It's important what you are wearing under the cleanroom garments!

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Studies on the particle emission of cleanroom garments

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The importance of the correct cleanroom undergarments under the cleanroom garments was again proven in a Body-Box study. Here, lab coats and overalls were each examined in combination with cotton garments or rather cleanroom compatible undergarments underneath.

The fact that cleanroom garments, as the only filter between human and products, should play a decisive role in contamination control in the clean process environment is not denied in most cases. However, it is more difficult to convince users and operators that cleanroom garments should be understood as a system and not „just" as an overall or a lab coat. The professional decontamination, the employee training and thus also motivation, the coordination with the additional garment elements such as gloves or face masks should be mentioned here in the first place. But even more important is the question: „What do the employees actually wear under the cleanroom garments?

There were already meaningful studies and publications from the 1990's and updated in 2002. Nevertheless, in perception of the cleanroom operators the cleanroom suitable undergarments are often a marginal topic, which is willingly pushed aside (not least for cost reasons).

In order to be able to use conditions that are as close as possible to practical conditions, the Body-Box from Dastex in Muggensturm was used for these investigations (Fig. 1).



Cleanroom suitable undergarments – functionality meets design!

The Body-Box is a defined cleanroom, which allows determining particle quantities originating from the respective test person and the garments worn by him/her. In idle mode, i.e. at full filter performance without the test person being in the Body-Box, an air cleanliness class ISO 4 (according to ISO 14644-1) is achieved. If a person enters this cleanroom, all impurities detected afterwards must originate from this person and his/her clothing. A comparative measurement between different garment systems is possible, provided that one and the same test person always wears them. Each person emits different amounts of contaminants and therefore it is absolutely necessary to always use the same test person in the course of such a study. In addition, a sufficiently large number of repetitions must be ensured with the respective test setup, since the values of a single person can also vary considerably.

Apart from the subjects of the test person, types of garments and the number of repetitions, the Body-Box itself has to be examined more closely. Although the test method is rudimentary described in an American recommended practice (IEST-RP-CC003.4), but experience with this measurement technique over the last 15 years has shown that some parameters can significantly influence the measured values. This does not only refer to temperature conditions or humidity in the Body-Box, but rather to the routeing of air flow/air change rates and the general air duct from the test cabin to the measuring points. One conclusion from these rather general findings is that it is most likely not possible to compare results on the same topics, but which were recorded in different Body-Box test cabins.

Results of the comparative study

A goal of the current comparison study was to prove metrological the meaning of cleanroom suitable undergarments, in particular when using cleanroom gowns/lab coats. For this purpose, the following two garment versions were compared with each other in the first test phase: Version 1 with cotton garments under the lab coat and version 2 with cleanroom compatible undergarments under the lab coat (see Fig. 2). Ten measurements were carried out for each version, each with fresh, newly prepared goods. The results shown in the following charts are based on average values: particle number per minute and cubic meter emitted by the test person with the respective test garments.

Chart 1 shows the clear measurement results. The particle counts of version 2, in which the lab coat was combined with cleanroom suitable undergarments made of synthetic fibres, are clearly below the particle counts of version 1 with the cotton garments.

A particle reduction of more than 90% can be achieved without too much effort by using an undergarments designed for the cleanroom requirements. At ambient conditions that typically prevail in cleanroom classes ISO 7 - ISO 9, as well as in production areas of technical cleanliness, these are remarkable results. As a rule, the air duct via the filter ceilings in these production areas is turbulent. In addition, there are further turbulences caused by the movements of the employees. This significantly increases the risk that contaminants that fall out of the coats towards the bottom are easily brought back to product level by the turbulences and can contaminate the product. In addition to the positive results in terms of contamination prevention, the right undergarments can also significantly improve the wearing comfort of the entire clothing system. Typical fibres, which most people already know from sportswear, ensure a pleasant wearing sensation, promote breathability, and in some cases unpleasant odours can also be reduced by antimicrobial functionality. These antimicrobial effective undergarment components are therefore expressly recommended for use in life sciences areas, as they reduce the growth of viable contaminations even under cleanroom garments.

Another important aspect argues in favour of generally recommending the use of defined cleanroom compatible undergarments in all controlled areas: The private street clothing of employees cannot be controlled from the cleanroom operator's point of view. All types of contamination from private household, from the environment or from other areas of the company's own manufacturing/production can thus enter the cleanroom.

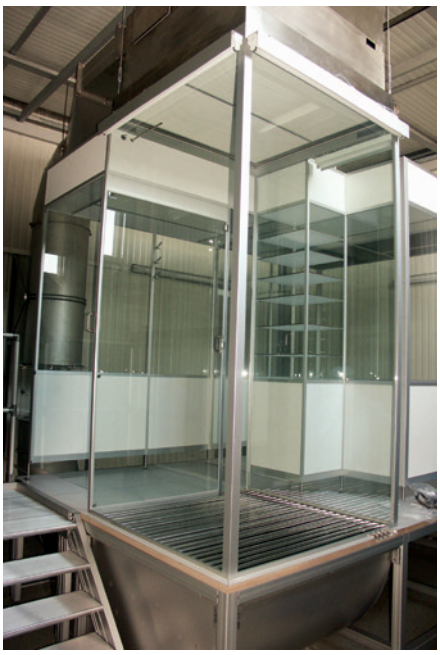

Fig. 1a + b: Body-Box (test cabin) in Muggensturm

Encouraged by the unambiguous measurement results with regard to the lab coats, the second test phase was started. The chosen test set-up or rather procedure was similar to that of the first phase. This time, however, the aim was to check and document the influence of the undergarments under cleanroom overalls, as well as a possible difference between cleanroom lab coats and cleanroom overalls to be worked out metrological. The probed garment variants are shown in Fig. 3.

As chart 2 shows, the differences in the measurement results with the overalls instead of the lab coats were not quite as dramatic, but were nevertheless clear in the end. Version 4 with the cleanroom compatible undergarments showed lower particle counts than version 3 with the cotton undergarments.

If the cleanroom suitable undergarments are not too important when standing, the influence with regard to the reduction of possible contamination from the garments worn underneath the overall becomes all the more clear when moving. A particle reduction of approx. 60% in the walking movement could be proven for the smaller particles (≥ 0.5 µm) as well as for the slightly larger contaminations (≥ 5.0 µm). The fact that the difference is not quite as significant when standing is the advantage of the filtration efficiency of the cleanroom overall as a whole. If one compares the initial values of versions 1 and 3 (i.e. with the cotton undergarments in each case), the efficiency of the overall can be clearly seen (chart 3).

No less interesting, however, is the statement that version 2 (cleanroom overall with cleanroom compatible undergarments) shows comparable results – in some cases even better values (chart 4) – with version 3 (cleanroom overall / cotton undergarments). So if employees reject a cleanroom overall in environmental conditions of ISO 7 – 9 on the basis of acceptance criteria, a cleanroom overall / cleanroom compatible undergarments would be an acceptable alternative from the point of view of contamination control.

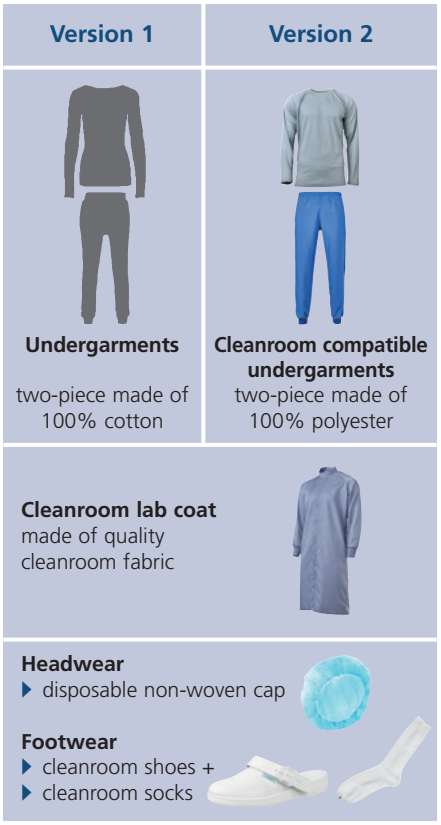

Fig. 1: The materials used for this Body-Box study with a cleanroom lab coat

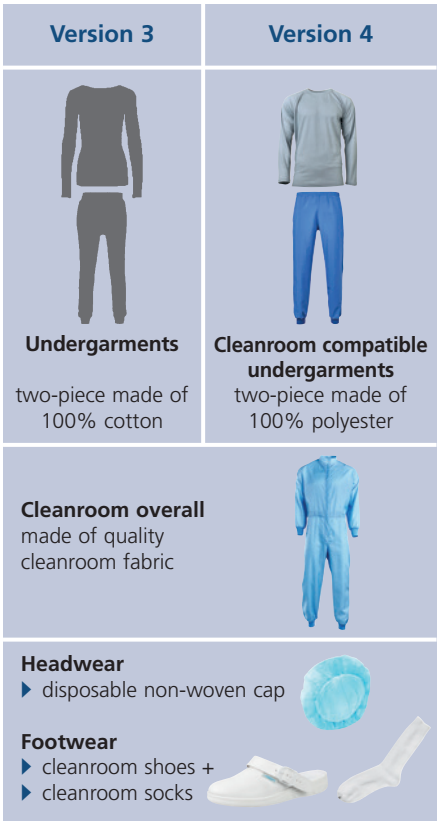

Fig. 2: The materials used for this Body-Box study with a cleanroom overall

Versions	standing		walking	
	≥ 0.5 µm	≥ 5.0 µm	≥ 0.5 µm	≥ 5.0 µm
1 Cleanroom lab coat & cotton undergarments	7 711	12	359 609	4 949
2 Cleanroom lab coat & cleanroom compatible undergarments	675	0	27 082	196

Chart 1: Particles per m³/minute with the combinations cleanroom lab coat with different undergarments

Versions	standing		walking	
	≥ 0.5 µm	≥ 5.0 µm	≥ 0.5 µm	≥ 5.0 µm
3 Cleanroom overall & cotton undergarments	596	11	49 575	198
4 Cleanroom overall & cleanroom compatible undergarments	508	0	20 113	79

Chart 2: Particles per m³/minute with the combinations cleanroom overall with different undergarments

Versions	standing		walking	
	≥ 0.5 µm	≥ 5.0 µm	≥ 0.5 µm	≥ 5.0 µm
1 Cleanroom lab coat & cotton undergarments	7 711	12	359 609	4 949
3 Cleanroom overall & cotton undergarments	596	11	49 575	198

Chart 3: Particles per m³/minute with the combinations cleanroom overall and lab coat each with cotton undergarments

Versions	standing		walking	
	≥ 0.5 µm	≥ 5.0 µm	≥ 0.5 µm	≥ 5.0 µm
2 Cleanroom lab coat & cleanroom compatible undergarments	675	0	27 082	196
3 Cleanroom overall & cotton undergarments	596	11	49 575	198

Chart 4: Particles per m³/minute with the combinations cleanroom lab coat with cleanroom compatible undergarments and cleanroom overall with cotton undergarments

Conclusion

The bachelor thesis has clearly proven the importance and efficiency of an undergarment adapted to cleanroom requirements and has again proven previous studies in this direction. Especially for users in less critical areas, such as those in parts of technical cleanliness, in „low-dust" environmental conditions as well as in cleanrooms of air cleanliness classes ISO 7 – ISO 9, the use of suitable undergarments is an appropriate measure to reduce the contamination caused by employees simply and at the same time to a considerable extent.

Despite difficult air conditions due to the turbulent air duct in these process areas, risks of cross-contamination (originating from the employees) can be significantly reduced.

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