

Clean Products Last Longer

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Cleanliness becomes more important as precision increases

The precision of parts has long been something that has been taken for granted; cleanliness is increasingly seen as an indispensable measure of quality. After all, contamination particles are a real curse for technology. If they get the upper hand, problems can already arise directly in assembly or startup.

Sometimes, malfunctions only become apparent after a certain amount of time has passed, specifically when particles clog nozzles, promote wear and tear on bearings or lead to corrosion in other areas. Even during cementing or adhesion processes, foreign bodies lower quality. And more and more areas are using cementing as a production process, high tech branches such as the aerospace industry for example. Here, plastic and composite materials are being increasingly used and without high-quality adhesives nothing would work. The trend towards miniaturization also requires clean parts. As the power density of power systems and machines increases and parts are positioned closer and closer to each other, foreign bodies quickly become a problem. Furthermore, manufacturer warranties are being extended as a result of legislation or market influences. Cleanliness is vital for a long service life.

Take the automotive industry, for example. Carmakers are increasingly taking a pioneering role in technical cleanliness. VDA Directive Volume 19 (Quality Management in the Automotive Industry) published in 2004 deals with the Inspection of Technical Cleanliness

and the Particle Contamination of Automotive Parts Relevant to Functionality. Critical areas in a vehicle include the fuel injection system and the brakes. For this type of neuralgic area, manufacturers specify particle sizes and concentrations which must not be exceeded. These sizes and concentrations are listed in ISO Standard 16232 (Road Vehicles - Cleanliness of Components and Fluid Circuits). The standard also contains information on methods and evaluations. This international standard is largely based on VDA Directive 19. Other industrial partners have formulated similar directives; however, the room required here to list them all would exceed the scope of this article. The first standardization approaches come from the hydraulic area. Oil filters have always existed.

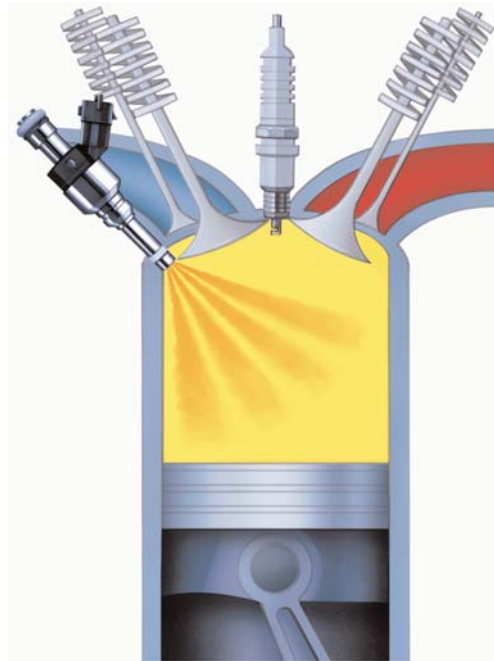


Figure 1: Fuel-injection nozzles are among the most sensitive parts of a combustion engine. The requirements on cleanliness are particularly high.

Photo: Carl Zeiss SMT

Clean is relative

Technical cleanliness is a specifiable parameter. It is given in milligrams (mg) or number of particles and the size of the particles per wet part volume or part surface. The part is wetted with a cleansing liquid to remove contaminants from the part. In general, a cold cleanser is used. This has proven to be very effective for a variety of part surfaces. Simply put, the first step in determining technical cleanliness is to wash the part. A specialist formulates it much more precisely and differentiates between four washing methods: shaking, spraying, rinsing and ultrasound bath. The process of transferring the particles to the cleansing liquid is called extraction or sampling.

Which extraction method is used depends on the part. The oil and water system of an engine block is sprayed, while a small gearwheel may perhaps be placed in an ultrasonic bath. There are often regulations on which method to use. "If it is not specified how to remove the particles from an object, the know-how of the tester comes into play," explains Andreas Tissen, Director of the new Technical Cleanliness Division at Quality Analysis GmbH. When you think about the ultrasonic bath, it quickly becomes clear that this work deals with "washing" with a fine touch. The optical engineer dips the eyeglasses into the bath until they are visibly clean. Tissen: "Ultrasound with too much energy may release particles from the structure of the part. This could falsify the test result."

Nanoparticles become visible

The cleaning or test liquid is collected in the catch basin after sampling and then passed through a filter membrane. The particles remain on the membrane. What was previously invisible is now visible. There are various ways of evaluating the membrane:

1. Gravimetric analysis. Here, the membrane is weighed to an accuracy of 0.01 mg to determine the weight of the particle catch.
2. Light microscope. A sensor automatically scans the membrane and records particle sizes up to 5 µm. Various illumination systems are used, including polarizing light sources so that the different materials can be differentiated (metallic shine is detected). The particles are counted fully automatically using special software.

3. Scanning electron microscopes (SEM) permit evaluation of even smaller particles – down to the nano range. These particles can be displayed in 3D.

4. Energy Dispersive X-ray (EDX). This technique permits an analysis of the element composition. Here, the X-ray radiation emitted from the sample is used to examine the material. This technique is integrated into the latest SEMs.

The work of the inspector does not end with the washing procedure and evaluation. Contaminants are tougher than you think. Additional washing procedures deliver additional particle catches. However, the concentration declines considerably – when you play according to the rules. If the ultrasound treatment is too intense, or if there are other errors during extraction, it can prevent the number of particles from declining as already mentioned. Usually, six measurements are made. The tester illustrates the six cleanliness values in a decay curve (see Fig. 6). There, the ratio of the number of particles or the particle weight of each measurement is set in relation to the cumulative total of the previous measurements. This results in proportional figures in percent, beginning with 100% for the first measurement. In accordance with the VDA directive, the test must continue until the cleanliness value declines to at least 10%. The value of 10% means that only $\leq 10\%$ of the total number of particles/total particle weight remains on the part. If the decay criteria are not achieved within six samples, the sampling conditions must be changed and the test repeated.



Figure 2: An EVO MA scanning electron microscope from Carl Zeiss.

Photo: Carl Zeiss



Figure 3: Particle catch after extraction.
Photo: Jomesa

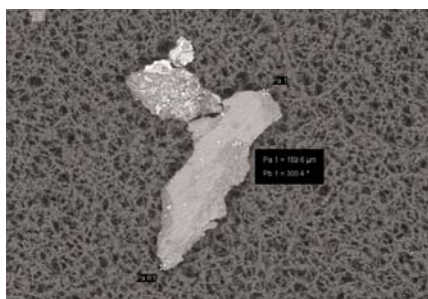


Figure 4: Measurement of a particle: the longest side is approx. 170 µm
Photo: Carl Zeiss SMT

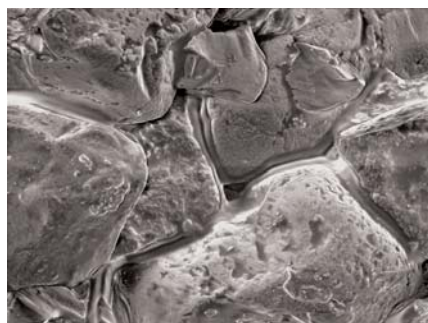


Figure 5: The SEM enlarges the very small. Image of oily sand.
Photo: Carl Zeiss SMT

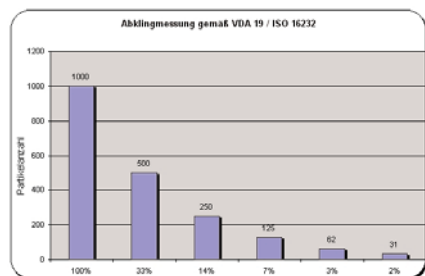


Figure 6: Example of a decay curve. The 6th measurement contains only 2% of the total number of particles.
Photo: Quality Analysis

High-tech particle determination

The new lab for technical cleanliness at Quality Analysis features state-of-the-art equipment:

- Class 8 clean room with people and material locks.
Parts up to 1700 x 925 x 650 mm can be processed
- 2 extraction systems for small and mid-sized parts
- 1 extraction system for large parts (engine blocks, cylinder heads, etc.) with handling system
- 1 light microscope with polarized light and special software from Jomesa for fully automatic evaluation, 4x stage
- 1 EVO MA25 scanning electron microscope with EDX technology and 5x swivel stage from Carl Zeiss SMT
- 1 precision lab scale featuring measuring accuracy of 0.01 mg
- Software from Alicona for the fully automatic 3D SEM evaluation
- Extensive database backend for evaluation/archiving

The company is certified in accordance with ISO 9001:2000 and has already submitted the paperwork for accreditation for inspection labs in accordance with ISO 17025.

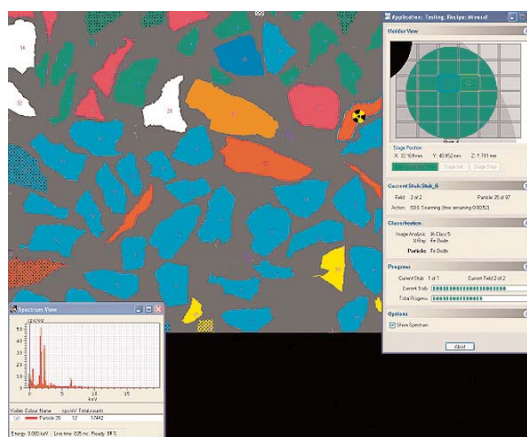


Figure 7: Particles are evaluated automatically by the camera sensor and special software.
Photo: Carl Zeiss SMT

Fit for the future

The staff responsible at Quality Analysis decided on the large-scale solution when equipping the new lab. This means that the entire range of technology for particle determination will be available in the future, including SEM-EDX technology. The central work area of Andreas Tissen and his employees will be an ISO 8 class clean room. "Based on current standards, a clean room would be urgently needed for our work. Because we comply with standards that are considerably higher than the commonly used standards and directives, we are well-prepared for the future," emphasizes Tissen. Both people and the parts to be tested must pass through locks to enter the clean room. "Our work in the clean room is also 100% software-supported, i.e. completely paper-free," adds the cleanliness specialist.

Parts are examined in the clean room. What do the processes involve? The Dettingen, Germany-based company also deals with this aspect. "If desired, we also examine the cleanliness conditions at the manufacturing company's site," explains Andreas Tissen. "We take particle samples from specific locations along the production line and evaluate them in our lab." This approach is then necessary when certain particles, whose origin is unknown, are detected while examining a part. Parts are frequently processed by different companies or at least in different departments within a company. Each work stage can deposit particles on the part. A high-tech analysis, such as that offered by Quality Analysis with SEM-EDX method in the future, will detect the single elements of the particle catch. On-site support enables the identification and elimination of the source of the particles.

Quality Analysis, Dettingen/Teck
www.quality-analysis.de



Figure 8: Andreas Tissen who is responsible for the new Technical Cleanliness Division at Quality Analysis: "We are well-prepared to meet the needs of the future."

Photo: Quality Analysis



Global Solution Provider

The Nano Technology Systems Division of Carl Zeiss SMT provides its customers with complete solutions featuring the latest leading-edge EM technology. The company's extensive know-how, meticulously acquired over 60 years in the field of e-beam technology, has brought many pioneering innovations to the market. Our global applications and service network ensure fast, reliable and high quality support sharply focused on customer requirements. Combined with dedicated upgrade strategies, this will protect your investment for its entire lifetime. The core technology embedded in our innovative products enables us to provide solutions which add value to our customers' businesses.

Customer feedback is always welcomed and gathered by collecting valuable information at trade shows, in workshops, in user meetings and upon instrument installation. The Division's business services also include outstanding support from sales consultancy to technical service options even when the warranty has expired.

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