

# Flexclean™

**Technical cleanliness for seals**



## If Cleanliness is vital in your processing system...

### Technical Cleanliness – meeting new requirements based on continuous development

Stricter regulations and continuous technical development in vehicle production, the electronics industry, semiconductor fabrication and pharmaceutical manufacturing have led to an increased demand for clean sealing solutions.

To meet our customers' needs for technical cleanliness throughout the supply chain, Trelleborg Sealing Solutions has defined three technical cleanliness standards.

Depending on the type of technical cleanliness needed and the material properties of the seals, clean solutions are achieved by different cleaning and production processes.

As Trelleborg Sealing Solutions respects the environment, cleaning methods are non-toxic and environmentally-friendly.

### Verifiable Cleanliness – throughout the supply chain

Technical cleanliness is now a vital component of many processing systems. The right cleaning methods and production processes are therefore a necessity.

The technical cleanliness processes Trelleborg Sealing Solutions uses for seals give you, the customer, the security that your cleanliness requirements are met throughout the complete production and delivery process. Choose from a variety of cleaning and production processes depending on your requirements and the material properties of the seals.

### Cleanliness as a Quality Characteristic

Today, technical cleanliness is an essential quality characteristic for seals in some applications and clean sealing solutions have become indispensable in the production of the highest quality products.

Cleaning is increasingly becoming a value-added process. Trelleborg Sealing Solutions is a specialist in the area of technical cleanliness for seals.



### Cleanliness – a Question of Definition

Residues on components are considered to be contamination if they constrain or interfere with subsequent production processes or the function of the component. What constitutes contamination in one application though may not necessarily have an impact in another. The required type and level of technical cleanliness therefore tends to be specific to a seal's application.

Methods of verification are also variable. Different results will be achieved depending on the verification media and parameters, as well as on the way verification is carried out. Appropriate methods of analysis to prove the cleanliness of a component are required depending on the particular cleanliness requirements of the customer.

Cleanliness is defined and achieved by existing and appropriate verification methods.



### **Customer-specific technical cleanliness Solutions**

Trelleborg Sealing Solutions can provide seals cleansed from greases, oils, particles and other such substances using environmentally-friendly methods. To aid customers in specifying cleanliness levels and verifying these, Trelleborg Sealing Solutions has defined three standards of technical cleanliness.

These standards are based on the different definitions of technical cleanliness for different industries as well as the degree of technical cleanliness required for the application.

In this brochure, we will present these three cleanliness standards in detail and provide you with comprehensive technical information.

In most cases the three standards will meet customer needs. If specific requirements are not covered, contact your local Trelleborg Sealing Solutions marketing company.

### **The three Trelleborg Sealing Solutions technical cleanliness standards are based on accepted industry and international standards:**

- 1** Defined particulate cleanliness
- 2** Freedom from Paint Wetting Impairment Substances – PWIS-free
- 3** Class 5 Cleanroom Quality, ISO 14644-1

### **Precise Results**

Test procedures to verify technical cleanliness of components usually follow three basic steps. Using specific methods, residual pollutants are removed from a component's surface, collected and subsequently analyzed.

It is important that the component itself is not be damaged by the test process as this may bias test results. This can be challenging, particularly if seals are made of elastomers or thermoplastics.

This is why Trelleborg Sealing Solutions uses analysis methods that are tailored to the required technical cleanliness levels, as well as to the quality and condition of the seal.

## Defined particulate Cleanliness

### More complex Requirements

Components and assemblies are becoming smaller, more complex and efficient all the time. This means functional density is increased, narrowing tolerances and making component parts more sensitive to contamination by particles.

This is particularly true in the automobile industry but also other sectors impose demanding requirements on the particulate cleanliness of seals.

### Damage due to Particulate Contamination

In dynamic situations lubricating films that ensure low friction against mating surfaces can be destroyed by large dirt particles on contact points. This can result in increased friction and wear, potentially impairing or damaging components and possibly causing scoring in bearings or cylinder bores.

Even in quasi-static applications dirt particles may lead to damage, for example, if they clog fine injection nozzles.

### Particulate Cleanliness of Seals ensures Quality

Technical cleanliness has therefore become an important quality characteristic, even for seals. Particles of dirt can adhere to seals following seal production, during handling or transport. These can cause problems in certain types of applications.

During the assembly and use of the seals, any particles adhering to a seal's surface may become loose and migrate into a component's operating system. The limit for permissible particles depends on the application. Usually there is a maximum acceptable particle size and if applicable an overall mass of permissible residual contamination.

Seals cleaned according to these specifications will reduce contamination from dirt particles that are too large or not allowed.

### Particulate Cleanliness classes

As standard, Trelleborg Sealing Solutions provides two classes of defined particulate cleanliness. In both, depending on the material and cleanliness level, seals are cleaned using a wet cleaning procedure in a cleanroom class 8 (ISO 14644-1) environment.

Cleaned seals are packed in packaging units defined by the customer, heat-sealed in bags and marked. A cleanliness analysis for initial samples is obligatory.

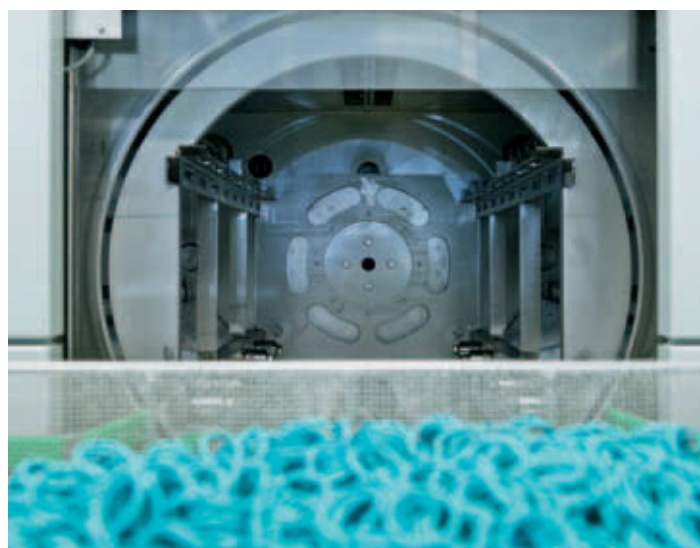
The particulate cleanliness classes depend on the different particulate cleanliness requirements and limits particularly common within the automotive industry.

	Maximum permissible particle size	Permissible residue contamination mass (gravimetry) per 1000 cm <sup>2</sup> seal surface
Cleanliness class 1	X = 200 µm	≤ 10 mg
Cleanliness class 2	X = 400 µm	≤ 25 mg

Trelleborg Sealing Solutions cleanliness classes for particulate cleanliness

### Verification of Particulate Cleanliness

The verification of particulate cleanliness and corresponding test reports will, depending on the specific seal, usually be performed by a pressure rinsing method in strict accordance with ISO 16232 and VDA volume 19.



Cleaning equipment for small parts

**Note:** The cleanability of a seal depends on its geometry, condition and material properties and has to be checked individually.

## The Advantages

- Reduced risk of increased friction caused by damage to lubrication by dirt particles
- Prevents clogging of nozzles due to ingress of particulate contaminations

## The Cleanliness Analysis

Trelleborg Sealing Solutions verifies defined particulate Cleanliness according to the recommendations of the ISO 16232 and VDA volume 19 standards.

For further details see page 10.



## Benefits to you:

- Reduced risk of scoring in bearings or cylinder bores
- Components such as valves are less likely to seize
- Extended service life of components
- Less friction-induced noise

## Seals free of Paint Wetting Impairment Substances – PWIS-free

### Requirements

Clean components are a particular requirement within the lacquering process. Not only must the surface to be lacquered, but also even the smallest components within the painting system have to be free from any contamination that may cause disturbances or disorders in lacquer wettings. This is because these mostly pasty residual contaminations impair the uniform paint application and lead to blemishes or flaws in the painted surface, the so-called craters.

In order to meet these cleanliness requirements, manufacturers whose components are used in the painting, coating industry or in general painting areas are dependent on cleaning processes. The components they use need to be cleaned of contaminations on the surface and, if necessary, on the inside, in order to ensure they are free of any paint wetting impairment substances (PWIS).

Our range of PWIS-free seals is able to provide the lacquering industry and other industries with solutions for compliance to cleanliness requirements. For example, this applies to soldering work in the electronics industry, as this is also affected by contaminations from oily or greasy substances.

### Prevention of Substances that disturb Lacquer Wettings

The cleanliness requirements for elastomeric seals are particularly sophisticated. Simply cleaning the surface of seals by wet cleaning, for example, is not sufficient in lacquering applications.

Due to the composition of seals and the way they are produced, softeners or processing agents contained in the elastomer of the seal may gradually excrete from the material and be deposited on the seal surface. Elastomeric seals must therefore be cleaned not only on the surface, but also on the inside, if they are intended for the use in painting or similarly sensitive applications.

### PWIS-free Seals

To meet the requirements of the lacquering process Trelleborg Sealing Solutions has developed a combined wash and plasma cleaning regime that cleans substances from the surface of the seal as well as from the inside of the seal. This conforms to the absence of PWIS according to VW test specification “Colors and Paints”, PV 3.10.7. Cleaned seals are packaged as required by the customer, heat-sealed in bags and marked PWIS-free.

### Verification of PWIS-free

There are different approaches to verification of the freedom of substances that disturb the lacquer wettings of components. The automotive industry has dealt with this issue intensively and developed specifications for verification.

As results may vary depending on the method of verification methods, it is necessary to precisely define the specification the PWIS-free designation is based on.

By default, Trelleborg Sealing Solutions works on the Volkswagen test specification PV 3.10.7.



Faultless paint on a silver car body

**Note:** The cleanability of a seal depends on its geometry, condition and material properties and has to be checked individually.

### The Advantages

- No ingress of substances that impair paint wetting
- No contamination of soldered joints caused by oily or greasy residues on or in the seals
- Cleanliness to recognized international automotive standard

### The Cleanliness Analysis

To verify the absence of PWIS, Trelleborg Sealing Solutions works according to the Volkswagen's specification PV 3.10.7.

For details, please see page 11.



### Benefits to you:

- Cleanliness during painting enables flawless application of paint or lacquer
- Reduction in reject and rework rate
- Prevention of complaints
- Increased safety when soldering due to no hidden defects

## Class 5 Cleanroom Quality, ISO 14644-1

### Requirements

The semiconductor fabrication, medical and pharmaceutical industries require a high level of cleanliness in manufacturing, usually utilizing cleanrooms in Classes 5 to 8, according to ISO 14644-1.

The construction of cleanrooms and the way they are maintained are defined by statutory regulations and product-specific requirements.

In order to ensure the quality of the ambient air in the production environment, all brought in components must be prepared using adequate production technologies or cleaning processes.

### Cleanrooms according to ISO Classification

Cleanrooms are controlled-atmosphere environments and a primary requirement of these is the control of the concentration of air-borne particles per volume unit of the internal atmosphere to a defined level. The infiltration, the development and the depositing of particles must be as minor as possible.

The cleanliness of cleanroom zones is assessed by the measurement of the number of air-borne particles and other relevant parameters such as temperature, humidity and pressure.

In order to ensure the quality of the ambient air in the production environment, all components including seals must be prepared using appropriate production technologies or cleaning processes.

### Excerpt from the cleanroom classification according to ISO 14644-1

ISO Class	Maximum value of the particle concentration (particles per m <sup>3</sup> of air)					
	0,1 µm	0,2 µm	0,3 µm	0,5 µm	1 µm	5 µm
...	...	...	...	...	...	...
Class 5	100000	23700	10200	3520	832	29
Class 6	1000000	237000	102000	35200	8320	293
Class 7	—	—	—	352000	83200	2930
Class 8	—	—	—	3520000	832000	293000
...	...	...	...	...	...	...

### Seals from Normal Production, Washed and Packed in Class 5 Cleanroom, ISO 14644-1

For basic cleanliness requirements, Trelleborg Sealing Solutions provides seals from normal production washed and packed in Class 5 cleanroom (ISO 14644-1).

Cleaning and drying of seals is performed, tailored to their condition in a Class 5 cleanroom and double packed according to cleanroom requirements. The bags are then heat-sealed and marked washed and packed in Class 5 cleanroom (ISO 14644-1).

### Seals from Cleanroom Production, Washed and Packed in Class 5 Cleanroom, ISO 14644-1

Trelleborg Sealing Solutions offers seals already manufactured in Class 8 cleanroom conditions. Following manufacture at this level of cleanliness, the seals are cleaned in a three-stage process with ultra-pure deionized water, dried and double packed according to cleanroom requirements.

The seals produced and washed this way meet the highest cleanliness requirements that go beyond simple washing and packing in Class 5 cleanroom, as specified for seals from normal production. Special materials, except for silicones and fluorosilicones, can be offered from Class 8 cleanroom production.

**In both cases, the packaging units are assigned by the customer according to their needs. Seals can be individually packed if needed.**

### The Advantages

- Minimization of the infiltration of air-borne particles from bought-in seals
- No incidents in cleanroom controls caused by brought in seals

**Note:** The cleanability of a seal depends on its geometry, condition and material properties and has to be checked individually.



## Specific solutions for the Medical and Pharmaceutical Industry

Additional cleaning options to deplete microbial, chemical or particulate pollution are available to meet specific cleanliness requirements of customers in the medical or pharmaceutical industries. Each cleaning option may be combined with the other or with a sterilization process.

Trelleborg Sealing Solutions develops and utilizes cleanliness solutions based on the appropriate sealing material in close cooperation with the customer.

**For further details contact your local Trelleborg Sealing Solutions marketing company.**

### Cleanroom Classifications

- Class 5 cleanroom according to ISO 14644-1 is equivalent to Class 100 cleanroom according to the former US Federal Standard 209E
- Class 8 cleanroom according to ISO 14644-1 is equivalent to Class 100000 cleanroom according to the former US Federal Standard 209E



### Benefits to you:

- Reduced effort in cleanroom control
- Safety in cleanroom production

## Technical Expertise

### The Cleanliness Analyses

There are different methods to verify the technical cleanliness of cleaned or uncleaned components.

To achieve reliable results, Trelleborg Sealing Solutions uses two methods as standard to verify the technical cleanliness of seals. These have been developed based on cleanliness requirements and the seal composition and properties. The standards are:

- Examination of seals for particulate residual contamination by means of pressure rinsing, verified according to ISO 16232
- Examination of seals for substances that impair paint wetting according to the VW test specification PV 3.10.7, by means of an extraction test

For seals to Class 5 cleanroom quality according to ISO 14644-1 there is a permanent and adequate verification of the cleanroom zones according to ISO 14644.



Examination of seals for particulate residual contamination by means of pressure rinsing method according to ISO 16232.

### Examination of Seals for particulate residual Contamination

Examination of cleanliness is carried out in two steps. In the first step, the particles adhering to the component are removed or extracted in an extraction process.

By default, Trelleborg Sealing Solutions uses pressure rinsing for this purpose.

The size and quantity of the removed particles and their overall weight (gravimetry) is determined in the second step of the analysis. An appropriate preconditioning and subsequent drying of the analysis filter is obligatory.

#### The Pressure Rinsing Process

In the injection process, the test liquid is applied to the seal via an open jet. Particles adhering to the seal's surface are removed by the pressure rinsing process.

Flushing is carried out in a collection pan. The test liquid is put through an analysis filter in which the removed particles are collected for the subsequent analysis. As many components as required are analyzed in order to achieve a component surface of 200cm<sup>2</sup> to 1,000cm<sup>2</sup>.

Depending on seal geometry, the pressure rinsing process allows the application of different nozzles and operating pressures in order to achieve an effective removal of dirt particles. Pressure rinsing can be specially adapted to the properties of different seals.

#### The Analysis

The particles collected are then analyzed in two ways.

- Residual contamination is weighed to determine total mass
- Fully automatic light-optical microscopic analysis determines size, number and size distribution of residual particles

#### Suitability of the Test Procedure and Test Parameters

The efficiency of an extraction method is crucial for the suitability of a test procedure to verify a component's cleanliness.

As it is impossible to determine the exact mass of contaminants, decay measurements are carried out according to VDA volume 19 and ISO 16232.

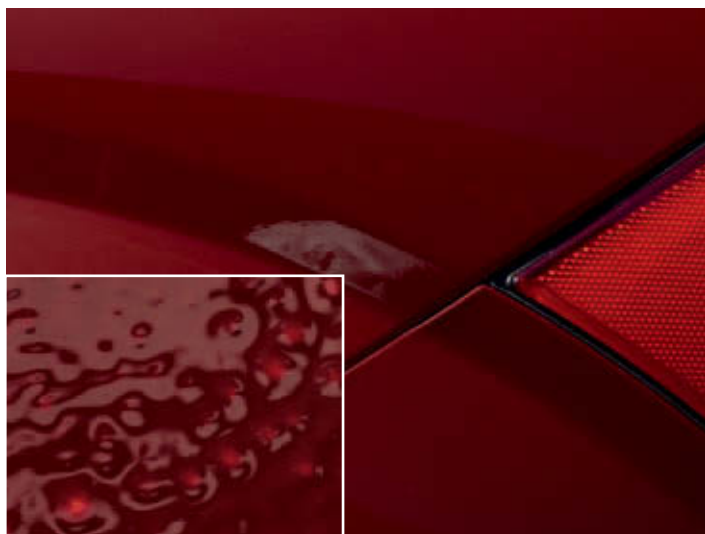
Repeated sampling of components with defined parameters is used in order to determine whether the removed mass of contaminants is reduced and whether an adequate extraction procedure is applied.

## Examination of Seals for PWIS

Examination of seals for substances that disturb lacquer wettings is generally carried out using the following procedure.

At first, perceived contaminants are extracted, removed or dissolved from the test specimen and collected on an appropriate base. After that, this base is lacquered over in order to check whether the collected substances have a disturbing effect on lacquer wettings.

Trelleborg Sealing Solutions generally works to Volkswagen's test specification "Colors and Paints" PV 3.10.7:2005 to determine if seals are absent of PWIS. This methodology indicates whether the test specimen releases substances that impair paint wetting and verifies the effectiveness of seal cleaning.



Typical impairment of the paint wetting process is shown using the example of red lacquering.

### The PWIS-Test

The extraction test based on the PV 3.10.7 is used to verify freedom from PWIS.

During this test, test specimens are deposited on an appropriate base, sprinkled with a transport medium and removed after a short application time. The transport medium will dissolve any possibly existing substances that disturb lacquer wettings from the surface and the inside of the seal, and transport to the surface of the test base.

After the remaining test liquid has dried, the test base is lacquered over and the result of the lacquering is assessed.

### The Test Equipment and its Suitability

Sheets of glass are used as a test base, as these allow a particularly reliable and simple assessment of the varnish.

A mixture of 40 parts benzene, 30 parts methyl ethyl ketone (MEK) and 10 parts cellulose thinner are used as a transport medium. A white automotive refinish paint from a spray can is used for the lacquering of the test base.

The suitability of the used glass sheets, transport medium and test lacquer have to be examined in a nil test, i.e. in a test run without test specimens. For this purpose, the glass sheet is cleaned with the transport medium and, after the sheet has dried, lacquered over with the test lacquer.

Clean work is required during the complete test. The seals to be tested should not be touched with bare hands but preferably with cotton gloves or PWIS-free tweezers.

### Interpretation of Test Results

Craters appearing on the test plate directly after lacquering indicate that, on those spots, substances that disturb lacquer wettings were deposited on the glass sheet. The examined seal is therefore not PWIS-free. The glass sheet remains translucent on the blemishes creating point or funnel-shape dents.

If the glass sheet is covered by an unbroken coat of lacquer, the test specimen does not exhibit any substances that disturb lacquer wettings and may therefore be classified as PWIS-free.

An inspection of the glass sheet against the light is helpful and supports a correct interpretation of the appearance. A repeated lacquering over is recommended if you have any difficulties with the interpretation of the failure pattern.

## Examination of Seals for Contamination according to customer-specific Test Procedures

**If other verification methods are required, contact your local Trelleborg Sealing Solutions marketing company.**

Working together with customers, Trelleborg Sealing Solutions will define possible cleanliness solutions for your application and the right customized verification methods.

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Trelleborg is a world leader in engineered polymer solutions that seal, damp and protect critical applications in demanding environments. Its innovative engineered solutions accelerate performance for customers in a sustainable way. The Trelleborg Group has local presence in over 40 countries around the world.



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