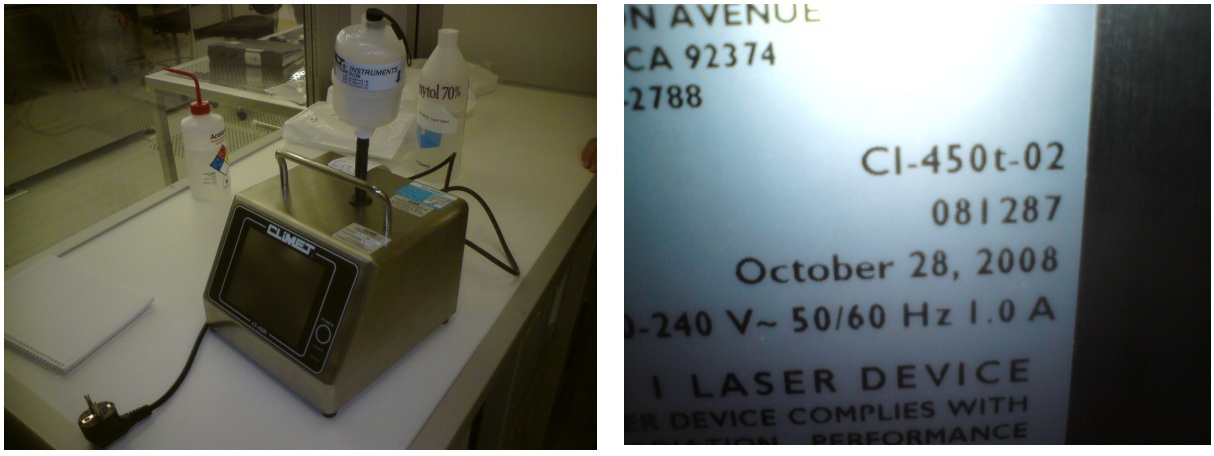


Figure A2. *Photo of the particle counter and model label, CI-450t-02, serial number 081287.*

Measuring equipment:
These instruments have been used when calibrating the probe.

Parameter	Name	Serial no.
Air velocity	Windtunnel SWEMA 2	A/N 8
Differential Pressure	MKS Baratron	R/N 1
Reference instrument	SwemaAir 300	See Cal.Setup
Atmospheric Pressure	HALSTRUP /BA90	A/N 69
Air Temperature	Rotronic I200	A/N 5
Relative Humidity	Rotronic I200	A/N 5

Traceability:
The measuring equipment is traceable calibrated to these official measuring centres

Parameter	Measuring centre
Air velocity	Swedish National Testing and Research Institute
Differential pressure	Swedish National Testing and Research Institute
Air temperature	Swedish National Testing and Research Institute
Atmospheric Pressure	Swedish National Testing and Research Institute
Relative humidity	Rotronic SCS

SWEMA
Tel: +46 (0)8 94 00 90 Fax +46 (0)8 93 44 93
E-mail: swema@swema.se www.swema.se
Delivery address: Pepparv. 27, SE-123 56 Farsta, Sweden
Postal address: Pepparv. 27, SE-123 56 Farsta, Sweden

Certificate no: 0029509

Calibration Certificate

Calibration without adjustment of an Air speed probe SWA 31

Calibration results:

```
S/N: 382989
Manufact. date: 1999-02-10
Required Software version:  1.00
Required Hardware version:  1.00

Cal. date: 2010-01-29
Cal. setup: SWEMA2 (A/N 46)
Next cal. date: 2011-01-29

Cal. cond.: 983 hPa  12 %RH

 True val.   Read val.   Corr
 ---------   ---------   ----
 60.0 cm/s   59.2 cm/s    0.8
 1.00 m/s    0.99 m/s    0.01
 2.00 m/s    1.98 m/s    0.02
 3.00 m/s    2.94 m/s    0.06
 5.00 m/s    4.94 m/s    0.06
 7.00 m/s    6.89 m/s    0.11
 10.0 m/s    10.0 m/s     0.0
  (At 1013 hPa)

 22.5 dgC    22.5 dgC     0.0
```

Calibrated by

Andreas Lanteli

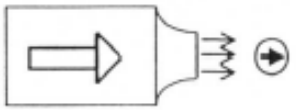
OK!
2010-02-05

Uncertainty of measurement:
Coverage probability 95%
Instrument uncertainty - see manual

Velocity
0,07-0,50 m/s = ± 0,02 m/s.
0,50-3,00 m/s = ± 0,03 m/s
3,00-12,00 m/s = ± 0,04 m/s
Temperature ±0,3°C

Measuring method:
Calibration in a free air stream

The sensors position in the air stream:
Horizontal with the arrow in the air stream direction.



SWEMA

SWEMA ISO 9001 QUALITY MANAGEMENT