INTERNATIONAL STANDARD

ISO 11844-3

Second edition
2020-01

Corrosion of metals and alloys — Classification of low corrosivity of indoor atmospheres —

Part 3:

Measurement of environmental parameters affecting indoor corrosivity

Corrosion des métaux et alliages — Classification de la corrosivité faible des atmosphères d'intérieur —

Partie 3: Mesurage des paramètres environnementaux affectant la corrosivité des atmosphères d'intérieur

Reference number
ISO 11844-3:2020(E)

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Published in Switzerland

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Foreword

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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 156, *Corrosion of metals and alloys*.

This second edition cancels and replaces the first edition (ISO 11844-3:2006), which has been technically revised. The main changes compared with the previous edition are as follows:

- the normative references have been updated;
- a reference to ISO 16000 in Clause 5 has been added;
- the detection limits in 7.3.1 and 7.3.2 have been updated;
- a new Clause 9 has been added.

A list of all parts in the ISO 11844 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

This document deals with environmental parameters for the characterization of indoor atmospheres and methods of measurement.

The environmental parameters for the characterization of indoor atmospheres include more airborne contaminants than are normally used for the characterization of the outdoor environment.

Measurement of environmental parameters is a way of characterizing the corrosivity of the indoor atmosphere and will always be required if it is necessary to consider measures for reducing the corrosivity.

Corrosion of metals and alloys — Classification of low corrosivity of indoor atmospheres —

Part 3:
Measurement of environmental parameters affecting indoor corrosivity

1 Scope

This document specifies methods for measuring the environmental parameters used to classify the corrosivity of indoor atmospheres on metals and alloys.

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 7708, *Air quality — Particle size fraction definitions for health-related sampling*

EN 12341, *Ambient air — Standard gravimetric measurement method for the determination of the* PM_{10} *or* $PM_{2,5}$ *mass concentration of suspended particulate matter*

3 Terms and definitions

No terms and definitions are listed in this document.

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/

4 Principle

Different combinations of parameters affect the corrosivity of indoor atmospheres. Knowledge about possible sources of environmental effects shall be obtained before decisions regarding the type of measurements needed are taken. The characterization of indoor atmospheric corrosivity using environmental parameters is more complicated than measuring the corrosivity with metal specimens. However, in many cases, the measurement of environmental parameters can give a good indication of how to establish the corrosivity of an environment and will, in combination with the information given in ISO 11844-1, give a good indication of the corrosivity categories for the materials in the selected environment.

5 Environmental parameters

In indoor atmospheres, corrosion processes are characterized by a more complex group of parameters than in outdoor atmospheres. In general, three groups of parameters should be measured:

a) humidity and temperature;

b) airborne contaminants, such as gases and particles, which in turn are affected by c);

c) dry deposition velocity and air flow.

Fluctuation in temperature and humidity, particularly at higher humidity levels, can cause condensation on cooler surfaces. The frequency and time of condensation is an important factor for indoor corrosion.

The corrosion effects from these groups of parameters are usually interdependent. A particular level of humidity is needed before corrosion begins, and this can vary for different contaminants. Combinations of contaminants can accelerate the corrosion processes.

Methods for sampling and analysis of various air pollutants in indoor atmospheres are described in the ISO 16000 series. Of specific relevance is ISO 16000-1, which describes a general measurement strategy for measuring indoor air pollution and specific standards for measuring selected compounds such as volatile organic compounds (see ISO 16000-5) and nitrogen dioxide (see ISO 16000-15).

NOTE ISO 16000 (all parts) is mainly devoted to compounds hazardous to human health and the environment and not to compounds resulting in high corrosivity of the environment.

6 Humidity and temperature parameters

6.1 Relative humidity

Use continuous measuring devices, such as hygrographs, thermohygrographs or logging hygrometers.

The measuring period is preferably one year, to cover seasonal variations. If shorter measuring periods are needed, select a measuring period where large variations in the relative humidity are expected. The period shall be at least one month per season.

The data shall be reported as monthly values. The average, maximum and minimum values for each month shall be reported.

The calculation of time with relative humidity in given intervals represents useful information.

6.2 Temperature

Use continuous measuring devices, such as thermohygrographs or logging thermometers.

The measuring period is preferably one year, to cover seasonal variations. If shorter measuring periods are needed, select a measuring period where large variations in the temperature are expected. The period shall be at least one month per season.

The data shall be reported as monthly values. The average, maximum and minimum values for each month shall be reported.

The calculation of time with temperature in given intervals represents useful information.

6.3 Temperature–humidity complex

Continuous measurements of temperature and humidity give data for the calculation of frequency and time with condensation.

7 Airborne gas contaminants

7.1 Principle

The gas concentration or deposition can be measured by several techniques:

- continuous gas concentration measuring instruments;

- average gas concentration with an active sampler and air pump;
- average gas concentration with a passive sampler;
- average gas-deposition equipment.

The results from concentration measurements are typically given in µg/m^3 and for deposition measurements as mg/m^{2}d. The results obtained from the two types of measurements can be difficult to compare but give complementary information, see Clause 9. Reagents used for both passive and active samplers are given in Annex A.

7.2 Placing of measuring equipment

7.2.1 General

The corrosivity of the indoor atmosphere can vary dramatically from one point to another in a room. Cooler areas can have moisture condensation with a high corrosion effect. Corners often have higher contaminant concentrations and lower air circulation than the rest of the room. If the problem is located in a specific area, measurements shall be performed in that location. If the problem is more general, then measurements should be made in a central open area in the room.

7.2.2 Continuous gas-measuring instruments

The instrument shall be placed so it is protected from unauthorised people. Polyethylene or polytetrafluoroethylene (PTFE) tubing can be used to collect the air sample from the selected area of the room. The length of the tubing should not exceed 2 m.

7.2.3 Active sampler

The active sampler shall be placed according to the same rules as the continuous gas-measuring instrument.

7.2.4 Passive sampler

The passive sampler shall be placed in a part of the room where there is free movement of air. The sampling device shall be placed with the open end facing downward.

7.2.5 Gas-deposition equipment

The equipment shall be placed in a part of the room where there is free movement of air. The equipment shall be sheltered from settling particles that can interfere with the analyses of the gases.

7.3 Measuring methods and duration

7.3.1 Continuous measurement

The measurements should be carried out for one year to record the seasonal variation of the gas pollutants. The data from continuous measuring instruments shall be reported as monthly average values, together with the maximum and minimum values of the month.

Standard instruments have detection limits in the 10^{-9} (volume fractions) range. Specially designed instruments may have detection limits of one-tenth of these values.

7.3.2 Measurement and calculation with the active sampler

The methods are based on pumping air through an absorption unit with a reactive surface or liquid, with subsequent laboratory analysis of the amount absorbed. The result will be given as an average concentration for the sampling period. The sampling time shall be one week or longer. The sampling period is preferably one year, or at least one month for each season of the year.

With active samplers, the volume of air passed through the absorption unit (V) is known. The average concentration (C) is then given by Formula (1):

$$C = \frac{m}{V} \qquad (1)$$

where

C is the average concentration, in µg/m^3;

m is the gas absorbed, in µg;

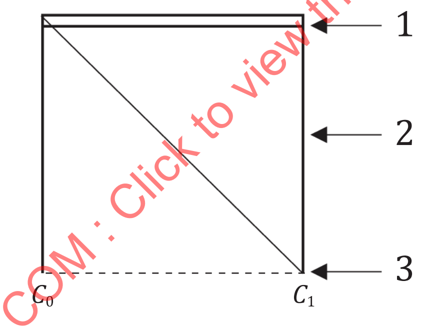
V is the volume of air passed through the absorption unit, in m^3.

The data shall be collected weekly, reported as average weekly values and converted to average monthly values for four weeks. The maximum and minimum values for the period shall also be reported.

NOTE The detection limits for air concentrations depend on the sensitivity of the analysing instruments and the duration of the sampling. Standard instruments result in detection limits of 0,1 µg/m^3 for weekly mean values.

7.3.3 Measurement and calculation with the passive sampler

Mean gas concentrations can be calculated using passive sampling devices. The principle used for passive sampling is shown in Figure 1.



Key

1 absorbent

2 tube

3 permeable screen for gases

C_1 is the ambient concentration of gas

C_0 is the concentration of gas at the absorbent, equal to zero

Figure 1 — Principle of construction of a passive-sampling device

The basic idea for the use of passive samplers is that Fick's first law for gas diffusion applies inside the tube. Fick's first law is valid if the air inside the tube is stagnant and the absorbent in the upper end of the tube will completely absorb the gas that reaches the surface. See Formula (2):

$$F_1 = -D_1 \frac{\mathrm{d}C}{\mathrm{d}z} \qquad (2)$$

where

F_1 is the flux of gas, in µg/m^{2}s;

D_1 is the diffusion coefficient for gas, in m^2/s;

dC/dz is the concentration gradient that is negative to the flow direction, in µg/m^4 .

When D_1 is known and the absorbed amount (Q) of gas pollutant is measured, Fick's law can be transformed to Formula (3):

$$C_1 = \frac{Q \cdot z}{D_1 \cdot A \cdot t} \tag{3}$$

where

Q is the total amount of gas absorbed, in µg;

C_1 is the concentration of gas in air, in µg/m^3;

A is the area of absorbent, in m^2;

t is the exposure time, in s;

D_1 is the diffusion coefficient for gas, in m^2/s;

z is the length of diffusion, in m.

D_1 for gases in air is temperature dependent. However, the adjustment is minor in normal climates. The expected change is 0,2 %/°C.

In practice, all different commercial types of passive samplers marketed will have small adjustments to the simple formula presented. The detection limits for air concentrations depend on the diffusion rate of the gas, the sensitivity of the analysing instruments and the duration of sampling. Normal sensitivity for weekly mean values may be 0,1 µg/m^3.

7.3.4 Measurement and calculation of deposition rate of gas pollution

The deposition takes place on an absorbing surface similar to the surfaces used for passive sampling devices. The gas will react when it reaches the surface. Since the absorption system is open, the speed of deposition will depend on the movement of the air.

The results shall be expressed as the gas deposition rate (R), as shown by Formula (4):

$$R = \frac{m}{A \cdot t} \tag{4}$$

where

R is the deposition rate, in mg/m^{2}d;

m is the total mass of gas on the test plate, in mg;

A is the area of the test plate, in m^2;

t is the exposure time, in d.

The sensitivity depends on the analysing instrument and the duration of sampling.

A complete description for SO_2 measurement is given in ISO 9225.

8 Airborne particle contaminants

8.1 Principle

Particles can affect the corrosion processes in different ways. Water-soluble particles, such as sea-salt aerosols depositing on surfaces, will react with most metals if sufficient humidity is present. Soot will adsorb gases such as SO_2 and act as a source for acidic reaction on metals. Solid particles can form dust layers on parts of a surface and create deposit corrosion on metals.

The particles may either be measured as a concentration, in $\mu g/m^3$, or as a deposit on the surface, in mg/m^2d. Dust particles are normally defined as the size fraction from 1 µm to 100 µm. Different types of instruments exist for measuring the concentration of particles. However, the instruments in use have a cut-off value for the size of particles that is much lower than 100 µm. This is related to acceptable limits for health effects. Many of the instruments are able to separate the different particles into size fractions.

8.2 Volumetric measurements

The most important limits for the classes of particles are as the follows.

- PM_{10}: Particulate matter (PM) with an aerodynamic diameter less than 10 µm. These particles are respirable. The largest particles will stick in the nasal and mouth passage while the smaller fraction will go deeper. The smaller faction $PM_{2,5}$ will reach the lung.
- $PM_{2,5}$: PM with an aerodynamic diameter less than 2,5 µm.
- Total suspended particles (TSP) gives values without a special cut-off diameter. In indoor atmospheres, the result will often be comparable with PM_{10} results.

NOTE 1 Acceptable limits for particles in ambient air are normally given only for health considerations. The EC limit for the acceptable PM_{10} concentration for people is 50 $\mu g/m^3$ as a 24 h average. In the USA, the ambient air quality standard given for $PM_{2,5}$ is 65 $\mu g/m^3$.

Particles can be collected with a sampler suitable for recording PM_{10} particles. The samples used shall be qualified for PM_{10} measurements in accordance with EN 12341 when PM_{10} has a specification in accordance with ISO 7708.

The sampler shall have a PM_{10} sampling inlet directly coupled with a filter substrate and regulated flow device to keep a steady airflow during the sampling period. The sampling shall be followed by a gravimetric determination of the PM_{10} mass collected. The result shall be reported as a concentration, in $\mu g/m^3$, by dividing the filter mass loading by the total flow during the sampling time.

NOTE 2 A sampler suitable for $PM_{2,5}$ sampling can be used in accordance with EPA-454/R-98-012.

The normal recommended duration for sampling is 24 h but, in indoor applications, sampling times of up to one week may be used. The total sampling period is preferably one year, or one month for each season of the year.

For corrosion effects, it is important to measure the water-soluble part of the amount of particles. After the total amount of particles in the samples is measured, the sample is washed with deionized water and the water is analysed for Cl^-, SO_4^{2-} and NO_3^-. The results are given, in $\mu g/m^3$.

8.3 Measurement of particle deposits

The deposition rate for water-soluble particles on a surface can be measured by exposing a defined clean surface area for a selected time period, normally between one week and one month. The surface shall be washed with a known amount of deionized water. The water shall be collected and analysed for the most important ions. The deposition rate for an ion (mg/m^2d) can be calculated by dividing the total amount of the ion collected with the area and time exposed. Indoor sampling equipment can be fairly simple.

NOTE If an evaluation of corrosion risk on existing surfaces is needed, collection of water salts can be carried out in accordance with ISO 8502-6.

9 Dry deposition velocity and measurements of air flow

The relation between deposition and concentration measurements for gases (see Clause 7) and particles (see Clause 8) is denoted the dry deposition velocity, as shown by Formula (5):

$$v_\mathrm{d} = \frac{F}{C} \tag{5}$$

where

v_d is the dry deposition velocity, in m/s;

F is the flux of gas (amount of net transported gas per time and area), in µg/m^{2}s;

C is the concentration of gas in air, in µg/m^3.

The dry deposition velocity is a very useful parameter when assessing the transport and deposition of gaseous and particulate contaminants. It is an important parameter when assessing the mass transport limitations in indoor environments and the corresponding corrosion rates[6]. It is therefore recommended to measure both the concentration and deposition of contaminants, or, if only one of these is measured, make an estimation of the dry deposition velocity based on air flow measurements or air flow data, i.e. ventilation rates.

Annex A
(informative)

Reagents used for both passive and active samplers

A.1 Sulfur dioxide (SO_2)

The most common absorbents for SO_2 are KOH or Na_2CO_3. To keep the surface moist, glycerol is often added to the absorbent. KOH is not recommended in areas with high relative humidity, due to its ability to absorb water and CO_2.

Ion chromatography is the most frequently recommended analytical method for SO_2.

Diffusion coefficient for SO_2 at 25 °C = 1,32 × 10^{-5} m^2/s.

A.2 Nitrogen dioxide (NO_2)

The most commonly used method for absorption consists of using triethanolamine (TEA), using either ion chromatography or spectrophotometry for analysis of NO_2 as nitrite. For a long exposure time and high temperature NaI + $NaCO_3$, KI + arsenite or NaI + NaOH seem to be better. Spectrophotometric analysis of nitrite is the most common analysing method.

Diffusion coefficient for NO_2 at 25 °C = 1,54 × 10^{-5} m^2/s.

A.3 Dihydrogen sulfide (H_2S)

Sulfides are absorbed on a surface with silver nitrate. The amount of sulfur absorbed can be analysed by inductively coupled plasma atomic emission spectrometry (ICP-AES).

Diffusion coefficient for H_2S at 25 °C = 1,81 × 10^{-5} m^2/s.

A.4 Ammonia (NH_3)

Ammonia will be absorbed on organic acids such as oxalic, citric or tartaric acid. NH_3 is analysed by photospectroscopy.

Diffusion coefficient for NH_3 at 25 °C = 2,54 × 10^{-5} m^2/s.

A.5 Ozone (O_3)

Passive samplers for ozone were introduced in the 1990s. Both $NaNO_2$ + K_2CO_3 + glycerol and KI buffered to pH 9, have been used. Spectrophotometry is normally used for the analysis.

Diffusion coefficient for O_3 at 25 °C = 1,62 × 10^{-5} m^2/s.

A.6 Formic acid

The passive sampler for formic acid has been introduced. K_2CO_3 dissolved in water has been recommended as an absorbent for formic acid. Ion chromatography with analysing of formate has been used for the final analysis.

Diffusion coefficient for formic acid at 25 °C = 1,2 × 10^{-5} m^2/s.