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Cleanroms and associated controlled environments —

Part 17: Particle deposition rate applications

Salles propres et environnements maîtrisés apparentés —

Partie 17: Applications de taux de dépôt de particules

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Introduction

Cleanrooms and associated controlled environments are used to control contamination to levels appropriate for accomplishing contamination-sensitive activities. Products and processes that benefit from the control of contamination include those in industries such as aerospace, microelectronics, optics, nuclear, food, healthcare, pharmaceuticals, and medical devices.

ISO 14644-1:2015 considers airborne particles in cleanrooms and classifies cleanroom cleanliness by maximum permitted concentrations, and both ISO 14644-9:2012 and IEST-STD-CC1246E:2013 consider the concentration of surface particles. This document considers the rate of particle deposition onto cleanroom surfaces and is based on VCCN Guideline 9[5] . The particle deposition rate is important, as the probability of contamination by airborne particles onto contamination sensitive, vulnerable surfaces, such as manufactured products, is directly related to the particle deposition rate.

ISO 14644-3:2019 gives an overview of methods for the determination of deposition of particles, larger or equal to 0,1 µm. In this document, the focus is on the rate that macroparticles larger than 5 µm deposit on surfaces, and the application of this information to controlling contamination in cleanrooms.

Various sizes of particles are generated in cleanrooms by personnel, machinery, tools, and processes, and distributed by air moving about the cleanroom. According to ISO 14644-1, cleanrooms and controlled environments with a particle class of the ISO 5 series, or cleaner, contain zero or very low concentrations of airborne particles larger than 5 µm. However, in operating cleanrooms, many more particles in the size range of 5 µm to 500 µm, and greater, are found on surfaces than suggested by the classification limits of the size of particles given in ISO 14644-1. The main reason for this is that the largest particles in the range of sizes of macroparticles are not counted by particle counters because of deposition losses in sampling tubes, and at the entry to and within particle counters. Also, for the same reason, only a proportion of the smaller particles in the range of sizes is measured. In many cases, large particles cause contamination problems and their presence and potential for deposition onto contamination sensitive, vulnerable surfaces is best determined by measuring the particle deposition rate onto surfaces.

Particles smaller than 5 µm are most likely to be removed from the cleanroom air by the ventilation system but, for particles above 10 µm, more than 50 % is removed from the air by surface deposition. Above 40 µm, more than 90 % is deposited (see Reference [6]). The dominant deposition mechanism of this size of particles has been shown to be gravitational but air turbulence and electrostatic attraction can also cause deposition (see Reference [7]). These deposited particles can be re-dispersed by walking and cleaning actions, but not by air velocities associated with the cleanroom air. It is important that these particles are removed by cleaning.

The presence and redistribution of particles >5 µm in cleanrooms is mostly related to human or mechanical activity. In a cleanroom "at rest", there is likely to be little activity and dispersion of particles, and the concentration of particles larger than 5 µm is close to zero with no significant particle deposition. Therefore, it is only in the "operational" occupancy state that the particle deposition rate should be considered.

The particle deposition rate is an attribute of a cleanroom or clean zone that determines the likely rate of deposition of airborne particles onto cleanroom surfaces, such as product or process area. Using a risk assessment, the acceptable amount of contamination of a vulnerable surface can be defined, and the particle deposition rate can then be obtained that ensures that this amount of contamination is not exceeded.

Methods of measuring the particle deposition rate in a cleanroom or clean zone are given in this document. These are used during the operation of the cleanroom to ensure that the required particle deposition rate is obtained, and for monitoring the cleanroom and clean zones to demonstrate continuous control of airborne contamination. Monitoring the particle deposition rate also enables PDR peaks to be correlated with activities so as to detect sources of contamination, and indicate what changes are required to working procedures to reduce the contamination risk.

The particle deposition rate is the rate of deposition of particles onto surfaces over time, and can be calculated as the change of particle surface concentration per m^2 during the time of exposure in hours and can be expressed as Formula (1):

$$R_D = \frac{C_{f_D} - C_{i_D}}{t_f - t_i} \quad (1)$$

where

R_D is the deposition rate of particles equal to, or larger than D (μm) per m^2 per hour;

C_{f_D} is the final particle surface concentration (number per m^2) for particles equal to and larger than D (μm);

C_{i_D} is the initial particle surface concentration (number per m^2) for particles equal to and larger than D (μm);

t_f is the final time of exposure (h);

t_i is the initial time of exposure (h).

If the particle deposition rate is determined on, or in close proximity to, a vulnerable surface, such as product, then an estimate of the deposition of airborne particles onto the surface can be obtained by applying Formula (2):

$$N^D = R^D \cdot t \cdot a \quad (2)$$

where

N_D number of deposited particles larger than or equal to particle size D (μm);

t is the time the surface is exposed to particle deposition (h);

a is the surface area exposed to airborne contamination (m^2).

Some industries use cleanrooms to manufacture optical instruments and components, such as mirrors, lenses, and solar panels used in aerospace. The quality of these products is related to the amount of light absorbed or reflected by particles on the surface. Therefore, this document also considers particle obscuration rate of test surfaces exposed in cleanrooms in Annex C. Using the particle deposition rate of various particle sizes, the particle obscuration rate of airborne particles depositing onto a surface and obscuring light can be calculated and used in a similar way to the particle deposition rate to reduce the risk of surface contamination.