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Particle Generation from Humans And Filtration efficiency of cleanroom garments

Methods for Experimental Studies in Cleanroom Technology

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Austin Contamination Index

| Activity | Snap Smock | Membrane coverall | Ratio |
|--|------------|-------------------|--------|
| Sitting or standing still | 100,000 | 10 | 10,000 |
| Light movement: head, leg, arm | 500,000 | 50 | 10,000 |
| Heavy movement: head, leg, arm, foot | 1,000,000 | 100 | 10,000 |
| Change position: sitting down, rising up | 2,500,000 | 250 | 10,000 |
| Walking 0.9 m/s | 5,000,000 | 500 | 10,000 |
| Walking 1.6 m/s | 7,500,000 | 750 | 10,000 |
| Walking 2.2 m/s | 10,000,000 | 1,000 | 10,000 |

Number of particles generated by a person per minute, at different degrees of activity, wearing two different types of clothing ($\geq 0.3\mu\text{m}$), Austin and Timmerman 1965. The ratio between snap smock and membrane coverall has been inserted by the authors



Male, 68 kg, 176 cm tall. No facial hair and moderate hair length

Cleanroom coverall and hood (100 % polyester), single use facial protection and latex glove

Sitting totally still

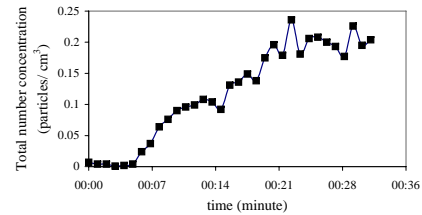
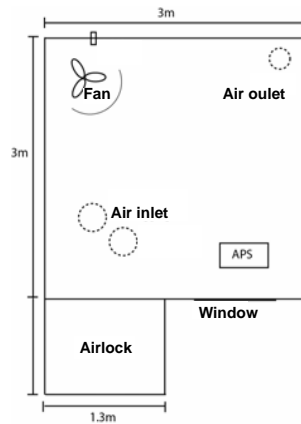
Sitting while performing arm movements – One arm, at a time was moved at an angle of 90°, back and forth in a sweeping motion. The original position of the arm was directed straight ahead with a 90° bend at the elbow. The movement frequency was one second for one arm to be moved back and forth.

Standing with rotating torso – Both hands grabbing the waist and rotating the upper body from side to side, as far as possible in each direction. The time for turning from one side to the other was about two seconds.

Walking on the spot – Walking on the spot with a frequency of two steps per second.



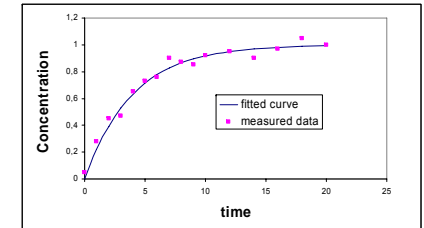
Experimental Set-up



The particle concentration in a well mixed room

The particle concentration can be described using

$$C(t) = \frac{\dot{m}}{Q} \left(1 - e^{-\frac{Q}{V}t}\right)$$



C = particle concentration (number/m³)

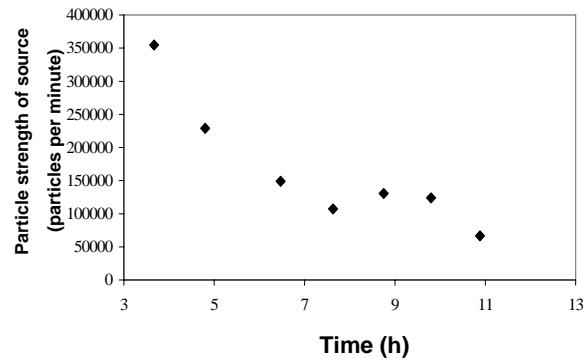
m = source strength (number/s)

Q = sink as ventilation and deposition (m³/s)

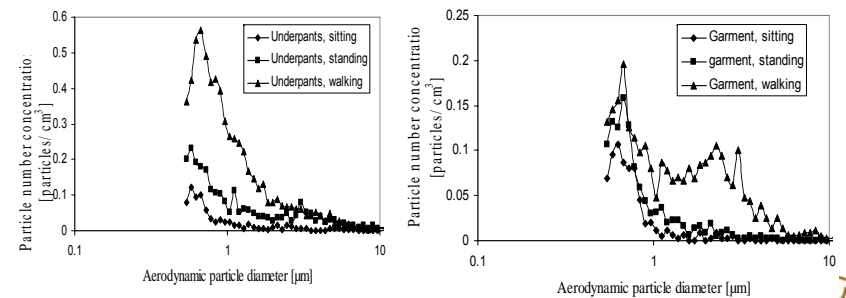
V = volume of room



Particle release vs Time after shower



Particles size distributions: Underpants and Cleanroom Garment



The Results Obtained

| Activity | Underpants (particles/min) | Cleanroom garment (particles/min) | Ratio |
|--------------------------|-------------------------------|--------------------------------------|-------|
| Sitting still | 40,000 | 40,000 | 1.0 |
| Sitting: arm movements | 90,000 | 70,000 | 1.3 |
| Standing: rotation torso | 140,000 | 60,000 | 2.3 |
| Walking on the spot | 400,000 | 180,000 | 2.2 |

Particle strength of source for the test person performing various physical activities and wearing underpants and cleanroom garment. ($D_g \geq 0.53 \mu\text{m}$). The ratio of underpants and cleanroom garment has been inserted.

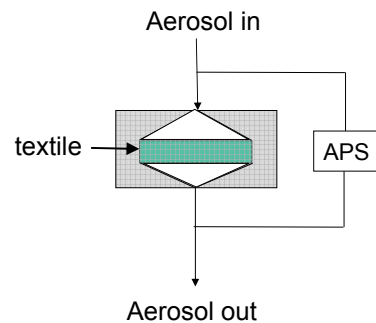


Conclusions and Implications

- The number of particles presented in this paper cannot be directly compared to the data obtained by Austin since these data only apply to particles $\geq 0.3 \mu\text{m}$ and the test method is unknown.
- Our results cannot be considered as general since only one person has been tested.
- However, a method that can be used to study the efficiency of protective garments in cleanrooms has been developed. Further studies are now in progress at our laboratory in Lund.



Test of filtration efficiency through cleanroom textiles



$$\text{Efficiency} = \frac{C_{in} - C_{out}}{C_{in}}$$

If $C_{out} = 0$,
100% efficiency



Measured filtration efficiency of a textile from a cleanroom garment

