

# The Role of Material Cleanliness in Material Selection Processes

## The importance of material cleanliness in material selection

The selection of materials is a crucial step in product development and engineering that has a significant influence on the functionality, cost-effectiveness and sustainability of a product. At a time when technological innovation and environmental awareness are becoming increasingly important, the careful selection of suitable materials is becoming a complex challenge. The material selection process involves systematically analysing the requirements, properties and life cycle costs of different materials in order to find optimal solutions for specific applications. Technical aspects as well as ecological and economic factors play a central role here.

At the beginning of the material selection process, the specific requirements for the material are defined. These include technical requirements, e.g. mechanical or thermal properties, functional requirements such as chemical resistance, as well as economic and ecological aspects. Based on the results, a search is carried out for suitable materials. Using simple model tests, the most promising candidates are initially identified from the preselection. In further experiments, the target application is approached more and more closely and the range of potential materials is narrowed down. Finally, the final testing and qualification can take place in a final field test.

The cleanliness of materials plays a crucial role in various industries, as it significantly influences the quality and performance of products. In the food industry, the cleanliness of materials is of paramount importance to ensure consumer safety and avoid contamination. In the medical industry, the sterility of instruments and devices is crucial to prevent infections and protect the health of patients. In the electronics and semiconductor industry, the cleanliness of materials is also crucial to ensure the functionality and longevity of electronic components. This shows that the cleanliness of the materials must also be included in the material selection process for a holistic approach. Applications in these areas often take place in cleanrooms. Strict regulations regarding cleanliness apply to these. The DIN EN ISO 14644 series of standards regulates the classification of cleanrooms and controlled environments. It specifies standardised criteria for controlling contamination. Materials used in cleanrooms must fulfill these criteria and be tested accordingly. VDI 2083 Sheet 17 describes standardised procedures for examining various aspects of cleanliness suitability for the selection of appropriate materials [1]. The parameters to be considered include particle emission behaviour, outgassing, ESD properties, chemical and corrosion resistance as well as cleanability.

**Table 1:** Industry-specific overview of critical types of contamination, adapted from [1]

	Particle	Outgassing	ESD	Cleanliness	Chemical resistance
Semiconductor industry	++	++	++	+	+
Microsystems technology	++	+	++	+	+
Pharmacy	++	0	+	++	++
Biotechnology	+	+	0	++	++
Medical technology	+	0	+	++	++
Photovoltaics	+	+	+	0	0
Food products	+	+	0	++	++
++ mandatory	+ recommended			0 not generally required, individual decision	

### **Particle emission**

Cleanrooms are classified according to DIN EN ISO 14644-1 based on their air cleanliness. Analysing the particle emission therefore allows statements to be made as to whether a material pairing is suitable for use in a specific cleanroom class. Under a defined and reproducible tribological load, the concentration of particles produced is determined for a defined material pairing. In order to ensure a reliable measurement, a controlled test environment with a low cleanroom class and no sources of cross-contamination must be available, i.e. there should be no turbulent air flows in an open cleanroom and the samples or the test bench must also be sufficiently cleaned before the experiment. It must also be ensured that all particles produced are analysed using an optical particle counter.

### **Outgassing**

In addition to contaminating particles, chemical contamination can also be the cause of a lack of compatibility of cleanliness of materials. The guideline describes a test method for this that enables a comparison of different materials with regard to their outgassing of volatile organic compounds. The test is carried out in two steps. First, a defined quantity of the material is tempered in a test chamber and the emitted volatile compounds are transferred to an adsorption medium via a purge gas. Subsequently, the volatile organic compounds can then be released from the adsorbent by means of thermal desorption and analysed using GC/MS.

### **ESD-Properties**

Wherever contaminating particles are a problem, it is essential to know the electrostatic properties of the materials used. If friction between materials occurs in an application or an electric field acts on the materials, electrostatic charging can occur. This means that particles caused by friction, for example, stick to the material and can be emitted in an uncontrolled manner later during use. Depending on the application of the material, a distinction must therefore be made between antistatic, electrically conductive, electrically dissipative and electrostatically insulating. For this purpose, parameters such as surface resistance or volume resistance are determined in accordance with DIN EN 61340-5-1, DIN EN 1081 or SEMI E78-0309.

### **Chemical & corrosion resistance**

In the various processes that are carried out in cleanrooms or for cleaning products or assemblies, the materials are exposed to a wide variety of media and substances. VDI 2083 Sheet 17 therefore considers the aspect of chemical resistance and the corrosion behaviour of materials. For the test, the materials are stored in the relevant chemicals for a defined period of time and then analysed solely for changes. The assessment can be carried out in accordance with DIN EN ISO 2812-1 or DIN EN 423, for which visual characteristics are generally used. However, changes in material properties such as hardness or tensile strength can also be assessed.

### **Cleanability**

The procedure described in VDI 2083 Sheet 17 for checking the cleanability of materials relates exclusively to particles contaminating the material surfaces. In order to be able to measure these, the difference before and after cleaning must be evaluated. To do this, the particles on the surface are counted in several size ranges before and after cleaning. The measured number of particles before cleaning is set in relation to the number of particles after cleaning, allowing a cleaning efficiency to be determined that can be classified in relation to a reference system. In addition, the surface cleanliness classes can be determined in accordance with DIN EN ISO 14644-9 to enable the materials to be categorized.

### **Materialies thinks performance and cleanliness together**

Material selection processes for use in cleanrooms confront companies with a complex challenge. Our experience in high-performance industries such as semiconductor technology and aerospace has shown us that the combination of performance and cleanliness is becoming increasingly important as technology advances. This is why we have created a test and evaluation concept for the pre-selection of materials for cleanroom applications based on VDI 2083 Sheet 17. We also advise on individual cleanliness requirements, such as topics from the field of chemical trace analysis, and draw up the appropriate evaluation and test concepts.

With our expertise as material and cleanliness specialists, we help to make development processes more accurate, more reliable and faster. Feel free to contact us.

[1] VDI 2083 Blatt 17, Cleanroom technology – Compatibility of materials with the required cleanliness, Verein Deutscher Ingenieure e.V., Düsseldorf, 2013.