Fully engaged

Do cleanroom garments affect the ability to concentrate?

A large number of activities in cleanrooms generally requires a high level of concentration from employees, which must be maintained over a long period of time. Difficult work always requires a high degree of accuracy, so mistakes can not only cost a lot of money, but also have much more far-reaching consequences, such as in some activities under cleanroom conditions in the pharmaceutical industry.

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Even if the quest for ever higher levels of automation is intended to help reduce the „human error source", it is precisely these more complex work steps that continue to make humans irreplaceable in the production process.

If a person now feels uncomfortable in a certain environment, attention will certainly suffer here. The ability to concentrate will decrease and thus the frequency of errors will increase. The challenge for the cleanroom operator is to make the working environment as comfortable as possible for the cleanroom staff, despite all the technical cleanliness requirements, in order to counter the risk of higher error rates. The cleanroom garments play a decisive role in this.

Up to now, most studies on wearing comfort and cleanroom garments have been limited primarily to the thermal and physiological

factors, i.e. water-vapour permeability and thermal conductivity. Here, the water-vapour resistance is a meaningful parameter for determining / defining the breathability of a cleanroom textile.

Corresponding studies from the past have shown that the water-vapour resistance values can differ between different cleanroom textiles by 100% and more.
In other words, there are fabrics that can be described as breathable with quiet conscience – others are more likely to be classified as non-breathable.

A second important factor when assessing the wearing comfort of a cleanroom textile is certainly the feel - the softness - the haptics of a textile. Often the employee decides in the first five seconds whether or not the textile is comfortable to wear by simply feeling it. This very subjective assessment procedure is extremely difficult to simulate in terms of measurement technology.

Based on the above criteria, i.e. skin sensory characteristics in combination with thermophysiological factors and in interaction with ergonomic wearing comfort characteristics (fit, cut, design), employees will sometimes feel more, sometimes less comfortable in different cleanroom garments. Now the question arises: How does this feeling of well-being influence the performance of the employees? Can differences between different garment systems be recognized and if so, how significant are these differences? It is easy to understand that these are not only important questions for the employees who have to wear such garments on a daily basis, but should also be decision-relevant factors for a company. With decreasing ability to concentrate and a simultaneous increase in the frequency of errors, companies are faced with higher costs, which will ultimately have a direct influence on the competitiveness of their own products and services. Since activities under clean room conditions very often represent the heart of a production, errors in this area usually weigh particularly heavily.

Dastex, together with the Hohensteiner Institutes in Bönnigheim, Germany, has taken up the above question and tested various garment systems in a series of studies to determine whether they affect the ability of people to concentrate and, if so, to what extent. The basis for this series of studies involving several test persons was a test procedure specially developed at Hohenstein, which is based on internationally recognised and standardised test systems used in occupational psychology. The test subjects were first subjected to a 10-minute concentration exercise (stressor phase) under defined conditions. This was immediately followed by the 80-minute test. In this phase, the test subjects' ability to concentrate was recorded by computer. The system determines both the reaction time and the error frequency (number of errors).

The following garment systems were used for the study series (see also Table 1):

- normal, private street clothes
- cleanroom reusable garments (washable), also consisting of a hood, an overall and a pair of overboots, made of a standard textile (= fabric A) from Dastex.
- another set of cleanroom garments (washable) consisting of a hood, an overall and overboots, but made of a slightly lighter fabric (= fabric B) compared to fabric A.
  With regard to breathability (water-vapour permeability), the fabric from test series 3 shows worse values than the material from test series 2.
  The overboots were taken from test series 2, as they probably have little influence on the overall measurement result.
- disposable garments, consisting of an overall, hood and overboots made of a material that is currently mostly used as disposable garments (type 4) in the cleanroom industry.

Garments	Everyday clothing	Reusable garments made of fabric A	Reusable garments made of fabric B	Disposable garments (type 4)
Undergarments	none	cleanroom suitable two-piece	cleanroom suitable two-piece	cleanroom suitable two-piece
Hood	none	fabric A	fabric B	disposable
Face mask	none	disposable, 3-layer	disposable, 3-layer	disposable, 3-layer
Overall	everyday clothing	fabric A	fabric B	disposable
Overboots	street shoes	fabric A	fabric A	disposable

Table 1: Garment systems

	n = 6	Everyday clothing	Fabric A	Fabric B	Disposable garments (type 4)
Divided attention (multitasking)	mean reaction time (RT) [millisecond]	359.3	349.0	361.2	384.3
	number of errors	4.3	4.0	2.3	5.5
Selective sustained attention	mean reaction time (RT) [millisecond]	275.3	264.3	277.3	282.0
	number of errors	4.3	4.3	4.8	9.7

Table 2: Results

The concentration parameters of divided attention (multitasking) and selective sustained attention were tested. The test subjects carried out the tests on different days at the same time of day under defined conditions (20 °C, 42 - 44% relative humidity) in an ISO Class 5 cleanroom. In this way the disturbance variables of fluctuating room temperature and personal daily biorhythm could be eliminated. In order to exclude the influence of external visual stimuli, the tests took place in a closed cabin, the so-called „stress box".

The aim of the measurements was to monitor the test persons' ability to concentrate over a defined period of time. The age-adjusted mean reaction time (RT) to visual or acoustic stimuli was determined, as well as the number of errors made per test module. The results are now explained in more detail below (Fig. 1 and 2).

Results

It is certainly surprising that private street clothes, in which the test persons feel comfortable, do not perform best in these studies. One would assume that cleanroom garments, as an important and necessary filter between people and products, have a negative effect on the well-being of employees in direct comparison to normal private everyday clothing. However the studies presented here, show that the combination of cleanroom suitable undergarments and cleanroom garments made of fabric A even tends to perform better than normal streetwear – but by no means worse. On the other hand, the results of both the combinations of fabric B and the disposable version are worse than those of the streetwear.

The differences between the various cleanroom garment systems are also interesting. The disposable garment system performs significantly worse than the two reusable garment variants (cleanroom). Both in the case of divided attention as well as in the case of selective continuous attention, the ability to react decreases while the frequency of errors increases. The differences between the two cleanroom reusable garment systems are not quite as significant. Here, at the beginning of the tests, the lighter, denser fabric initially shows the better values in the area of divided attention, while the somewhat heavier, but more breathable fabric clearly shows better values in the selective sustained attention area.

Since activities in the cleanroom are usually of a more long-term nature and the ability to concentrate must therefore be maintained over a longer period of time, sustained attention is the more decisive criterion, which ultimately means that fabric A can be rated as the best cleanroom garment system tested in this study. A possible explanation for why the denser fabric B performed slightly better at the beginning of the tests (divided attention) is that the higher breathability (i.e. the lower water-vapour barrier) of fabric A only had a positive effect on the concentration ability of the test subjects after a longer test duration, whereas at the beginning the lower basis weight of fabric B was more advantageous.

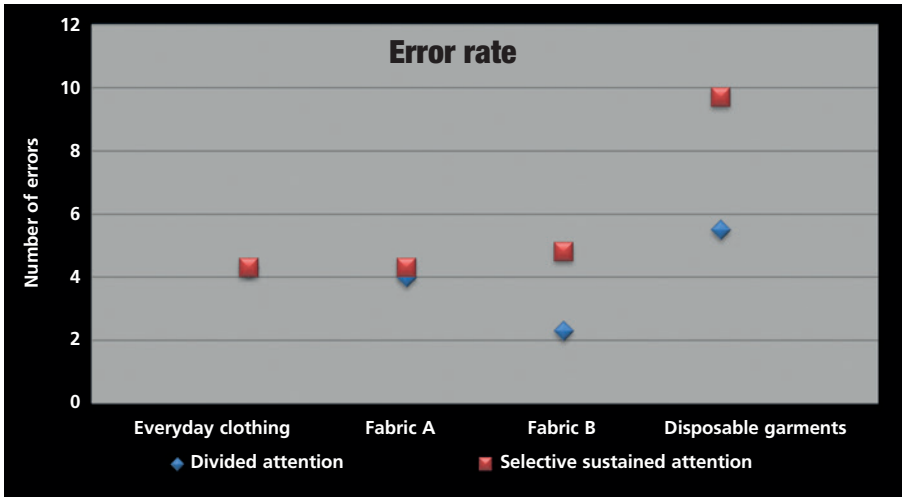

Fig. 1: Error rates when wearing different garment systems

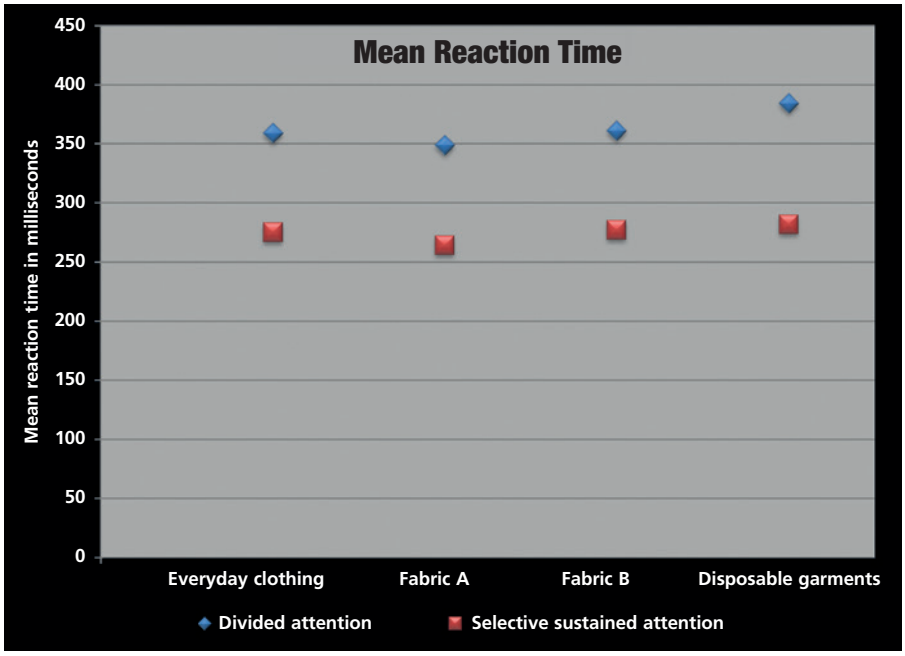

Fig. 2: Mean reaction time in different garment systems

Conclusion

Wearing cleanroom garments can have a significant impact on the ability of employees to concentrate.
This can have health, qualitative and economic consequences during production. With the Hohenstein Test System, the relevant parameters can be reliably measured for the first time. The reusable cleanroom garment systems tested here had little or no negative influence on the mental performance of the test subjects. The general statement that wearing cleanroom garments generally has a negative influence on the performance of the employees can therefore no longer be maintained based on the results with fabric A.

In the study presented here, the tested disposable garments in the classic style showed a negative influence on the mental performance of the employees, compared to the examined washable reusable cleanroom garment systems. It is also important to take a closer look at reusable garment systems with regard to maintaining the ability to concentrate over a longer period of time, as differences were found depending on the breathability of the fabric.

The authors

Carsten Moschner
Dr. Timo R. Hammer
Prof. Dr. Dirk Höfer

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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