INTERNATIONAL STANDARD

ISO 11844-3

First edition
2006-05-15

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 11844-3:2006(E)

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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.

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ISO 11844-3 was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*.

ISO 11844 consists of the following parts, under the general title *Corrosion of metals and alloys — Classification of low corrosivity of indoor atmospheres*:

- *Part 1: Determination and estimation of indoor corrosivity*
- *Part 2: Determination of corrosion attack in indoor atmospheres*
- *Part 3: Measurement of environmental parameters affecting indoor corrosivity*

Introduction

This part of ISO 11844 deals with environmental parameters for the characterisation of indoor atmospheres and methods of measurement.

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

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

INTERNATIONAL STANDARD ISO 11844-3:2006(E)

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

Part 3:
Measurement of environmental parameters affecting indoor corrosivity

1 Scope

This part of ISO 11844 describes methods for measuring the environmental parameters used to classify the corrosivity of indoor atmospheres on metals and alloys.

2 Normative references

The following referenced documents are indispensable 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 7708:1995, *Air quality — Particle size fraction definitions for health-related sampling*

ISO 9225:1992, *Corrosion of metals and alloys — Corrosivity of atmospheres — Measurement of pollution*

ISO 11844-1, *Corrosion of metals and alloys — Classification of low corrosivity of indoor atmospheres — Part 1: Determination and estimation of indoor corrosivity*

EN 12341:1998, *Air quality — Determination of the* PM_{10} *fraction of suspended particulate matter — Reference method and field test procedure to demonstrate reference equivalence of measurement methods*

3 Principle

Different combinations of parameters affect the corrosivity of indoor atmospheres. Knowledge about possible sources of environmental effects must be obtained before decisions regarding the type of measurements needed are taken. The characterisation of indoor atmospheric corrosivity using environmental parameters is more complicated than measuring the corrosivity with metal specimens. However, in many cases, 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.

4 Environmental parameters

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

- humidity and temperature;
- airborne contaminants, such as gases and particles.

Fluctuation in the temperature and humidity, particularly at higher humidity levels, may 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 might accelerate the corrosion processes.

5 Humidity and temperature parameters

5.1 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.

5.2 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.

5.3 Temperature–humidity complex

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

6 Airborne gas contaminants

6.1 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.

6.2 Placing of measuring equipment

The corrosivity of the indoor atmosphere may vary dramatically from one point to another in a room. Cooler areas may 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.

6.2.1 Continuous gas-measuring instruments

The instrument shall be placed so it is protected from unauthorised people. Polyethylene or polytetrafluoroethene (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.

6.2.2 Active sampler

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

6.2.3 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.

6.2.4 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.

6.3 Measuring methods and duration

6.3.1 Continuous measurement

The measurements shall preferably 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 a range from 4×10^{-5} to 1×10^{-6} volume fractions. Specially designed instruments may have detection limits of one-tenth of these values.

6.3.2 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 (V) is known. The average concentration (C) is then

$$C = \frac{m}{V} \tag{1}$$

where

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

m is the gas absorbed, in µg;

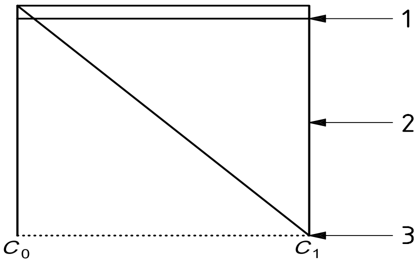
V is the air passed through the absorption unit, in m^3.

The data shall be collected weekly and 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. The normal sensitivity for the instrument is 0,01 µg/cm^3 and weekly mean values with detection limits better than 0,1 µg/m^3 can easily be obtained.

6.3.3 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 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.

$$F_1 = -D_1 \frac{\mathrm{d}C}{\mathrm{d}z} \tag{2}$$

where

F_1 is the flux of gas (amount of net transported gas per time and area);

D_1 is the diffusion coefficient for gas in area per time;

$\mathrm{d}C/\mathrm{d}z$ is the concentration gradient that is negative to the flow direction.

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

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

where

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

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

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

t is the exposure time, in seconds;

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

z is the length of diffusion, in cm.

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 equation 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.

6.3.4 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 gas (SO_2) deposition rate (R) in milligrams per square metre per day

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

where

$R_{\mathrm{SO_2}}$ 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 days.

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

A complete description for SO_2 is given in ISO 9225.

7 Airborne particle contaminants

7.1 Principle

Particles can affect the corrosion processes in different ways. Water-soluble particles, like sea-salt aerosols depositing on surfaces, will react with most metals if sufficient humidity is present. Soot will adsorb gases like 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 µg/m^3, or as a deposit on the surface, in mg/m^2.d. 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.

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

7.2 Volumetric measurements

The most important limits for the classes of particles are the following:

- PM_{10}: Particles 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.
- $PM_{2.5}$: Particles 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.

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 according to 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 µg/m^3, by dividing the filter mass loading by the total flow during the sampling time.

NOTE A sampler suitable for $PM_{2.5}$ sampling can be used according to EPA-454/R-98-012.

The result of this sampling shall be reported as a concentration, in µg/m^3, by dividing the filter mass loading by the total flow during the sampling time.

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 µg/m^3.

7.3 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^2/d) 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 according to ISO 8502-6.

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 = $1{,}32 \times 10^{-5}$ 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 = $1{,}54 \times 10^{-5}$ 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 = $1{,}81 \times 10^{-5}$ m^2/s.

A.4 Ammonia (NH_3)

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

Diffusion coefficient for NH_3 at 25 °C = $2{,}54 \times 10^{-5}$ 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 = $1{,}62 \times 10^{-5}$ 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 = $1{,}2 \times 10^{-5}$ m^2/s.

A.7 Acetic acid

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

Diffusion coefficient for acetic acid at 25 °C = $1{,}1 \times 10^{-5}$ m^2/s.

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[2] EPA-454/R-98-012, *Guidance for using continuous monitors in* $PM_{2.5}$ *monitoring networks.* USA Environmental Protection Agency Guidance

ICS 77.060

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