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Cleanrooms and associated controlled environments —

Part 9: Assessment of surface cleanliness for particle concentration

Salles propres et environnements maîtrisés apparentés —

Partie 9: Évaluation de la propreté des surfaces en fonction de la concentration de particules

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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).

This second edition cancels and replaces the first edition (ISO 14644-9:2012), of which it constitutes a minor revision. The changes are as follows:

— "Class" (classification, classified) has been changed to grade or assessment where appropriate;

— ISO 14644-6 has been removed from the opening text of Clause 3 and, as a result, Clause 2;

— entry 3.8 removed from Clause 3;

— ISO 4287 and ISO 4288 replaced by ISO 21920-2 and ISO 21920-3, respectively;

— ISO 16232-2, ISO 16232-3, ISO 16232-4 and ISO 16232-5 replaced by ISO 16232;

— minor editorial changes.

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

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.

Introduction

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

ISO 14644-1 to ISO 14644-8, ISO 14698-1 and ISO 14698-2 deal exclusively with airborne particle and chemical contamination. Many factors, besides the assessment of surface cleanliness, should be considered in the design, specification, operation and control of cleanrooms and other controlled environments. These factors are covered in some detail in other parts of ISO 14644 and ISO 14698.

This document provides an analytical process for the determination and designation of surface cleanliness levels based on particle concentration. This document also lists some methods of testing, as well as procedure(s) for determining the concentration of particles on surfaces.

Where regulatory agencies impose supplementary guidelines or restrictions, appropriate adaptations of the testing procedures might be required.

NOTE When assessment of surface cleanliness by particle concentration (SCP) at critical control point(s) is used as an additional cleanliness attribute to classification of air cleanliness by airborne particle concentration in accordance with ISO 14644-1, then the space can be described as a cleanroom or clean-zone. If SCP is used alone, then the space is described as a controlled zone.

Cleanrooms and associated controlled environments —

Part 9: Assessment of surface cleanliness for particle concentration

1 Scope

This document establishes a procedure for the assessment of particle cleanliness levels on solid surfaces in cleanrooms and associated controlled environment applications. Recommendations on testing and measuring methods, as well as information about surface characteristics, are given in Annexes A to D.

This document applies to all solid surfaces in cleanrooms and associated controlled environments, such as walls, ceilings, floors, working environments, tools, equipment and products. The procedure for the assessment of surface cleanliness by particle concentration (SCP) is limited to particles of between 0,05 µm and 500 µm.

The following issues are not considered in this document:

— requirements for the cleanliness and suitability of surfaces for specific processes;

— procedures for the cleaning of surfaces;

— material characteristics;

— references to interactive bonding forces or generation processes that are usually time-dependent and process-dependent;

— selection and use of statistical methods for assessment and testing;

— other characteristics of particles, such as electrostatic charge, ionic charges and microbiological state.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

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

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

3.1
descriptor for specific particle size ranges
differential descriptor that expresses surface cleanliness by particle concentration (SCP) level within specific particle size ranges

Note 1 to entry: The descriptor may be applied to particle size ranges of special interest or those particle size ranges that are outside the range of the grading system and specified independently or as a supplement to the SCP levels.

3.2
direct measurement method
assessment of the contamination without any intermediate steps

3.3
indirect measurement method
assessment of the contamination with intermediate steps

3.4
solid surface
boundary between the solid and a second phase

3.5
surface particle
solid and/or liquid matter adhered and discretely distributed on a surface of interest, excluding film-like matter that covers the whole surface

Note 1 to entry: Surface particles are adhered via chemical and/or physical interactions.

3.6
surface cleanliness by particle concentration
SCP
condition of a surface with respect to its particle concentration

Note 1 to entry: The surface cleanliness depends upon material and design characteristics, stress loads (complexity of loads acting on a surface) and prevailing environmental conditions, along with other factors.

3.7
surface cleanliness by particle concentration level
SCP rating
grading number stating the maximum allowable surface concentration, in particles per square metre, for a considered size of particles [surface cleanliness by particle concentration (SCP) grades 1 to 8], where level 1 represents the cleanest level

3.8
surface particle concentration
number of individual particles per unit of surface area under consideration

4 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

AFM	atomic force microscopy
CNC	condensation nucleus counter
EDX	energy dispersive X-ray spectroscopy
ESCA	electron spectroscopy for chemical analysis
ESD	electrostatic discharge

IR	infrared (absorption spectroscopy)
OPC	optical particle counter
PET	polyethylene terephthalate
SCP	surface cleanliness by particle concentration
SEM	scanning electron microscopy
UV	ultraviolet (spectroscopy)
WDX	wavelength-dispersive X-ray spectroscopy

5 The surface cleanliness level assessment system

5.1 ISO-SCP grading level format

The degree of SCP in a cleanroom or associated controlled environment shall be designated by a cleanliness level grading number, N, specifying the maximum total particle concentration on surfaces permitted for a considered particle size. N shall be determined from Formula (1) with the maximum permitted total particle concentration on the surface, $C_{SCP;D}$, in particles per square metre of surface, for each considered particle size, D:

$$C_{SCP;D} = k \frac{10^N}{D} \tag{1}$$

where

$C_{SCP;D}$ is the maximum permitted total surface concentration, in particles per square metre of surface, of particles that are equal to or larger than the considered particle size; $C_{SCP;D}$ is rounded to the nearest whole number, using no more than three significant figures;

N is the SCP cleanliness level grading number, which is limited to SCP grade level 1 to SCP grade level 8; the SCP grade level number N is qualified by the measured particle diameter D, in micrometres;

NOTE N refers to the exponent base 10 for the concentration of particles at the reference particle size of 1 µm.

D is the considered particle size, in micrometres;

k is a constant 1, in micrometres.

NOTE 1 The SCP grade level based on the particle concentration can be a time- and process-dependent value due to the dynamic characteristics of particle generation and transportation.

NOTE 2 Due to the complexity of statistical evaluations and readily available additional references, the selection and use of statistical methods for testing are not described in this document.

The concentration $C_{SCP;D}$, as derived from Formula (1), shall serve as the definitive value. Table 1 presents selected SCP grading levels and corresponding maximum cumulative permitted total surface concentrations for considered particle sizes.

Figure 1 provides a representation of the selected surface particle grade levels in graphical form.

Table 1 — Selected SCP grading levels for cleanrooms and associated controlled environments

Units in particles per square metre

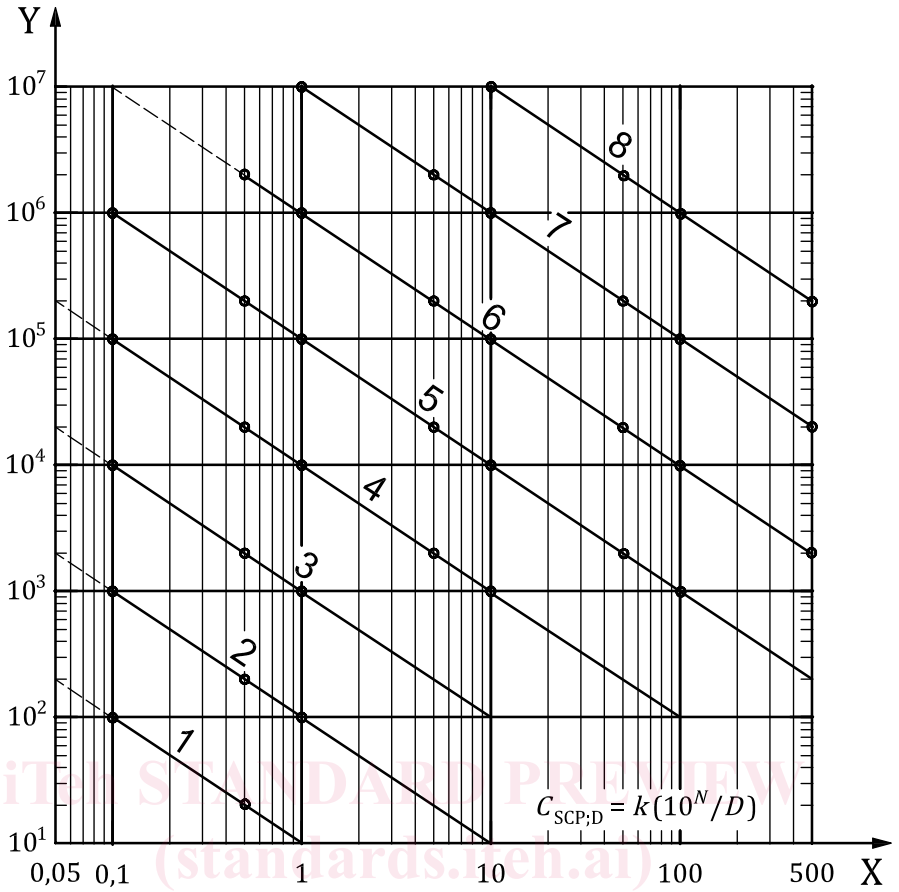
SCP level	Particle size								
	≥ 0,05 µm	≥ 0,1 µm	≥ 0,5 µm	≥ 1 µm	≥ 5 µm	≥ 10 µm	≥ 50 µm	≥ 100 µm	≥ 500 µm
SCP level 1	(200)	100	20	(10)					
SCP level 2	(2 000)	1 000	200	100	(20)	(10)			
SCP level 3	(20 000)	10 000	2 000	1 000	(200)	(100)			
SCP level 4	(200 000)	100 000	20 000	10 000	2 000	1 000	(200)	(100)	
SCP level 5		1 000 000	200 000	100 000	20 000	10 000	2 000	1 000	(200)
SCP level 6		(10 000 000)	2 000 000	1 000 000	200 000	100 000	20 000	10 000	2 000
SCP level 7				10 000 000	2 000 000	1 000 000	200 000	100 000	20 000
SCP level 8						10 000 000	2 000 000	1 000 000	200 000

The values in Table 1 are concentrations of particles of the related particle size and SCP level per surface area of one square metre (1 m^2) equal to or larger than the considered particle size ($C_{SCP;D}$).

For figures in parentheses, the corresponding particle sizes should not be used for level determination purposes; select another particle size for more accurate determination.

The minimum area for testing should be statistically representative of the surface under consideration.

NOTE Assessment of the lower SCP levels requires numerous measurements to establish a significant value.



Key

X considered particle size, D (µm)

Y particle concentration on a surface ≥ D, $C_{SCP;D}$ (particles/m^2)

1 SCP grade level 1

2 SCP grade level 2

3 SCP grade level 3

4 SCP grade level 4

5 SCP grade level 5

6 SCP grade level 6

7 SCP grade level 7

8 SCP grade level 8

The solid lines shown on the graph shall be used for level assessment purposes. The dashed lines should not be used for level assessment purposes.

NOTE Particle distribution on surfaces typically is not a normal distribution, but is affected by different factors, such as roughness, porosity, electrostatic charge and deposition mechanisms (see Annex A).

EXAMPLE SCP grade level 5 (1 µm) signifies that 1 m^2 of surface may carry a maximum of 10^5 particles with a considered particle size ≥ 1 µm (D = 1). SCP grade level 5 (10 µm) signifies that 1 m^2 of surface may carry a maximum of 10^4 particles per square metre with a considered particle size ≥ 10 µm (D = 10). Any other measured particle size ($D = x$) which leads to a concentration that lies below the relevant SCP line is within the specification of SCP grade level 5 (x µm).

Figure 1 — SCP grade levels

For particle sizes outside the limits of the level numbering system and in cases where only a narrow particle range or individual particle sizes are of interest, a descriptor can be used (see Annex B).

5.2 Designation

The SCP grade level number shall be formatted as follows: SCP grade level *N* (*D* µm).

The designation of the SCP grade for cleanrooms and associated controlled environments shall also include the following:

a) the surface type measured;

b) the surface area measured;

c) the measurement method applied.

Details of measurement methods applied, including sampling techniques and measurement devices, should be retrieved from test reports.

The considered particle size should be determined by agreement between the customer and supplier.

The SCP grade level shall be stated in relation to the measured particle size diameter.

EXAMPLE 1 SCP grade level 2 (0,1 µm); wafer or glass substrate, surface area: 310 cm^2; surface particle counter.

EXAMPLE 2 SCP grade level 5 (0,5 µm); inner wall of a bottle, surface area: 200 cm^2; liquid dispersion — liquid particle counter.

5.3 General information on surface cleanliness levels of particle concentration

Airborne particle concentration and surface particle concentration are generally related. The relationship is dependent on many factors, such as airflow turbulence, rate of deposition, time of deposition, deposition velocity, concentration within the air and surface characteristics such as electrostatic charge (see A.2.4).

To determine SCP, various parameters (see Annex C) and surface characteristics (see Annex A) that influence testing should be taken into account.

6 Demonstration of conformity

6.1 Principle

Conformity with SCP grade cleanliness level requirements, as specified by the customer, is verified by performing tests and by providing documentation of the results and conditions of the testing.

Details for demonstrating conformity (see 6.3) shall be agreed upon between the customer and supplier in advance of testing.

6.2 Testing

Tests performed to demonstrate conformity shall be conducted in a controlled environment using suitable test methods and calibrated instruments, whenever possible.

Direct and indirect test methods can be used for demonstrating conformity and are given in Annex D. The list of typical methods described is not exhaustive. Alternative methods of comparable accuracy may be specified by agreement.

NOTE Measurement by different methods, even when correctly applied, can produce different results of equal validity.

Repeated measurements are recommended.

The test method and environment shall be agreed upon between the customer and supplier.