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Cleanrooms and associated controlled environments —

Part 10: Classification of surface cleanliness by chemical concentration

Salles propres et environnements maîtrisés apparentés —
Partie 10: Classification de la propreté chimique des surfaces

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 14644-10 was prepared by Technical Committee ISO/TC 209, *Cleanrooms and associated controlled environments*.

ISO 14644 consists of the following parts, under the general title *Cleanrooms and associated controlled environments*:

— *Part 1: Classification of air cleanliness by particle concentration*

— *Part 2: Specifications for testing and monitoring to prove continued compliance with* ISO 14644-1

— *Part 3: Test methods*

— *Part 4: Design, construction and start-up*

— *Part 5: Operations*

— *Part 6: Vocabulary*

— *Part 7: Separative devices (clean air hoods, glove boxes, isolators, mini-environments)*

— *Part 8: Classification of air cleanliness by chemical concentration (ACC)*

— *Part 9: Classification of surface cleanliness by particle concentration*

— *Part 10: Classification of surface cleanliness by chemical concentration*

The following part is under preparation:

— *Part 12: Classification of air cleanliness by nanoscale particle concentration*

Cleaning of surfaces to achieve defined levels of cleanliness in terms of particle and chemical classifications will form the subject of a future Part 13.

Cleanrooms and associated controlled environments —

Part 10: Classification of surface cleanliness by chemical concentration

1 Scope

This part of ISO 14644 defines the classification system for cleanliness of surfaces in cleanrooms with regard to the presence of chemical compounds or elements (including molecules, ions, atoms and particles). This part of ISO 14644 is applicable to all solid surfaces in cleanrooms and associated controlled environments such as walls, ceilings, floors, working environment, tools, equipment and devices.

NOTE 1 For the purpose of this part of ISO 14644, consideration is only given to the chemical characteristics of a particle. The physical properties of the particle are not considered and this part of ISO 14644 does not cover the interaction between the contamination and the surface.

NOTE 2 This part of ISO 14644 does not include the contamination generation process and any time-dependent influences (deposition, sedimentation, ageing, etc.) or process-dependent activities such as transportation and handling. Neither does it include guidance on statistical quality control techniques to ensure compliance.

2 Normative references

The following referenced documents are recommended for the application 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 14644-1:—[1], *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness by particle concentration*

ISO 14644-6, *Cleanrooms and associated controlled environments — Part 6: Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14644-6 and the following apply.

3.1
air cleanliness by chemical concentration
ACC
level, expressed as an ISO Class *N*, which represents the maximum allowable concentration of a given chemical species or group of chemical species, expressed in grams per cubic metre (g/m^3)

Note 1 to entry: This definition does not include macromolecules of biological origin, which are judged to be particles.

3.2
contaminant category
common name for a group of compounds with a specific and similar deleterious effect when deposited on the surface of interest

1) To be published. (Revision of ISO 14644-1:1999.)

3.3
chemical contamination
chemical (non-particulate) substances that can have a deleterious effect on the product, process or equipment

3.4
solid surface
boundary between the solid phase and a second phase

3.5
surface
boundary between two phases

Note 1 to entry: One of the phases is normally a solid phase and the other a gas, a liquid or another solid.

3.6
surface cleanliness by chemical concentration
SCC
condition of a surface with respect to its chemical concentration

3.7
surface cleanliness by chemical concentration class
N_{SCC}
common logarithm (to the base of 10) of the chemical concentration on a surface in grams per square metre (g/m^2)

4 Classification

4.1 Principles for establishing classification of clean surfaces in cleanrooms and controlled environments

Classification shall be specified by use of a classification descriptor. This descriptor is designated "ISO-SCC" and specifies the maximum total chemical concentration permitted on a surface for an individual chemical substance or group of substances. The classification of SCC is based upon the concentration of chemicals on a surface as calculated using Formula (1) (given in 4.2) and expressed in g/m^2. For calculation of the class, all other units shall be converted to g/m^2. In specific cases where low concentrations need to be specified, the maximum allowable concentration of chemicals on a surface may be expressed in atoms per square centimetre, ISO-$SCC_{\_atomic}$, using Formula (2) in 4.4.

4.2 Classification for surface cleanliness by chemical concentration

The SCC class shall be designated by a classification number, N_{SCC}, where N_{SCC} is the common logarithm index of concentration C_{SCC}, expressed in g/m^2. The SCC class statement shall always be connected with a chemical substance or group of substances to which it is related. Intermediate concentrations may be specified, with 0,1 being the smallest permitted increment of N_{SCC}. C_{SCC} is determined from Formula (1), in terms of N_{SCC}:

$$C_{SCC} = 10^{N_{SCC}} \tag{1}$$

Therefore, $N_{SCC} = \log_{10} C_{SCC}$.

C_{SCC}, the maximum allowable concentration of the specified chemical substance or group of substances, is expressed in g/m^2. The measured chemical concentration on a surface shall not exceed the maximum allowable concentration of SCC, C_{SCC} to satisfy the predetermined SCC that is agreed between the customer and supplier.

In all cases, N_{SCC} class numbers shall include the negative sign.

NOTE 1 An SCC class number is only valid in connection with a descriptor (see 4.3).

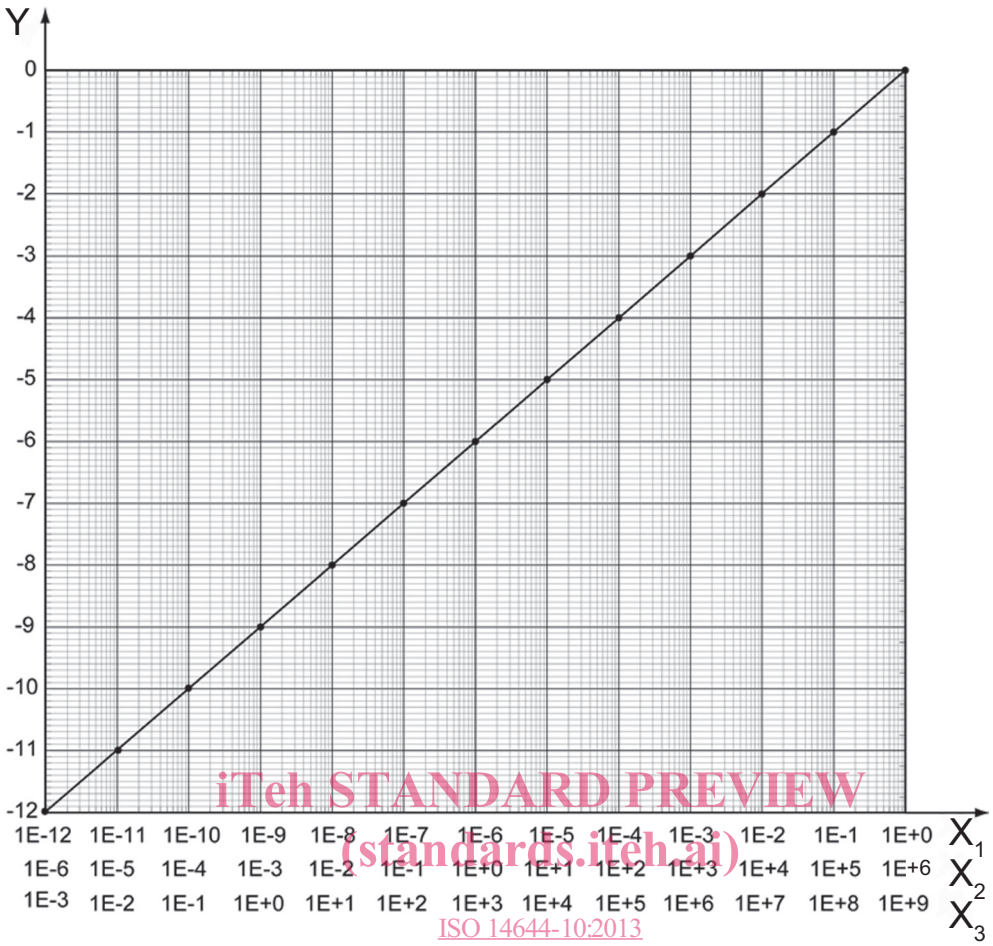
NOTE 2 For converting from gravimetric concentration (g/m^2) to numeric concentration (number of atoms, molecules or ions per unit area), see 4.4.

Table 1 and Figure 1 further illustrate the ISO-SCC classification as a function of chemical concentration on a surface.

Note also the parameters listed in Annex B that influence classification.

Table 1 — ISO-SCC classes

ISO-SCC class	Concentration (g/m^2)	Concentration ($\mu g/cm^2$)	Concentration (ng/cm^2)
0	10^{0}	10^{6}	10^{9}
−1	10^{-1}	10^{5}	10^{8}
−2	10^{-2}	10^{4}	10^{7}
−3	10^{-3}	10^{3}	10^{6}
−4	10^{-4}	10^{2}	10^{5}
−5	10^{-5}	10^{1}	10^{4}
−6	10^{-6}	10^{0}	10^{3}
−7	10^{-7}	10^{-1}	10^{2}
−8	10^{-8}	10^{-2}	10^{1}
−9	10^{-9}	10^{-3}	10^{0}
−10	10^{-10}	10^{-4}	10^{-1}
−11	10^{-11}	10^{-5}	10^{-2}
−12	10^{-12}	10^{-6}	10^{-3}



Key

X_1 surface mass concentration (g/m^2)

X_2 surface mass concentration (µg/cm^2)

X_3 surface mass concentration (ng/cm^2)

Y ISO-SCC class

Figure 1 — ISO-SCC classes as a function of concentration

4.3 ISO-SCC designation

An SCC class number is only valid in connection with a descriptor that includes the chemical substance or group of substances for which this class number is valid. The ISO-SCC descriptor is expressed in the format ISO-SCC Class *N* (*X*), where *X* is a chemical substance or group of chemical substances.

EXAMPLE 1 With an N-Methyl-2-pyrrolidone (NMP) sample, the measured value of chemical contamination on a surface was 9,8E-7 g/m^2. This is within the class limit of 1E-6 g/m^2 for Class −6. The designation would be: "ISO-SCC Class −6 (NMP)."

EXAMPLE 2 With an organic compound sample, the measured value was 6E-5 g/m^2 of total organic compounds (TOC). This is within the class limit of 1E-4 g/m^2 for Class −4. The designation would be: "ISO-SCC Class −4 (TOC)."

4.4 Converter for substances into surface atomic concentration

Very low concentrations are usually measured in surface number concentrations in the units of number of molecules, atoms or ions per surface area [1/m^2]. For classification purposes, these should be

converted into surface mass concentrations in the unit mass per surface area [g/m^2]. This conversion is made using Formula (2):

$$C_{SCC} = \frac{M(C_{SCC\_number})}{N_a} \quad (2)$$

where

C_{SCC_number} is the surface number concentration = number of molecules, atoms or ions per surface area [1/m^2];

C_{SCC} is the surface mass concentration [g/m^2];

N_a is Avogadro's number [6,02 × 10^{23}/mol];

M is the molar mass of atomic, molecular or ionic species [g/mol].

For information purposes, Figure A.4 in Annex A illustrates the relationship between chemical concentration on a surface (expressed in g/m^2) and the atomic concentration on a surface (expressed in atoms/m^2) for typical substances.

5 Measuring and monitoring the cleanliness of surfaces for chemical contamination and demonstration of compliance

5.1 Criteria for good cleanliness assessment

Figure D.2 in Annex D illustrates how to measure different types of contamination, showing differing sampling and measuring methods.

Tests performed to demonstrate compliance shall be conducted in a classified environment where the airborne chemical contaminant and the airborne particle contaminant levels do not negatively influence the classification. Suitable measurement methods and calibrated instruments shall be used for all tests. The environment, measurement methods and instruments shall be agreed upon between customer and supplier.

Additional test essentials are discussed in Annex C, while Annex D details measurement methods for demonstrating compliance.

The list of typical measurement methods is not exhaustive. Alternative methods that produce results with comparable accuracy may be specified by agreement between customer and supplier.

Measurement by different methods, even when those methods are correctly applied, may produce different results of equal validity.

Repeated measurements are recommended as part of the statistical approach.

Specific problems such as concentration spikes may occur when measuring high levels of cleanliness. Special quality control techniques will then be required, as explained in Figure D.4 in Annex D.

Precautions should be taken to reduce electrostatic charge around the test zone, as electrostatic charge enhances chemical deposition onto surfaces. If the surface is neither conductive nor grounded or charge-neutralized, electrostatic charges might occur. Therefore, test results may vary.

For typical methods of measurement for testing surface cleanliness by chemical concentration, refer to Annex D.

5.2 Documentation and reporting

5.2.1 Principle

Compliance with surface cleanliness by chemical concentration (SCC) class requirements, as specified by the customer, is verified by performing measurements and by providing documentation of the results and conditions of measurement. Details for demonstrating compliance shall be agreed upon between customer and supplier in advance.

5.2.2 Testing

Tests performed to demonstrate compliance shall be conducted using suitable measurement methods together with calibrated instruments whenever possible.

Measurement methods for demonstrating compliance are described in Annex D. The list of typical methods described is not exhaustive. The testing environment shall be agreed between customer and supplier. Alternative methods of comparable accuracy also may be specified by agreement between customer and supplier.

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

Repeated measurements are recommended.

The testing environment should be agreed between customer and supplier.

5.2.3 Test report

The results from testing each surface shall be recorded and submitted as a comprehensive report, together with a statement of compliance or non-compliance of the specified SCC class. The test report shall include as a minimum the following:

a) name and address of the testing organization;

b) name of the person performing the test;

c) measurement environment;

d) date, time and duration of sampling;

e) time of measurement;

f) number and year of publication of this part of ISO 14644, i.e. ISO 14644-10:2013

g) clear identification of the location of the surface measured and specific designations for coordinates of the surface, if applicable;

h) surface cleanliness by chemical concentration class with designation expressed as SCC class *N;*

i) acceptance criteria for the clean surface if agreed between customer and supplier;

j) specified measurement method(s), equipment resolution and detection limits;

k) details of the test procedure used, with any available data describing deviations from the test procedure (if agreed);

l) identification of the instrument(s) used and current calibration certificate(s);

m) number of measurements performed;

n) test results, including chemical concentration(s) data for given substances, for all measurements performed;

o) surface condition, i.e. after final cleaning, before or after packaging, with agreement on type and quality of packaging required.

An example of how this test report may be constructed can be found in Annex E. Other variations of the test report which are agreeable to both the customer and supplier may be used.

Annex A
(informative)

Conversion between different unit expressions of surface concentration for chemical substances

A.1 Principle

In addition to the unit of surface mass concentration of g/m^2, there exist several different units to express surface number concentration of an organic compound or a group of organics such as molecules/m^2, based on a number of organic molecules, and atoms C/m^2, based on a number of atoms of carbon composing organic compound(s) under consideration.

A.2 Examples

For information purposes, Tables A.1 to A.3 illustrate how the different units of surface number concentrations (molecules/m^2 or atoms C/m^2) can be converted into surface mass concentrations in terms of carbon (g C/m^2) or whole compound (g/m^2) respectively using the examples of heptane, hexadecane and di (2-ethylhexyl) phthalate.

Table A.1 — Illustration of the relationship between unit of surface concentration [g/m^2] and surface number concentration [molecules/m^2, atoms C/m^2] for heptane (C_7H_{16}), CAS No. 142-82-5

	Symbol	Unit	M = 100,2, N_c = 7			
			Example 1	Example 2	Example 3	Example 4
Surface number molecular concentration	$C_{molecule}$	[molecules/m^2]	1,00E+19	1,42E+18	7,16E+16	6,01E+16
Surface number concentration in terms of carbon	C_{carbon_number}	[atoms C/m^2]	7,00E+19	1,00E+19	5,00E+17	4,19E+17
Surface mass concentration in terms of carbon	C_{carbon_mass}	[g C/m^2]	1,39E-3	1,98E-4	1,00E-4	8,39E-6
Surface mass concentration	C_{SCC}	[g/m^2]	1,66E-3	2,36E-4	1,19E-4	1,00E-6

Table A.2 — Illustration of the relationship between unit of surface concentration [g/m^2] and surface number concentration [molecules/m^2, atoms C/m^2] for hexadecane ($C_{17}H_{34}$), CAS No. 544-76-3

	Symbol	Unit	M = 226,4, N_c = 17			
			Example 1	Example 2	Example 3	Example 4
Surface number molecular concentration	$C_{molecule}$	[molecules/m^2]	1,00E+19	6,20E+18	3,12E+16	2,60E+16
Surface number concentration in terms of carbon	C_{carbon_atom}	[atoms C/m^2]	1,59E+20	1,00E+19	5,00E+17	4,20E+17
Surface mass concentration in terms of carbon	C_{carbon_mass}	[g C/m^2]	3,19E-3	2,00E-4	1,00E-4	8,49E-6
Surface mass concentration	C_{SCC}	[g/m^2]	3,77E-3	2,35E-4	1,17E-4	1,00E-4