50+

A long-term study on cleanroom garments

dastex
REINRAUMZUBEHÖR

Carsten Moschner

One question that is always interesting from the user's perspective is: How long can I use cleanroom garments without hesitation and without running the risk of significantly reducing one of the most important functional properties, the filtration efficiency?

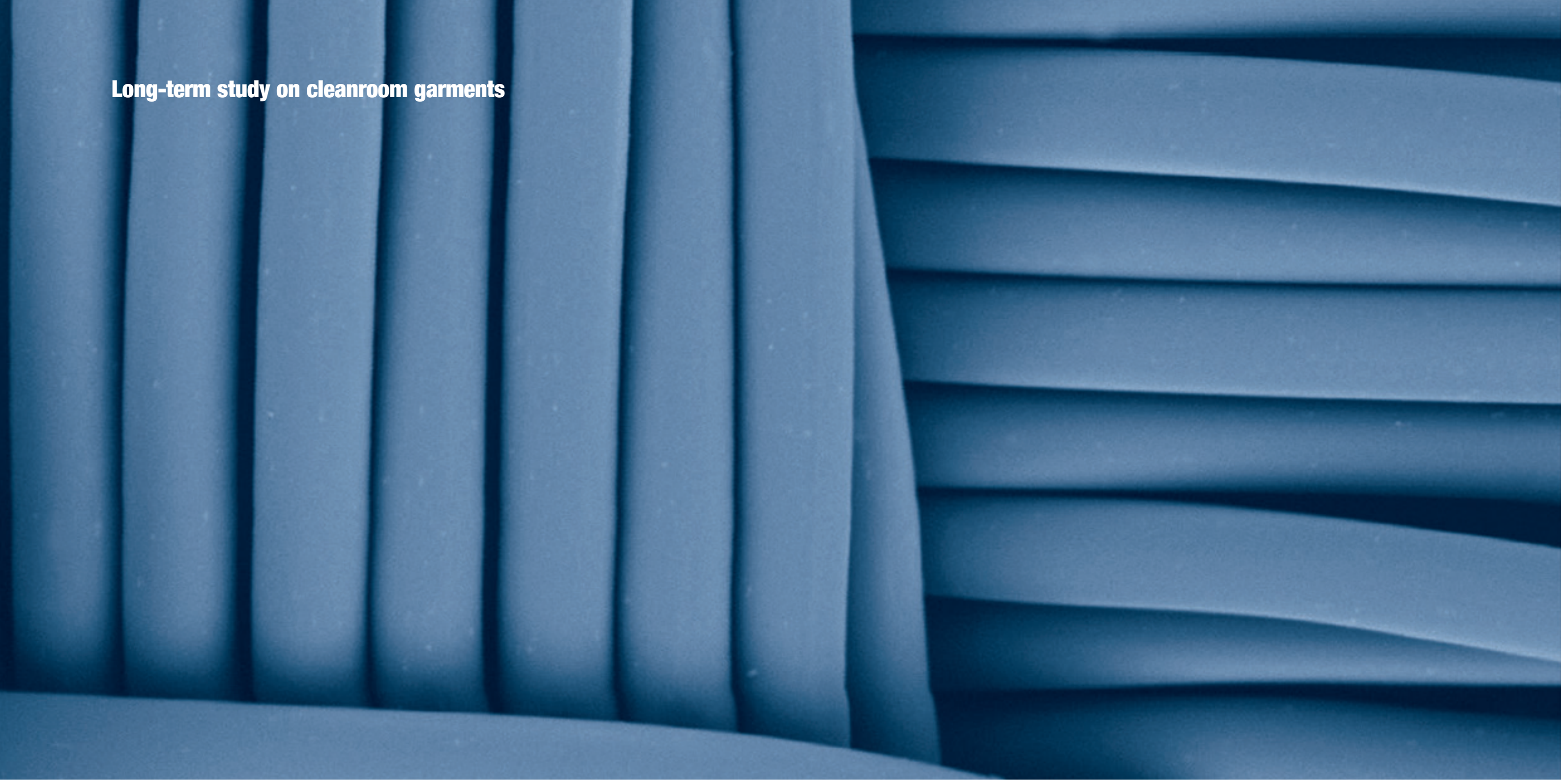
Although this question may seem quite simple at first sight, it is very difficult to answer from a practical point of view. Even with the definition „What is a significant worsening of the filtration properties of a cleanroom textile?" it becomes difficult, because depending on the process requirements of the end user, a decrease of 5% can be critical, while for another end user only a decrease of more than 10% is critical.

The so-called cleanroom undergarments are still one of the important influencing factors. If this clothing (worn under the cleanroom garments) emits only very few particles, a loss of 5% or 10% of the filtration property of the cleanroom garments may be less critical than feared.

In addition, there is also the issue of measurement technology and here primarily the tolerance limits for such filtration tests, which can vary considerably.

Limited period of use

On the other hand, even cleanroom garments are not infinitely durable and the mechanical stresses in the cleaning process, especially during drying and – if the garments are to be sterilised – in the sterilisation process, are considerable. After 50 cleaning cycles, a wide variety of ageing phenomena can usually be detected easily metrologically. These include, for example, a reduction in the tear force respectively the lower force and elongation



How does the particle emission of different cleanroom textiles change?

ratio. The textile thus loses stability, with the result that fibre breakage is more likely than in new condition. The air permeability often increases and in many cases the particle retention capacity also decreases.

The changes are generally known, but that doesn't really help the operators and deciders of a cleanroom production facility when it comes to the question of when the cleanroom garments in use should be replaced. Due to the complexity of this question (see above), it is at last a typical risk assessment, which should, if possible, revert to some well-founded data. A first indication is certainly provided by data – if available – on particle retention capacity as comparative data in original condition and after e.g. 50 decontamination cycles. In many cases, however, these values are not meaningful enough to make a corresponding decision based on them alone.

In this case, the much more practice-oriented, but also much more complex Body- Box measurement method offers much more meaningful test results. With the help of the Body-Box measurement method it is possible to quantitatively record and evaluate the impurities actually emitted by a person. The method offers the possibility to determine particle numbers depending on the respective tested garments, but also on the respective intensity of movement of the test persons. Of course, a person emits significantly less contamination in a resting activity, e.g. standing or sitting, than in a more movement-intensive state, e.g. walking, arm movement, etc.

Test setup and carrying out

Together with a global player customer, who operates cleanrooms of different cleanliness classes at different locations, different cleanroom garment textiles were compared under the same conditions over a long-term study lasting several years. In addition to the constant conditions inside the Body-Box, it was also necessary to ensure that the cleanroom garments tested in each case, made of different cleanroom fabrics, was identical in terms of cut and fit and that only measurement results of identical test persons were compared with each other.

The uniform garment system for this comparative study was defined as follows:
Full cover hood plus overall and cleanroom overboots. In addition, a high-quality three-layer cleanroom compatible disposable face mask with high filtration efficiency and cleanroom compatible nitrile gloves. A light cotton jogging suit was worn under the coverall to simulate normal streetwear. Under the full cover hood, a non-woven disposable hood was worn uniformly as a „pre-filter".
For all cleanroom textiles tested, first of all the data were determined in new condition (after 1–3 decontamination cycles) and then, using the same garment elements, the data for „used condition" after 50 – 53 decontamination cycles. Per test series, i.e. cleanroom garments made of material XY in new condition or later in used condition, at least 10 individual measurements were carried out in order to be able to average the very high fluctuation ranges usual in such measurements. The average measurement results for the textiles selected in this study are summarised in Table 1 for the particle sizes 0.5 µm and larger or 5 µm and larger used for evaluation.

Fabric/textile	New (decontaminated one to three times)				Used (decontaminated fifty to fifty-three times)			
	Intensity of the movement				Intensity of the movement			
	standing	walking	standing	walking	standing	walking	standing	walking
	≥ 0.5 µm	≥ 0.5 µm	≥ 5.0 µm	≥ 5.0 µm	≥ 0.5 µm	≥ 0.5 µm	≥ 5.0 µm	≥ 5.0 µm
Fabric A	4,253	27,409	28	269	14,177	72,775	61	591
Fabric B	6,616	20,320	14	52	11,342	35,443	24	425
Fabric C	3,733	16,298	21	137	7,516	20,231	63	63
Fabric D	9,924	54,818	24	373	4,726	38,750	180	1,545
Fabric E	10,869	32,607	57	156	16,067	83,172	156	1,200
Fabric F	11,342	66,632	9	161	8,034	48,674	104	709
Fabric G	5,135	14,240	8	55	2,835	8,672	0	24
Combination of F and G	2,334	9,404	0	24	1,500	5,281	6	6

Table 1: Measurement results summarised; particle number per minute and cubic metre, depending on movement

Fig. 1: Body-Box at rest

Fig. 2: Test person dressed, standing

Fig. 3: Test person dressed, walking

Fabric/textile	Used (decontaminated fifty to fifty-three times)			
	Intensity of the movement			
	standing	walking	standing	walking
	≥ 0.5 µm	≥ 0.5 µm	≥ 5.0 µm	≥ 5.0 µm
Fabric A	233 %	166 %	118 %	120 %
Fabric B	71 %	74 %	71 %	717 %
Fabric C	101 %	24 %	200 %	-54 %
Fabric D	-52 %	-29 %	650 %	314 %
Fabric E	48 %	155 %	174 %	669 %
Fabric F	-29 %	-27 %	1056 %	340 %
Fabric G	-45 %	-39 %	-99 %	-56 %
Combination of F and G	-36 %	-44 %	-	-75 %

Table 2: Percentage changes in the number of emitted particles of cleanroom garments in used condition

In order to be able to highlight more clearly the sometimes very significant changes in particulate emissions in used condition, these are listed in Table 2 in percentage terms.

Of particular interest here were the fabrics which, despite being decontaminated fifty times, performed better overall, i.e. emitted fewer particles than when new. These values are highlighted in colour. In charts 1 and 2, the results were illustrated in the form of bar charts. It is precisely the graphic representations that show the major differences between the individual cleanroom fabrics, all of which are strongly recommended for use in high-quality cleanroom classes, i.e. ISO 5 and better, according to the manufacturer's statements.

An approach to optimisation

The measured values determined in the course of this study and the knowledge gained from them ultimately led to the modification of the garment system (especially the overall).

In the process, employee concerns, i.e. wearing comfort characteristics, were also taken into account. The cleanroom garments made of fabric G showed the best results in the tests in the Body-Box and were among the garments that performed very well even after 50 decontamination cycles. However, compared to the other textiles, the cleanroom fabric G also did not exhibit particularly good properties in terms of breathability. A possible solution to combine filtration properties with improved breathability by making the front of the coverall from the denser fabric and the back from a more breathable cleanroom textile is obvious, but has not yet been studied in detail. This combination of the fabrics G and F formed the preliminary conclusion of the joint study and now serves as a basis for deciding on a possible greater fitting test at one of the end user locations.

Conclusions

The very extensive study impressively shows how differently cleanroom fabrics can prove their worth in practice, although they are classified as approximately equivalent according to the specification (data sheet). Even when new, fundamental differences can be seen, some of which have become more pronounced, but which have also been reversed in one or the other textile. The general assumption that the efficiency of cleanroom garments decreases demonstrably with more than 50 decontamination cycles is, due to the present measured values at least partially refuted. There are different chains of argumentation for interpretations as to why one fabric tended to deteriorate and the other tended to improve in terms of filtration properties. On the one hand, increased fibre breakage or increased air permeability due to a decrease in the fabric properties achieved by calendering could be reasons for the increase in particle numbers. On the other hand, a kind of fibre mingling effect is conceivable, or a reduction in the pumping effect, which could serve as a cause for the lower particle emission. In the end, it is up to the end user (deciders) to adjust the requirement profile for cleanroom garments in such a way that his own process requirements (in cleanroom operation) are reliably fulfilled over a defined period of time. The measured values determined in this study for the 2-material combination are another proof that a solution that is coordinated/optimised for the process can bring about considerable improvement potential in deviation from the standard systems that are often required. In this case an improved filtration efficiency over a longer period of use.

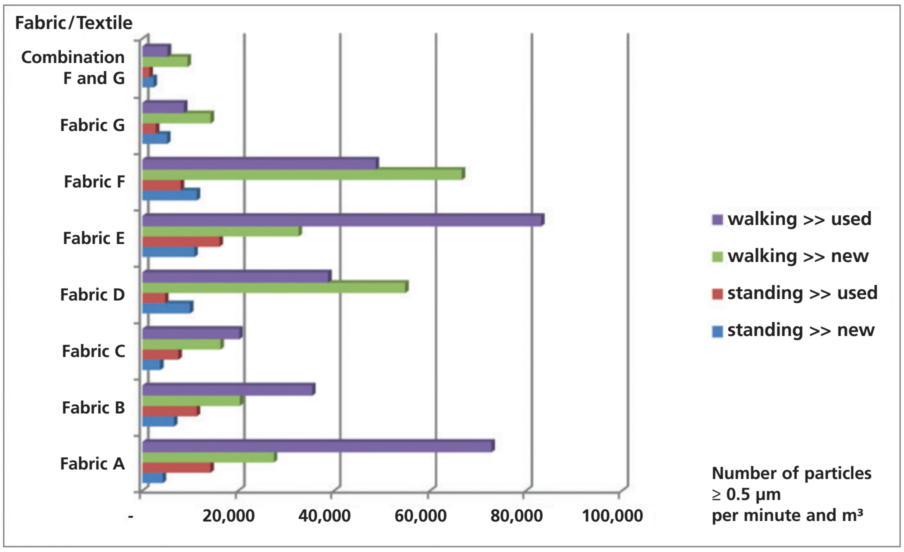


Chart 1: Comparison of particle emission ≥ 0.5 µm between new fabric and multiple decontaminated cleanroom garments

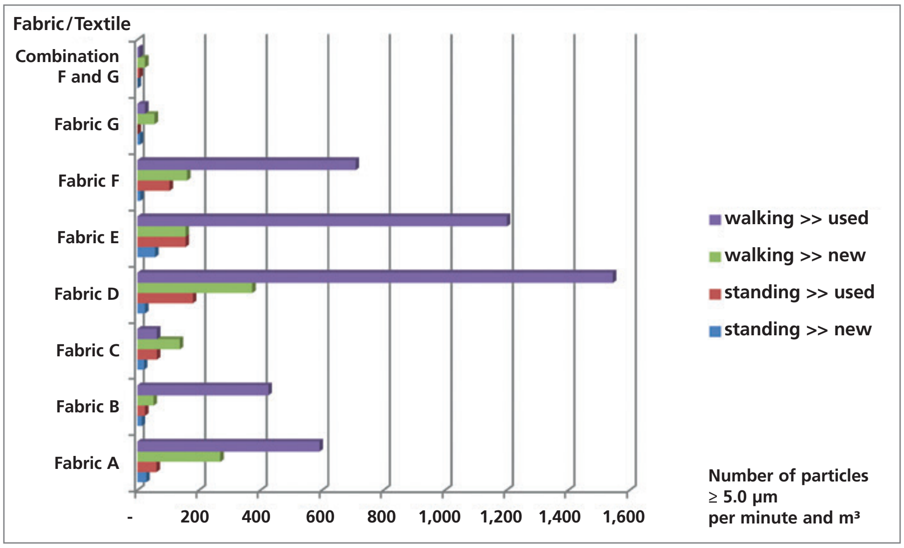


Chart 2: Comparison of particle emission ≥ 5 µm between new fabric and multiple decontaminated cleanroom garments

Author

Carsten Moschner

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Dastex Reinraumzubehör GmbH & Co. KG
Draisstr. 23
76461 Muggensturm
GERMANY
Telephone +49 7222 9696-60
Telefax +49 7222 9696-88
E-mail info@dastex.com

www.dastex.com