INTERNATIONAL STANDARD

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Second edition
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Corrosion of metals and alloys — Corrosivity of atmospheres — Measurement of environmental parameters affecting corrosivity of atmospheres

Corrosion des métaux et alliages — Corrosivité des atmosphères — Mesurage des paramètres environnementaux affectant la corrosivité des atmosphères

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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 9225 was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*.

This second edition cancels and replaces the first edition (ISO 9225:1992), which has been technically revised.

Introduction

The ability of an atmosphere to cause corrosion of metals and alloys is controlled by the following factors: the temperature-humidity complex and pollution. A basic requirement for the estimation of the corrosivity of atmospheres is standardized measurement of the important parameters describing the correlation between the corrosion and the environmental characteristics.

The methods included in this International Standard have been chosen for their easy applicability and good comparability of results. It is important to stress that the methods for estimation of the atmospheric corrosivity given in ISO 9223 are based on the measurement methods described in this International Standard.

Corrosion of metals and alloys — Corrosivity of atmospheres — Measurement of environmental parameters affecting corrosivity of atmospheres

WARNING — Some of the procedures included in this International Standard entail the use of potentially hazardous chemicals. It is emphasized that all appropriate safety precautions should be taken.

1 Scope

This International Standard specifies methods for measuring the parameters needed for corrosivity estimation used for classification of the corrosivity of atmospheres in ISO 9223.

This International Standard specifies methods for the measurement of environmental parameters for

- normative corrosivity estimation based on calculated first-year corrosion rates of standard metals, and
- informative corrosivity estimation based on characterization of the exposure environment.

This International Standard does not describe the usual analytical techniques for the measured parameters since this depends on the available analytical techniques used in laboratories. Specific methods for deposition measurement of SO_2 and Cl^- deposition rates and conversional factors for comparison of different measuring methods are presented in Annexes A, B, C, D, E and F.

For methods pertaining to the characterization of the atmospheric exposure site in general, see ISO 8565.

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 9223, *Corrosion of metals and alloys — Corrosivity of atmospheres — Classification, determination and estimation*

ISO 11844-3, *Corrosion of metals and alloys — Classification of low corrosivity of indoor atmospheres — Part 3: Measurement of environmental parameters affecting indoor corrosivity*

3 Principle

Different environmental parameters and their combinations affect the corrosivity of the atmosphere. Two methods for corrosivity estimation (normative and informative) are specified in ISO 9223.

In general, two groups of parameters are obtained or measured for standardized procedures of corrosivity estimation:

- humidity and temperature;
- airborne contaminants.

Standardized corrosivity estimation is based on information on levels of the dominating environmental parameters: the temperature-humidity complex, and pollution with SO_2 and airborne chlorides. Measurements of these parameters are mandatory for the purpose of corrosivity estimation.

Contaminants other than SO_2 and Cl^-, such as NO_x, O_3, H_2S, HNO_3, can also exert an effect on the corrosion rate. Corrosion active components of dust deposits (SO_4^{2-}, NO_3^-, Cl^-) react with metals in the presence of humidity. These factors are considered as accompanying factors (see ISO 9223). These environmental parameters, which contribute to the effect on corrosion of standard metals in multi-pollutant situations, are not included as mandatory parameters for corrosivity estimation in ISO 9223. Information on levels of these parameters can help in informative corrosivity estimation.

Methods for the measurement of environmental parameters to be used specifically for the estimation of low corrosivity of indoor atmospheres (IC) are given in ISO 11844-3.

4 Humidity and temperature parameters

4.1 Relative humidity

Reliable long-term average values for relative humidity can often be obtained from the meteorological authorities in the country. Several types of measuring devices can be used if collection of new data for the locality is needed. There are several continuous measuring devices, such as hygrographs, thermohygrographs or logging hygrometers, available on the market.

The period of measurement is preferably one year in order to cover seasonal variations and because the classification system is based on yearly average values. The data shall be expressed as yearly mean values.

4.2 Temperature

Reliable long-term average values for temperature can often be obtained from the meteorological authorities in the country. Several types of measuring devices can be used if collection of new data for the locality is needed. There are several continuous measuring devices, such as thermohygrographs or logging thermometers, available on the market.

The period of measurement is preferably one year in order to cover seasonal variations and because the classification system is based on yearly average values. The data shall be expressed as yearly mean values.

5 Airborne contaminants

5.1 Principle

The gas concentration or deposition rate may be measured using several techniques:

- continuous gas concentration measuring instruments;
- average gas concentration with active sampler and air pump;
- average gas concentration with diffusive (passive) sampler;
- average deposition rate equipment.

The results from concentration measurements are typically given in micrograms per cubic metre (µg/m^3) and, for deposition measurements, in milligrams per square metre per day [mg/(m^2·d)].

5.2 Placement of measurement equipment

5.2.1 Continuous gas concentration measurement instruments

The instrument shall be located in a place that is sheltered from the rain and protected from unauthorized people. Preferably, the instrument should be placed indoors with a tube leading out to the ambient air. Polyethylene or PTFE tubing is recommended and the length of the tubing should not exceed 2 m. The inlet shall be facing down with a wider hood at the inlet to reduce the risk of sucking particulates into the tube.

5.2.2 Measurement instruments with active sampler

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

5.2.3 Measurement instruments with diffusive sampler

The sampling device shall be placed with the open end facing downward under appropriate shelter. The air flow influences the gas diffusion in the sampler.

5.2.4 Deposition rate equipment

The equipment shall be sheltered from setting particles and from washing out by rain for outdoor deposition measurements. The air flow influences the deposition rate.

5.3 Measurement methods and duration

5.3.1 Continuous measurement

The measurements shall preferably be carried out for one year in order to record the seasonal variation of the gas pollutants. The data from continuous measuring instruments shall be recorded as monthly average values. For the corrosivity estimation, the data shall be expressed as yearly mean values.

Standard instruments have detection limits in a range from 4×10^{-5} volume fractions to 1×10^{-6} volume fractions.

5.3.2 Measurement with active sampler

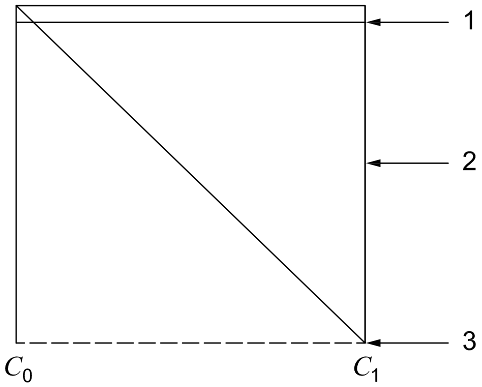
The methods are based on pumping air through an absorption unit with a reactive surface or liquid, with subsequent laboratory analysis of the amount absorbed. The sampling period shall be one week. The data shall be collected over the sampling periods and summarized to monthly average values. The result is given as an average concentration for the measuring period.

The measuring period is preferably one year or at least one month for each season of the year. For the corrosivity estimation, the data shall be expressed as yearly mean values.

NOTE The detection limits for air concentrations depend on the sensitivity of the analysing instruments and the duration of the sampling. For an analytical instrument with normal sensitivity, it is possible to obtain weekly average values with a detection limit better than 0,1 µg/m^3.

5.3.3 Measurement with diffusive sampler

Mean gas concentrations can be calculated using diffusive sampling devices. The principle used for diffusive sampling is shown in Figure 1. The recommended sampling period is one month, but can be extended to three months, corresponding to one measurement for each season of the year. The measurement period is preferably one year.



Key

1	absorbent
2	tube
3	permeable screen for gases
C_1	ambient concentration of gas
C_0	concentration of gas at the absorbent equal zero

Figure 1 — Principle of concentration calculation for a diffusive sampler

NOTE Normal sensitivity for weekly mean values is down to 0,1 µg/m^3 for SO_2, but higher for other gases. Generally the detection limit decreases with increasing sampling time.

The general calculation model is specified in ISO 11844-3.

The data shall be expressed as yearly mean values.

5.3.4 Measurement of deposition rate of pollution

The deposition takes place on an absorbing or collecting surface similar to the surfaces used for diffusive sampling devices. In the deposition method standardized for SO_2 deposition measurements, the gas reacts when it reaches the lead dioxide surface or alkaline surface (see Annexes A, B and C). In the methods standardized for airborne salinity measurements, particles (aerosol) are deposited on a wet or dry surface designed to collect this pollutant (see Annexes D and E). Since the collecting system is open, the deposition rate depends on the movement of the air.

NOTE The use of lead compounds can be restricted in some countries.

SO_2 deposition measurements performed by the lead dioxide plates and by the lead dioxide cylinder differ with regard to the kind and shape of the deposition surface. Both measurements give values with low correlation for monthly sampling periods due to the greater variation in weather characteristics. A high correlation exists for annual average values (see Annex F). Capture of sulfuric acid aerosols and sulfur-bearing species from precipitation and sea salt deposition can occur.

The SO_2 deposition values used for the derivation of the dose-response functions given in ISO 9223 are either based on deposition measurements on alkaline surfaces or converted values based on concentration measurements.

Chloride deposition rates determined by the dry plate method and by the wet candle method differ because the kind and shape of deposition surface are different (wet/dry surfaces, cylindrical/plate format of the deposition surface). There is little difference in the deposition rates determined by the two methods at locations with very low deposition rates, i.e. <10 mg/(m^2·d). On the other hand, at higher chloride deposition rates, the wet candle method gives deposition rates that are approximately twice as high as those given by the dry plate method. Both these measurements give values with low correlation for monthly sampling periods due to the great variation in weather characteristics. A high correlation exists for annual average values (see Annex F).

The chloride deposition values used for the derivation of the dose-response functions given in ISO 9223 are based on measurements with the wet candle method. If the chloride deposition is measured with the dry plate method (see Annex E), it is necessary that the transformation factor given in Annex F be applied before using the dose-response functions.

Annex A
(normative)

Determination of sulfur dioxide deposition rate on lead dioxide sulfation plates

A.1 Principle

Atmospheric sulfur dioxide (SO_2) reacts with the lead dioxide (PbO_2) to form lead sulfate ($PbSO_4$). The plates are withdrawn after exposure and sulfate analysis is performed on the contents to determine the extent of sulfur dioxide capture. The deposition rate of sulfur dioxide is expressed in milligrams per square metre per day [mg/(m^2·d)].

The lead dioxide reagent used in this method can also convert other sulfur-bearing compounds, such as hydrogen sulfide (H_2S) and mercaptans (C_2H_5SH), to sulfate.

The inverted position of the disc is intended to minimize sulfur capture from acid precipitation or sulfuric acid (H_2SO_4) aerosols.

A.2 Sampling apparatus

A.2.1 Sulfation plate

Sulfation plates may be purchased ready for exposure or may be prepared. The following method is recommended for the preparation of sulfation plates.

Bond filter paper circles to the bottom of polystyrene Petri dishes. The circle diameters may be 50 mm or 60 mm. Bonding is carried out by placing a filter paper rough side up, in the bottom of the dish. The filter paper should fit inside the dish without wrinkling. Carefully squirt acetone into the dish so that the filter becomes just saturated. Press the filter paper firmly with a glass rod so that it adheres completely to the dish. Allow the acetone to evaporate.

Place a batch of bonded plates (several tens of either 50 mm plates or 60 mm plates) in a rack and rinse with distilled or demineralized water. Fill the plates with water again and allow to stand for 1 h. Pour the water out of the plates and refill to between one quarter and one half with distilled or deionized water.

Add 3,5 g of tragacanth gum and 900 ml of distilled or deionized water to a high-speed blender. Set at a low speed and blend for 2 h.

Pour the contents of the blender into a 1 l beaker and pour 350 ml of the solution back into the blender. Pulp 3,5 g of filter paper, add them to the 350 ml of gum solution and set the blender at a moderate speed until the mixture appears smooth and uniform.

Pour 400 ml of the previously prepared gum solution into the blender and blend at a moderate speed for 1 min.

Set the blender at a high speed and add 112 g of lead dioxide. Blend for 2 min and then turn the blender back to a low speed.

Carefully pipette 10 ml of the mixture into each 50 mm plate or 15 ml into each 60 mm plate. Make sure that the mixture spreads uniformly to the edge of each plate.

Place the rack of plates in an oven set at 40 °C to 50 °C for 20 h.

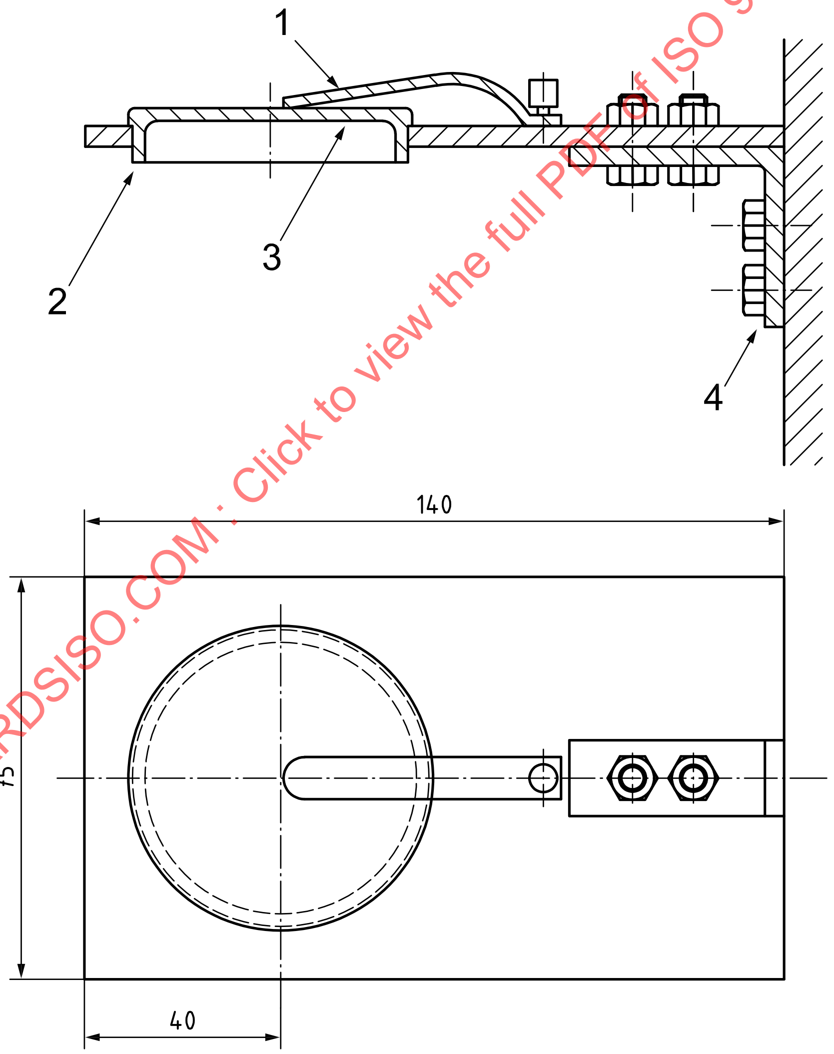
Remove the plates from the oven, allow to cool and seal them with tight-fitting covers to protect them until exposure begins.

Number the plates and expose them within 120 days of preparation. Retain at least three plates from each batch for reference.

A.2.2 Exposure rack

Brackets shall be used to hold the plates securely in an inverted position so that the lead dioxide mixture faces downwards. The plates shall be horizontal and shall not be obstructed from normal winds and air circulation currents. The brackets shall be constructed from a material which has adequate resistance to atmospheric corrosion. They shall include a retaining clip or other provision to hold the plate in the event of strong winds. A typical bracket design is shown in Figure A.1.

Dimensions in millimetres



Key

1 retainer

2 plastic Petri dish ∅ 60

3 lead dioxide (PbO_2) paste

4 bracket

Figure A.1 — Sulfation plate holder

A.3 Sampling

When monitoring exposure sites, a minimum of three plates shall be used for each sampling period.

The plates should be placed, if possible, at the highest and lowest levels of exposure of corrosion test specimens.

A (30 ± 2) day sampling period is recommended. At the end of the sampling period, the plates should be removed from the bracket and covered tightly to prevent additional sulfation. Analysis of the plates should be performed within 60 days of completing exposure. When the exposure is finished, the plate identification, exposure location and the dates of exposure initiation and completion shall be recorded.

A.4 Sulfate analysis

The contents of the sulfation plate are removed and dissolved, for example using a solution of sodium carbonate. Thereafter, conventional sulfate analysis may be employed, for example turbidimetrical or spectrophotometric methods.

A.5 Expression of results

The sulfation rate is calculated in terms of sulfur dioxide (SO_2) captured by the plate. The mass of SO_2 obtained from the plate analysis procedure is converted to net SO_2 mass by subtracting the blank value obtained from the batch of plates in question.

The deposition rate of sulfur dioxide (SO_2), expressed in milligrams per square metre per day [mg/(m^2·d)], $P_{\mathrm{d,p}}$, is given by Equation (A.1):

$$P_{\mathrm{d,p}} = \frac{m_1 - m_0}{A \cdot t} \qquad \text{(A.1)}$$

where

m_1 is the total mass, in milligrams, of sulfur dioxide in the exposed plate;

m_0 is the total mass, in milligrams, of sulfur dioxide in the non-exposed plate;

A is the area, in square metres, of the exposed part of the test plate (i.e. 0,03 m^2);

t is the exposure time, in days.

Annex B
(normative)

Determination of sulfur dioxide deposition rate on lead dioxide sulfation cylinder

B.1 Principle

Atmospheric sulfur dioxide (SO_2) reacts with lead dioxide (PbO_2) to form lead sulfate ($PbSO_4$). The cylinders are withdrawn after exposure and sulfate analysis is performed on the contents to determine the extent of sulfur dioxide capture. The deposition rate of sulfur dioxide is expressed in milligrams per square metre per day [$mg/(m^2 \cdot d)$]. The lead dioxide reagent used in this method can also convert other sulfur-bearing compounds, such as hydrogen sulfide (H_2S) and mercaptans (C_2H_5SH), to sulfate.

B.2 Sampling apparatus

B.2.1 Sulfation cylinder

The following method is recommended for the preparation of sulfation cylinders.

Cut a clean, broad cloth of yarn count 60 to a size of 10 cm × 10 cm and stick to the middle part of a cylinder (periphery 10 cm, length 15 cm) made of ceramics or plastics (see Figure B.1).

Dissolve 2 g of powder tragacanth gum in 10 ml of ethanol, add 190 ml of deionized water while stirring, mix well to prepare the tragacanth gum solution.

Knead well to a paste, 5 ml of tragacanth gum solution with 5 g of the powder of lead dioxide containing particles of less than 149 µm in size and particularly of lower sulfate content.

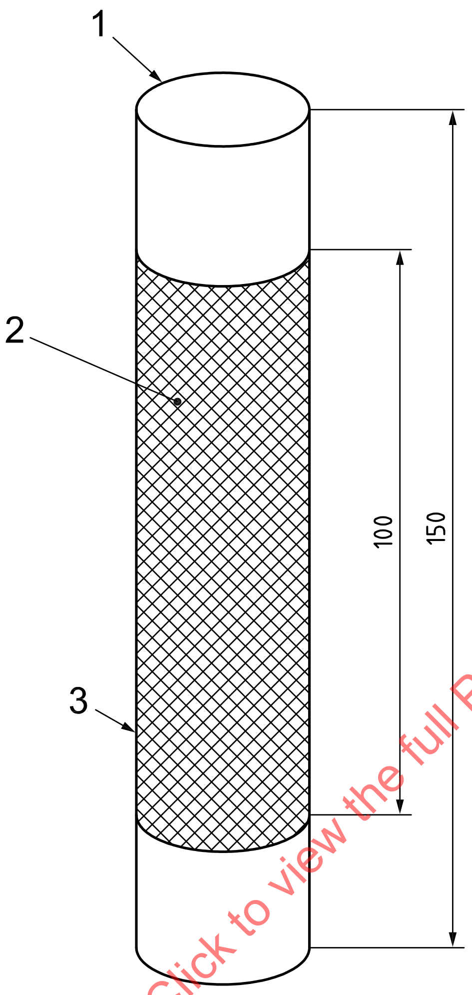
Coat uniformly with this paste, the surface of the broad cloth stuck on the cylinder surface using a brush or a clean rubber glove for surgical use, and dry in a desiccator. Retain the dried lead dioxide cylinder in a desiccator or an appropriate container until the exposure.

B.2.2 Exposure rack

The deposition of sulfur dioxide as well as aerosol particles depends on the shape and dimensions of the cover used to protect the sampler from rain.

Shelters should be used to hold the cylinders and prevent them from getting wet by rain and snow. The shelters shall not obstruct normal winds and air circulation. Meteorological sheds can be also used. The shelters shall be constructed from a material which has adequate resistance to atmospheric corrosion.

Dimensions in millimetres



Key

1 cylinder (periphery 100) made of ceramics or plastics

2 broad cloth of yarn count 60

3 lead dioxide (PbO_2) paste

Figure B.1 — Lead dioxide cylinder

B.3 Sampling

Lead dioxide cylinders shall be exposed vertically within an instrument screen or a shelter and placed near the exposure test rack or under a cover which keeps it away from rain and sunshine at a well-ventilated location.

The sampling period shall be one month, starting on the first day of each month and ending on the first day of the next month.

An exposed cylinder shall be stored to prevent additional sulfation.

B.4 Sulfate analysis

The sulfate analysis shall be performed within 60 days of completing exposure.

The lead dioxide cloth removed from the cylinder is put in a 500 ml beaker with 100 ml of demineralized water. 5 g of sodium carbonate is added and the content is mixed until dissolved. The mixture should boil for 30 min, keeping the water volume at approximately 100 ml by adding water and, after cooling down to room temperature, the mixture is filtrated and rinsed using a filter paper. Thereafter, conventional sulfate analysis may be employed, for example gravimetric or turbidimetrical methods.

B.5 Expression of results

The results shall be expressed as sulfur dioxide deposition rate (SO_2), in milligrams per square metre per day [mg/(m^2·d)], $P_{\mathrm{d,c}}$, and are calculated using Equation (B.1):

$$P_{\mathrm{d,c}} = \frac{m_1 - m_0}{A \cdot t} \tag{B.1}$$

where

m_1 is the total mass, in milligrams, of sulfur dioxide in the exposed cylinder;

m_0 is the total mass, in milligrams, of sulfur dioxide in the non-exposed cylinder;

A is the area, in square metres, of the exposed part of the test cloth (i.e. 0,01 m^2);

t is the exposure time, in days.

To obtain the $P_{\mathrm{d,p}}$ value, the relevant calculation in Annex F shall be applied.

Annex C
(normative)

Determination of sulfur dioxide deposition rate on alkaline surfaces

C.1 Principle

Sulfur oxides (SO_x) and other sulfur compounds of an acid character are collected on the alkaline surface of porous filter plates saturated by a solution of sodium or potassium carbonate (Na_2CO_3 or K_2CO_3). Sulfur compounds, which are converted into sulfates, are determined. The deposition rate of sulfur dioxide (SO_2) is expressed in milligrams per square metre per day [$mg/(m^2 \cdot d)$].

C.2 Sampling apparatus

C.2.1 Sulfation plate

Sulfation plates shall be prepared using the following method.

Immerse paper filter plates of 150 mm × 100 mm × 3 mm, for 2 min in a 70 g/l sodium or potassium carbonate solution. (It is admissible to use chromatographic paper filter plates or other materials of similar properties.)

Remove the plates from the solution, drain and dry for a few hours at a temperature of 70 °C to 90 °C with a tolerance of ±2 °C till the plates are dry. After drying, seal the plates in plastic containers (polyethylene, polypropylene). Take five plates from every processed series in which the sulfate content is determined as a blank.

C.2.2 Exposure rack

The test plates are exposed on a rack (see Figure C.1) in a vertical position so that their surfaces are parallel to the prevailing wind direction. The bottom edges of the plates shall be 1,8 m to 2 m above the ground. A roof over the rack prevents the plates from being washed out by rain but enables free circulation of air around the plates.

C.3 Sampling

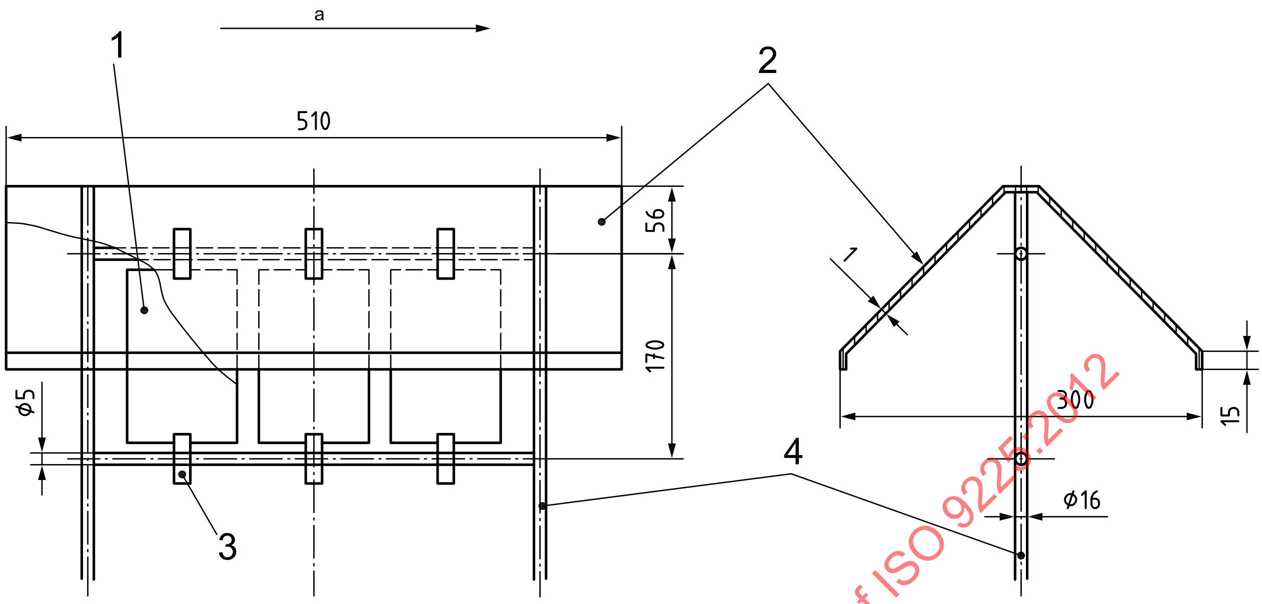
At the test location (test site), three test plates shall be installed with the fasteners on the rack. The sampling period of the test plates is (30 ± 2) days, unless the character of the test or the pollution level requires a different time (60 days or 90 days). After exposure is complete, remove the test plates without damaging the surface layer and seal them separately in plastic containers. Mark the plastic containers with the test site name and dates of exposure and removal.

C.4 Sulfate analysis

The sulfate analysis shall be performed within 60 days of completing exposure.

The exposed plate is extracted by 400 ml of demineralized water with the addition of 1 ml of hydrogen peroxide solution to oxidize the remaining sulfite. The mixture is boiled for 10 min. After 24 h the mixture is filtered and filled to a known volume (e.g. 500 ml). Thereafter, conventional sulfate analysis may be employed, for example gravimetric or spectrophotometric methods.

Dimensions in millimetres



Key

1 sulfation plate
2 roof
3 holder
4 frame

[a] Prevailing direction of winds.

Figure C.1 — Exposure rack for alkaline sulfation plates

C.5 Expression of results

The results shall be expressed as sulfur dioxide deposition rate (SO_2), in milligrams per square metre per day [mg/(m^2·d)], $P_{d,a}$, and are calculated using Equation (C.1):

$$P_{\mathrm{d,a}} = \frac{m_1 - m_0}{A \cdot t} \tag{C.1}$$

where

m_1 is the total mass, in milligrams, of sulfur dioxide in the exposed plate;

m_0 is the total mass, in milligrams, of sulfur dioxide in the non-exposed plate;

A is the area, in square metres, of the exposed part of the test plate (i.e. 0,03 m^2);

t is the exposure time, in days.

Annex D
(normative)

Determination of chloride deposition rate by the wet candle method

D.1 Principle

A rain-protected wet textile surface, with a known area, is exposed during a specified time. The amount of chloride deposited is determined by chemical analysis. From the results of this analysis the chloride deposition rate is calculated, expressed in milligrams per square metre per day [$\text{mg}/(\text{m}^2\cdot\text{d})$].

D.2 Sampling apparatus

D.2.1 Wet candle

The wet candle is formed from a wick inserted into a bottle. The wick consists of a central rod of about 25 mm in diameter made of inert material (polyethylene) over which is stretched or wound a double layer of tubular surgical gauze or a band of surgical gauze. The surface of the wick exposed to the atmosphere shall be about 100 cm^2, which corresponds to a wick length of about 120 mm. The exposed area shall be accurately known. One end of the wick is inserted into a rubber stopper. The stopper has two additional holes through which the free ends of the gauze pass (if tubular gauze is used, the lower end is cut along the length of the gauze until about 120 mm are left). The edges of the three holes are shaped into a funnel so that liquid running down the gauze drains through the stopper (see Figure D.1). The free ends of the gauze shall be long enough to reach the bottom of the bottle.

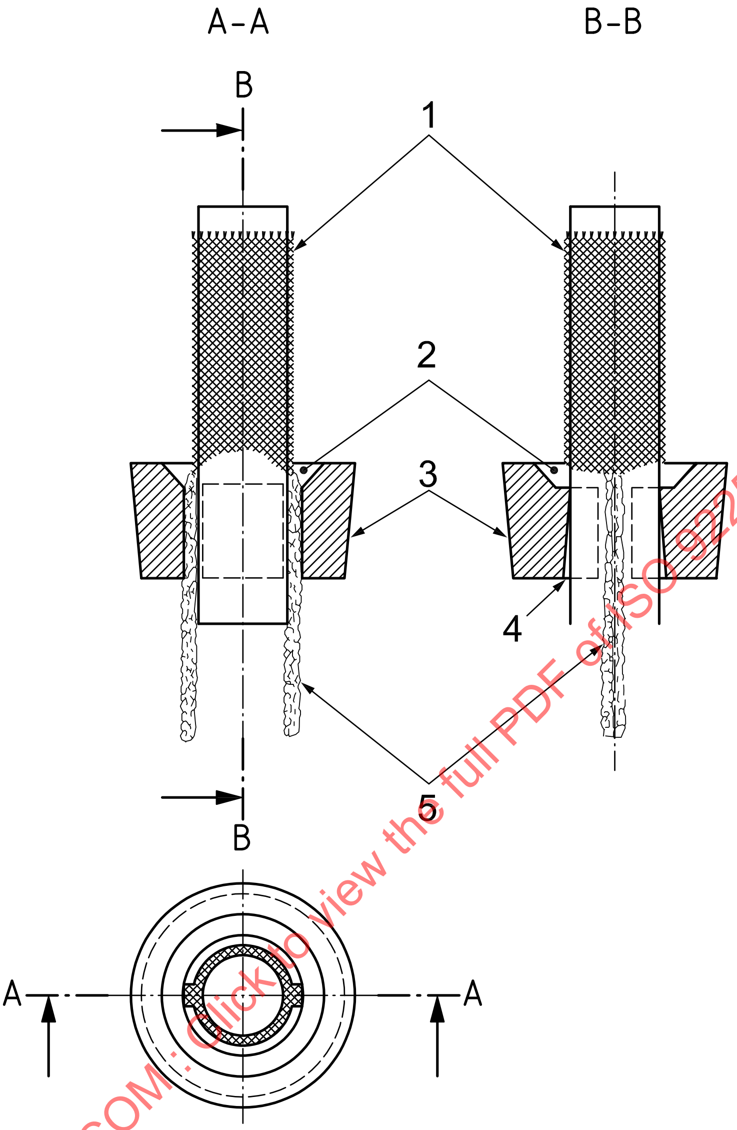
The stopper is inserted into the neck of a bottle of polyethylene or other inert material, with a volume of about 500 ml. The bottle contains 200 ml of a glycerol solution. The solution is made up by mixing 200 ml of glycerol [$\text{CHOH(CH}_2\text{OH)}_2$] with distilled water to a volume of 1 000 ml. To this solution is added 20 drops of octanoic acid ($\text{C}_8\text{H}_{16}\text{O}_2$) to prevent the growth of fungi such as *Aspergillus niger*.

In situations of prolonged extreme temperatures, i.e. greater than 25 °C or less than −25 °C, it can be necessary to increase the glycerol content to a volume fraction of 40 % to prevent freezing or excessive evaporation, or to replace the glycerol solution by ethylene-glycol at a volume fraction of 20 %.

D.2.2 Exposure rack

The wet candle is exposed on a rack under the centre of a roof as shown in Figure D.2. The roof should be a square of 500 mm side, inert and opaque. The candle should be attached so that the distance from the roof to the top of the wick is 200 mm and so that it is centred on the roof. The distance between the bottle and the ground level should be at least 1 m. The candle should be exposed towards the sea or other chloride source.

The source of uncertainty is derived from a combination of rain and strong winds (with speeds above 10 m/s to 12 m/s), which can lead to rain drops falling on the collector (gauze) and can significantly influence the measurement of the chloride deposition rate.



Key

1 wick

2 additional holes (funnel shaped) for free ends of gauze

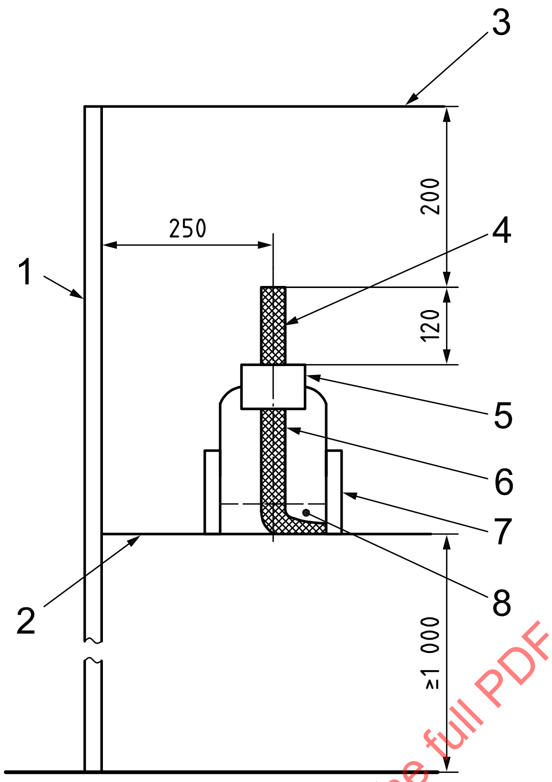
3 stopper

4 central hole for wick

5 free ends of gauze

Figure D.1 — Detail of rubber stopper

Dimensions in millimetres



Key

1	post	5	rubber stopper
2	support	6	free ends of gauze
3	roof (500 × 500)	7	bottle holder
4	cylindrical wick	8	solution

Figure D.2 — Sampling apparatus assembly

D.3 Sampling

The prefabricated candle shall be installed at the test location and the following steps shall be carried out:

a) the length of the exposed part of the wick shall be adjusted to the desired value;

b) the stopper and wick shall be removed from the bottle, the free ends of the gauze and the bottle shall be washed with distilled water;

c) 200 ml of the glycerol and water solution (see D.2.1) shall be placed in the bottle;

d) the wick and bottle shall be reassembled;

e) the candle shall be placed in the exposed position according to Figure D.2.

The glycerol and water solution shall be changed at monthly intervals in the following way:

- loosen the stopper in the bottle;
- wash the wick carefully with at least 200 ml of distilled water, ensuring that the water runs through the drain holes of the stopper and thereafter into the bottle;

- remove the stopper and wick from the bottle and wash the free ends of the gauze as they are withdrawn from the bottle;
- place the stopper and wick into a new bottle containing 200 ml of fresh glycerol and water solution, ensuring that the free ends of the gauze dip well into the solution; replace the candle in its holder;
- screw the lid on the bottle making sure that it does not leak.

The bottle shall be marked clearly with the test site name, location and dates of exposure and removal. The solution in the bottle is prepared for analysis.

D.4 Chloride analysis

Conventional chloride analysis may be employed for the analysis of the exposed and non-exposed gauze (as a blank sample).

D.5 Expression of results

The results shall be expressed as deposition rate of chloride (Cl^-), in milligrams per square metre and per day [mg/(m^2·d)], $S_{d,c}$, and are calculated using Equation (D.1):

$$S_{\mathrm{d,c}} = \frac{m_1 - m_0}{A \cdot t} \tag{D.1}$$

where

m_1 is the total mass, in milligrams, of chloride ions in the sample solution;

m_0 is the total mass, in milligrams, of chloride ions in the solution prepared from non-exposed gauze of the same area as the sampling gauze;

A is the area, in square metres, of the exposed gauze surface (see Note);

t is the exposure time, in days.

NOTE The area of the exposed gauze surface can be calculated by multiplying the diameter of the rod by π (3,14) and by the length of the wick protruding from the stopper.

Annex E
(normative)

Determination of chloride deposition rate by dry plate method

E.1 Principle

Gauze in double layers, with a known area, is exposed, protected from rain. The amount of chloride deposited on the gauze surface is determined by chemical analysis. From the results of this analysis, the deposition rate is calculated, expressed in milligrams per square metre per day [mg/(m^2·d)].

E.2 Sampling apparatus

E.2.1 Dry plate

Dry plates shall be prepared using the following method.

The dry plate is formed from a gauze mounted on wooden collection frames. A wooden inner frame having external dimensions of 120 mm × 120 mm and internal dimensions of 100 mm × 100 mm is fitted with a wooden outer frame having external dimensions of 150 mm × 150 mm and internal dimensions of 100 mm × 100 mm (see Figure E.1). The collection area shall be 200 cm^2 in total of both surfaces.

The gauze shall be cut to a size of 120 mm × 240 mm; chlorides shall be thoroughly leached from the gauze with deionized water and dried well. They are stored in a polyethylene bag until the time of use. The gauze shall be folded in two immediately before exposure and shall be attached to the collection frame without wrinkling.

E.2.2 Exposure rack

The dry plate is exposed on a rack under the centre of a roof as shown in Figure E.2.

The exposure rack shall intercept the direct sunlight, and the rain and snow. It shall be equipped with a holder capable of holding a dry plate vertically at a required position. The lower end of the dry plate shall be positioned at a height of 1 m to 1,2 m from ground level. The exposure rack shall not prevent air circulation to the dry plate surface. The dry plate shall be mounted on the exposure rack and shall be fixed firmly so as not to be swung by the wind.

The exposure site shall be near the exposure testing apparatus to expose the test specimens. The dry plate should be exposed towards the sea or other chloride source.

E.3 Sampling

The sampling period is one month and the exposure usually starts on the first day of each month.

The exposed gauze should be removed from the collection frame and put it in a polyethylene bag for storage until the analysis.