INTERNATIONAL STANDARD

ISO 14644-17

First edition
2021-02

Cleanrooms 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

Reference number
ISO 14644-17:2021(E)

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 209, *Cleanrooms and associated controlled environments*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 243, *Cleanroom technology*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

A list of all parts in the ISO 14644 series can be found on the ISO website.

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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.

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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.

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Cleanrooms and associated controlled environments —

Part 17: Particle deposition rate applications

1 Scope

This document gives direction on the interpretation and application of the results of the measurement of particle deposition rate on one or more vulnerable surfaces in a cleanroom as part of a contamination control programme. It provides some instructions on how to influence the particle deposition rate and reduce the risk of particle contamination on vulnerable surfaces.

This document gives information on how a cleanroom user can use the particle deposition rate measurements to determine limits that can be set for macroparticles on vulnerable surfaces. It also gives a risk assessment method by which an acceptable risk of deposition of particles onto vulnerable surfaces in a cleanroom can be established and, when this is not achieved, methods that can be used to reduce the particle deposition rate.

An alternative to the particle deposition rate is the particle obscuration rate which determines the rate of increase of coverage of particles onto an area of surface over time. The particle obscuration rate can be used in an analogous way to the particle deposition rate and the required particle obscuration rate for a specified surface can be calculated and the risk from deposited particles reduced.

This document does not:

— provide a method to classify a cleanroom with respect to particle deposition rate or particle obscuration rate;

— directly consider the deposition of microbe-carrying particles, although they can be treated as particles;

— give any consideration to surface deposition by contact as, for example, when personnel touch a product and contamination is transferred.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14644-3:2019, *Cleanrooms and associated controlled environments — Part 3: Test methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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3.1
cleanroom
room within which the number concentration of airborne particles is controlled and classified, and which is designed, constructed and operated in a manner to control the introduction, generation and retention of particles inside the room

Note 1 to entry: The class of airborne particle concentration is specified.

Note 2 to entry: Levels of other cleanliness attributes such as chemical, viable or nanoscale concentrations in the air, and also surface cleanliness in terms of particle, nanoscale, chemical and viable concentrations might also be specified and controlled.

Note 3 to entry: Other relevant physical parameters might also be controlled as required, e.g. temperature, humidity, pressure, vibration and electrostatic.

[SOURCE: ISO 14644-1:2015, 3.1.1]

3.2
clean zone
defined space within which the number concentration of airborne particles is controlled and classified, and which is constructed and operated in a manner to control the introduction, generation, and retention of contaminants inside the space

Note 1 to entry: The class of airborne particle concentration is specified.

Note 2 to entry: Levels of other cleanliness attributes such as chemical, viable or nanoscale concentrations in the air, and also surface cleanliness in terms of particle, nanoscale, chemical and viable concentrations might also be specified and controlled.

Note 3 to entry: A clean zone(s) can be a defined space within a *cleanroom* (3.1) or might be achieved by a separative device. Such a device can be located inside or outside a cleanroom.

Note 4 to entry: Other relevant physical parameters might also be controlled as required, e.g. temperature, humidity, pressure, vibration and electrostatic.

[SOURCE: ISO 14644-1:2015, 3.1.2]

3.3
critical particle size
smallest *particle size* (3.7) that negatively impacts on product or process quality

3.4
critical location
location where a *vulnerable surface* (3.12) is exposed to particle contamination

3.5
operational
agreed condition where the *cleanroom* (3.1) or *clean zone* (3.2) is functioning in the specified manner, with equipment operating and with the specified number of personnel present

[SOURCE: ISO 14644-1:2015, 3.3.3]

3.6
particle
minute piece of matter with defined physical boundaries

[SOURCE: ISO 14644-1:2015, 3.2.1]

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3.7
particle size
diameter of a sphere or the diameter of a sphere (circle) that encompasses a non-spherical particle, or an equivalent diameter

Note 1 to entry: The definition should be stated in relation to the measurement method.

Note 2 to entry: In ISO 14644-1, light scattering based detection is used. Other measurement methods yield different size definitions (see A.1).

3.8
particle deposition rate
PDR
number of particles depositing onto a known surface area during a known time of exposure

Note 1 to entry: It is expressed in number per m^2 per hour.

3.9
particle deposition rate level
PDRL
level of *particle deposition rates* (3.8) for a range of *particle sizes* (3.7)

3.10
particle obscuration rate
POR
rate of change of particle area coverage of a surface during time of exposure

3.11
test surface
surface of specific area and known surface cleanliness used to collect particles that deposit from the air in a specified time

Note 1 to entry: A test surface is used in this document to determine the *particle deposition rate* (3.8).

Note 2 to entry: A test surface can be a witness plate or an integral part of a measuring instrument.

3.12
vulnerable surface
surface whose functionality diminishes when particles larger than the critical size are present

3.13
witness plate
clean flat plate of a specified surface area used to collect particles that deposit from the air in a specified time

Note 1 to entry: A witness plate is exposed adjacent to a *vulnerable surface* (3.12) to obtain the particle deposition rate that occurs at that location.

Note 2 to entry: A witness plate is not normally part of a measuring instrument and, after exposure, the witness plate is taken to a measuring instrument for the counting and sizing of the particles deposited.

4 Symbols

a	product area in m^2
A	area of the silhouette of the observed particles (mm^2)
C_D	particle concentration in number of particles $\geq D$ µm per m^2
D	particle size in micrometres

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