CIT Energy Management AB
A Chalmers Industriteknik Company

Test report

Evaluation of particle generation from a chair for use in cleanrooms

HÅG Capisco Puls 8010

Ordered by:	**Scandinavian Business Seating AB** **Roy Bakken**
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Innehåll

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Summary

A chair of model HÅG Capisco Puls 8010 from Scandinavian Business Seating AB, was tested in a clean zone meeting the particle concentration requirements for ISO class 4 or class 5, depending on the intensity of activities performed. The tests were conducted for the four particle size intervals >0.3µm, >0.5µm, >1µm and 5µm.

The particle generation from the chair was found to be negligible compared to the particle generation from the person using the chair, when dressed in high quality cleanroom garments.

The cleanroom class of the working zone remained unchanged when the tested chair was used compared to the case with a reference chair without any moving parts.

There were observations that may indicate that particles are released from the gas-stem when operated for adjustment of the seat height. However, any particle generation from the gas stem is judged to be of less importance than the particle generation from moving people.

No microbial contamination could be detected on the plane surfaces of the seat and the back-rest after these had been rinsed with 70% ethanol.

The generation of particles from a human dressed in clean room clothes is roughly in the range 100 - 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 4-5 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 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.

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 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. However, chairs of other models, but with an equivalent construction, equivalent materials 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 27 May 2014 by Lars Ekberg and Tommy Sundström, CIT Energy Management AB.

The tests were performed in a test chamber in the laboratory at the division of Buildings Services Engineering, 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 of model HÅG Capisco Puls 8010 provided by Scandinavian Business Seating AB, see Figure 1. The chair is mainly made from solid materials; only a small part in the centre of the seat has padding/upholstery. Prior to the tests, the surfaces of the chair were rinsed using a cloth with alcohol.

Figure 1. Photographs showing the tested chair.

Measurement instruments

An optical particle counter, Met One 3313, serial number 030301047, was used for measurement of the number concentration of airborne particles. Results for particles larger than 0.3, 0.5, 1 and 5 µm are reported in Appendix 1 and 2. The instrument was calibrated 22 January, 2014. 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 3 January, 2014. Documentation of the calibration of the instruments is found in Appendix 4.

Method

The tests were conducted in a test chamber with the floor dimensions 1.25 m · 0.80 m and a ceiling height of 2.7 m. The ceiling of the chamber is covered with HEPA filters and the chamber has a unidirectional airflow with extract air located at floor level. 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 and relative humidity were about 21 °C and 45 %RH.

The test-person was dressed in high quality cleanroom clothes during the tests, see Figure 2. The clothing comprised cleanroom under-garments with long sleeves and legs, and a fully covering overall. 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)

Particle generation test-cases

Particle concentrations were measured for the following cases:

- 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 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 lacquered laminate, without padding or any moving parts.

The particle measurements were made in two alternative locations:

1) In the working-zone 1 m above the floor. This location represents the working zone, where the air cleanliness requirement of the class must be fulfilled, see Appendix 1.

2) In addition measurements were made in the air extracted from the test chamber at floor level. This measurement was made in order to estimate the particle generation rate, see Appendix 2.

Figure 2. *Chair with seated person.*

Test of cleanability

Initially, all surfaces of the chair were rinsed using 70% ethanol and a cleanroom cloth. After rinsing, agar contact plates were used to sample microbial contamination on the back rest and on the seat.

Thereafter, the chair was intensely handled by three persons not wearing gloves. The seat and the back-rest were firmly and repeatedly touched by bare hands. New microbial samples were collected on the centre of the seat and on the back-rest.

Finally, the chair was rinsed again using ethanol and a cloth. A third set of microbial samples were collected.

The agar plates were promptly delivered to *SIK – The Swedish Institute for Food and Biotechnology* for incubation and analysis. The analysis result is shown in Appendix 3.

Results

The results from measurements in the working zone (1 m above floor) are shown in Appendix 1, while results from measurement in the extract air are summarized in Appendix 2.

Measurements in the working zone
When the test person repeatedly moved by rising and sitting down the requirements were met for ISO Class 5, at >0.3µm, >0.5µm and 1 µm. This was the case both for the reference chair and the tested chair. The movement was intended as a "stress-test" to provoke a high level of particle generation. Thus, the movement was much too intense (continuously rising and sitting down every 4 second) to comply with the requirements of ISO class 4, both when using the tested chair and the reference chair.

The other tested cases (changing angle and height) showed particle concentrations in the working zone that met the requirement according to ISO Class 4, at >0.3µm, >0.5µm.

Measurements under the seat
The measurements in the extract air showed concentrations that met the requirement for ISO Class 5, except in the following cases:

- 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 similar concentrations.
- When the test person changed the height of the seat (activating the gas-stem)
    - Probably a large fraction of these particles was generated by the person operating the chair.
    - However, the observation might be an indication that particles were released from the gas-stem. 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). Thus, any particle generation from the gas stem is judged to be of less importance than the particle generation from moving people.

- Note that both cases above represent activities of an intensity that is unrealistic in cleanroom applications (continuously rising and sitting down, and continuously changing the height of the chair). The tests were made in order to provoke particle generation in order to estimate a worst case of the potential particle generation.

Conclusions

The particle generation from the chair was found to be negligible compared to the particle generation from the person using the chair, when dressed in high quality cleanroom garments.

The cleanroom class of the working zone remained unchanged when the tested chair was used compared to the case with a reference chair without any moving parts.

No microbial contamination could be detected on the plane surfaces of the seat and the back-rest after these had been rinsed with 70% ethanol.

Gothenburg, June 30, 2014

Lars Ekberg
CIT Energy Management AB

Appendix 1 Results – Measurements in the working zone

Table 1.1 summarizes the air cleanliness requirements according to the ISO Class 4 and 5, for four particle size intervals. 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 for ISO Class 4 and Class 5

Particle size [µm]	ISO Class 4 [number/cuft]	ISO Class 5 [number/cuft]
≥0.3	29	291
≥0.5	10	100
≥1.0	2	24
≥5.0	0.08	0.8

In the following tables, the results from measurements in the working zone (1 m above floor) are summarized, test case by test case.

Table 1.2. The tested Capisco Puls 8010 and the reference chair with a non-moving person, measured in working zone.

Particle size [µm]	Capisco Puls [number/cuft]	Reference chair [number/cuft]
≥0.3	12	18
≥0.5	8	10
≥1	4	3.3
≥5	1.3	1.3

Table 1.3. The tested Capisco Puls 8010 and the reference chair with a moving person (rise and sit down), measured in working zone.

Particle size [µm]	Capisco Puls [number/cuft]	Reference chair [number/cuft]
≥0.3	28	35
≥0.5	15	15
≥1	8	3,3
≥5	1.5	0,7

Table 1.4. The tested Capisco Puls 8010 chair with a person changing angle of the seat and back-rest, measured in working zone.

Particle size [µm]	Capisco Puls [number/cuft]	Reference chair [number/cuft]	
		Non-moving person	Moving person
≥0.3	17	18	35
≥0.5	8	10	15
≥1	4.3	3.3	3,3
≥5	1.3	1.3	0,7

Table 1.5. The tested Capisco Puls 8010 chair with a person changing height of the seat, measured in working zone.

Particle size [µm]	Capisco Puls [number/cuft]	Reference chair [number/cuft]	
		Non-moving person	Moving person
≥0.3	22	18	35
≥0.5	7	10	15
≥1	3	3.3	3,3
≥5	1.5	1.3	0,7

Appendix 2 Results – Measurements in the extract air

In the following tables the results from measurements in the air extracted from the test chamber at floor level are summarized, test case by test case.

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 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.

Table 2.1. The tested Capisco Puls 8010 and the reference chair with a non-moving person, measured in the extract air.

Particle size [μm]	Capisco Puls [number/cuft]	Reference chair [number/cuft]
≥0.3	38	44
≥0.5	13	21
≥1	2.7	8
≥5	0.3	1.3

Table 2.2. The tested Capisco Puls 8010 and the reference chair with a moving person (rise and sit down), measured in the extract air.

Particle size [μm]	Capisco Puls [number/cuft]	Reference chair [number/cuft]
≥0.3	578	588
≥0.5	279	301
≥1	95	121
≥5	12	19

Table 2.3. The tested Capisco Puls 8010 chair with a person changing angle of seat and back rest, measured in the extract air.

Particle size [μm]	Capisco Puls [number/cuft]	Reference chair [number/cuft]	
		Non-moving person	Moving person
≥0.3	98	44	588
≥0.5	33	21	301
≥1	8	8	121
≥5	0.7	1.3	19

Table 2.4. The tested Capisco Puls 8010 chair with a person changing height of the seat, measured in the extract air.

Particle size [μm]	Capisco Puls [number/cuft]	Reference chair [number/cuft]	
		Non-moving person	Moving person
≥0.3	419	44	588
≥0.5	240	21	301
≥1	100	8	121
≥5	18	1.3	19

Table 2.5. The tested Capisco Puls 8010 chair with a person standing beside the chair moving the seat backwards and forwards, measured in the extract air.

Particle size [µm]	Capisco Puls [number/cuft]	Reference chair [number/cuft]	
		Non-moving person	Moving person
≥0.3	206	44	588
≥0.5	95	21	301
≥1	37	8	121
≥5	5	1.3	19

Particle generation rate

The particle generation expressed as number of particles per second can be estimated by multiplying the values in Tables 2.1-2.5 by a factor of 13.5, which is the airflow rate through the test chamber measured in *cubic feet per second*.

For particles >0.5 µm, for example, the particle generation rate ranged from about 200 particles per second with a non-moving person, to about 4 000 particles per second for the case when the test person was moving by repeatedly rising and sitting down. The results were similar for the tested Capisco Puls 8010 and the reference chair.

Appendix 3 – Agar plate analysis result

The table below provides a translation of the result. Original analysis report shown on the next page.

State of contamination	Location	CFU/16cm^2
Rinsed by ethanol	Back-rest	0
	Seat	0
Contaminated	Back-rest	109 (of which 3 mould)
	Seat	108 (of which 2 mould)
Rinsed by ethanol	Back-rest	0
	Seat	0

CFU refers to the total number of colony forming units of aerobic microorganisms collected on contact plates, TSA with disinhibitor plus (TWI).

Analysrapport

Göteborg 2014-06-02

CIT Energy Management AB
Att Lars Ekberg
Sven Hultins gata 9
412 88 Göteborg

Analys av tryckplattor

Prov ankom 2014-05-28

Analysrapport klar 20140602
Provtyp: Tryckplattor för totalantal aeroba mikroorganismer.

Provbeteckning	CFU/16cm^2	CFU/cm^2
Referens		
Rygg referens	**0**	
Sits referens	**0**	
Nedsmutsning av stol		
Rygg nedsmutsad	**109 varav 3 mögel**	**7**
Sits nedsmutsad	**108 varav 2 mögel**	**11**
Rengjord stol		
Sits tvättad	**0**	
Rygg tvättad	**0**	
Luftprov		
Luftprov (nedfallstid saknas)	**0**	

Jag har valt att visa både resultatet för 16cm^2 som plattan markerar eftersom 5 av prover inte har någon växt alls och visar på ett mycket gott resultat.
Luftprover visar på att någon kontaminering från luften inte förelåg vid tillfället.

Med vänlig hälsning
SIK
Mikrobiologi och processhygien

Ingela Karlsson

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Appendix 4 – Documentation of instrument calibration

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CERTIFICATE OF CALIBRATION

Hach certifies that the calibration performed complies with the requirements of ISO 21501 in whole or in part, as requested by the customer. Th reported sizes in the calibration information section are accurate to +/- 10%.

The accuracy of the standards & equipment used for the calibration are traceable to the US National Institute of Standards and Technology (NI performed is maintained by Hach & performed in accordance with the Hach Quality Manual QA1001. This certificate may not be reproduced ot certificates without a watermark & an authorized signature are not valid.

General Information
Calibration Lab
AB Ninolab
Instrumentvägen 4
194 51 Upplands Väsby

Customer Name
CIT Energy Managment AB
Charmers
Vera Sandbergs Allé 5B, 4tr

412 96 GÖTEBORG
Lars Ekberg

Instrument Information

Counter Model	3313	Station ID	Kalibreringsrum	Temperature	21,9 °C
Part Number	2083993-01	Calibration Date	2014-jan-22	Relative Humidity	15,0 %
Counter Serial	030301047			Nominal Flow	28,3 LPM
Sensor Model	AIR	Calibration Due	2015-jan	Laser Current	56,4 mA
Sensor Serial	4087-04	RA Number	S11059	(Reference Only)	
Hach Procedure	CO88149-1 REV E				

Performance Information

Test Name	Test Result	Criteria	Pass/Fail
ISO-21501 Flow	28,3 LPM	±5%	Pass
Hach Noise	50,8 mV	Reference Only	N/A
Hach Peak to Valley	2:1	N/A	N/A
ISO-21501 False Count Rate	0,0 particles in 0,42 m³	0,0 particles in 0,42 m³	Pass

Calibration Equipment

Type	Model	Serial	Cal Due Date
PHA	Core Counter PHA	1004418002	2014-maj-10
DMM	Fluke 116	96430059	2014-aug-16
Stopwatch	Woco Split	UV-01	2014-sep-24
Thermometer	Vaisala HMI 41	U1020030	2014-jul-30
Flow Meter	822-13-OV1	47516	2014-mar-22

Calibration Information

Channel	Size (um)	Cal (mV)	Threshold (mV)	Particle Size (um)	Mfg	Lot Number	Expiration Date
1	0,3	73,0	73,0	0,296	Thermo	41699	2016-feb-01
2	0,5	460,0	460,0	0,498	Thermo	41529	2015-feb-01
3	1,0	699,46	691,37	1,019	Thermo	42129	2016-jun-01
4	3,0	1303,71	1303,08	3,002	Thermo	42335	2016-aug-01
5	5,0	2139,89	1998,91	5,3	Thermo	39502	2014-sep-01
6	10,0	5515,12	5665,18	9,8	Thermo	39409	2014-aug-01

Hach Calibration
030301047.01.22.2014

Bengt Boethius
Calibrator : Bengt Boethius

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Deviation < 5% OK
2014-01-29 Lars Ekberg

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AS RECEIVED DATA

General Information
Calibration Lab
AB Ninolab
Instrumentvägen 4
194 51 Upplands Väsby

Customer Name
CIT Energy Managment AB
Charmers
Vera Sandbergs Allé 5B, 4tr

412 96 GÖTEBORG
Lars Ekberg

Instrument Information

Counter Model	3313	Station ID	Kalibreringsrum	Temperature	21,9 °C
Part Number	2083993-01	Calibration Date	2014-jan-22	Relative Humidity	15,0 %
Counter Serial	030301047	Calibration Due	2015-jan	Nominal Flow	28,3 LPM
Sensor Model	AIR	RA Number	S11069	Laser Current	56,4 mA
Sensor Serial	4087-04	Hach Procedure	CO88149-1 REV E		

As Received Information

Test Name	As Received	As Calibrated	Deviation (%)	Criteria (%)	Pass/Fail
Flow	28,3	28,3	0	±5%	Pass
Noise	52,6	50,8	3,54	---	N/A
Laser Current	56	56,4	-0,71	---	N/A
Zero Count	PASS	---	---	---	N/A

Channel Information

Channel	Size	Calibrated (mV)	Pulse (mV)	As Received (mV)	As Received Size	Deviation(%)	Criteria(%)	Pass/Fail
1	0,3	73,0	73,0	78,0	0,298	-0,67	15,00	Pass
2	0,5	460,0	460,0	460,0	0,498	-0,40	15,00	Pass
3	1,0	691,37	699,46	682,0	0,975	-2,50	15,00	Pass
4	3,0	1303,08	1303,71	1345,0	3,133	4,43	15,00	Pass
5	5,0	1998,91	2139,89	2091,0	5,203	4,06	15,00	Pass
6	10,0	5665,18	5515,12	5625,0	9,944	-0,56	15,00	Pass

Deviation < 5%
Criterion 15%

2014-01-29

Bengt Boethius

Hach Calibration
030301047.01.22.2014
Calibrator : Bengt Boethius

 pg 1 of 1

Certificate no: 4003520

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: 2014-01-03
Cal. setup: SWEMA(A/N 89)
Next cal. date: 2015-01-03
Cal. cond.: 1001 hPa 30 %RH

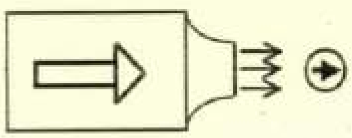
True val.	Read val.	Corr
10.0 cm/s	6.7 cm/s	3.3
25.0 cm/s	24.1 cm/s	0.9
60.0 cm/s	60.4 cm/s	-0.4
1.00 m/s	1.01 m/s	-0.01
2.00 m/s	2.01 m/s	-0.01
3.00 m/s	2.98 m/s	0.02
5.00 m/s	4.98 m/s	0.02
7.00 m/s	6.91 m/s	0.09
10.0 m/s	10.1 m/s	-0.1
(At 1013 hPa)		
21.2 dgC	21.5 dgC	-0.3

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.



Calibrated by

Pernilla Håkansson

SWEMA

SWEMA • ISO 9001 • QUALITY MANAGEMENT

Measuring equipment

Parameter	Name	Serial no.
Air velocity	Air velocity rig SWEMA 2	A/N 8
Differential Pressure	MKS Baratron	R/N 1
Reference instrument	Swema 3000	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 Differential pressure Atmospheric Pressure Air temperature	Swedish National Testing and Research Institute
Relative humidity	Rotronic SCS

SWEMA
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