Low-cost clean room process improvement

To lower costs within precision cleaning the first step is to define the specifications to be reached. Having the specifications clear, the measuring techniques can be defined and examined. Based on these fundamentals, it is possible to search for the optimal processes to reach the desired specification at lowest costs. This article is focussed on particle contamination. The above process has resulted in a structured approach to assist the improvement of clean room processes.

Specification and measuring tools
Within the Brainport region a common used cleanliness specification is 5 (UV-sensitive) particles / dm² for particles > 30 µm. It is assumed that this level of particle contamination only can be reached within an ISO-7 class clean room. The desired measuring technique is inspection using a UV-beam. This technique reveals about 1 percent of the particles. It means this specification could be exchanged by a specification of 500 normal visible particles /dm² for particles > 30 µm. The UV based specification can be measured using the UV Surface Particle Counter from Lighthouse. It is a practical measuring technique with reproducible results. To measure at lower contamination levels other techniques are needed.

Investigation
For this investigation the desired specification was set to < 50 particles /dm² for particles > 30 µm. To measure a cleanliness level as specified an improved measuring technique is needed. The PDM from SAC was used. This instrument can measure particles > 14 µm on a surface of 0.49 dm². Channels for particle dimensions can be set. For this measurement three channels were used (>30; >50; >100). The process measured deposited particles on witness plates. Before each measurement a zero measurement was done on each witness plate.

Within the ISO 14644-9 the Surface Cleanliness by Particles N (SCP-N) is defined by $10^N$ / m² for particles > 1 µm. The correction for the particle diameter is defined by $10^N$ part. / d / m². Based on this standard the common used specification is classified as SCP 6.2. for particles > 30 µm. The desired specification is classified as SCP 5.2 for particles > 30 µm.

Measurements
Within the clean room of Innovar two similar products are assembled in two sequential processes. On beforehand no instruction was given. On the workplace around the product 4 different witness plates were placed. The positioning of the witness plates is indicated in figure 3.

Before the start of the second process the operator was instructed with respect to improved clean room behaviour and some manufacturing engineering was done in order to minimize the number of
movements with tools and materials. As well a contaminated subassembly was mounted on a separate workplace and cleaned before assembling. The above description may give the impression that the operator was not trained, but he is standard trained. The first measurement indicates that the contamination level of the assembly was within specification, as calculated below.

In relation to the witness plates the working space was organised as shown in figure 3.

![Figure 3: Positioning of the witness plates](image)

Table 1 shows the results of the measurements. The results are given in number of particles per 0.49 dm$^2$. The average for the first measurement series over the 4 plates = 209 particles / 0.49 dm$^2$ for particles > 30 µm. This equals to 427 particles / dm$^2$. To calculate the SC, the number is multiplied by 100 and multiplied by the diameter of 30 µm. This results into an SCP 6.1 classification.

The average for the second measurement series over the 4 plates = 26 particles/0.49 dm$^2$ for particles > 30 µm. This equals to 53 particles / dm$^2$. To calculate the SCP the number is multiplied by 100 and multiplied by the diameter of 30 µm. This results into an SCP 5.2 classification.

### Additional information

The witness plates have been positioned on different places in the same room. The measured deposition rate on these places was < 1 particle / hour averaged over 24 hours. This correlates to an SCP 3.8 classification for a production step of one hour.

It is noteworthy that only after a few instructions the desired specification already was reached. Not a big challenge at all. During this investigation there was not time for additional improvement. Both manufacturing engineering and behaviour could be further improved and at least one similar improvement step could be reached.

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Table 1: Results of the measurements
Conclusion

The fact that particle contamination in a clean room is not directly related to the ISO classification of the clean room, is already known for some years. This measurements series is in line with this statement. This does not implicate that clean rooms have no impact on particle contamination. Surely not. The organisation of the work and the behaviour of the operators however, have that much impact on the particle contamination, that investments in higher class clean rooms will not have any impact on the SCP levels of the processes at all. Within an ISO-7 class clean room the SCP could be lowered at least two decades, just by manufacturing engineering and behaviour training of the operators.

The most interesting information, discovered by these measurements, is that process conditions could easily be determined with a PDM and that improvement steps of about 100 times less particle contamination can be examined and realised within a common clean room surrounding.

Challenged approach

The author of this article has set himself the challenge to set up a training to make it possible to reach an SCP 4.2 (30 µm based) classification of production lines within an ISO-7 class clean room. This equals < 5 particles /dm² for particles > 30 µm.

Part of the training is the verification of one production step improvement, within the end user clean room, using a PDM.

Additional parts of the training are improving clean room behaviour embedded into the work meeting structure at site and cross contamination training supported by fluorescent powder.

For more information see