INTERNATIONAL STANDARD

ISO 10062

Third edition
2022-11

Corrosion tests in artificial atmosphere at very low concentrations of polluting gas(es)

Essais de corrosion en atmosphère artificielle à très faible concentration en gaz polluants

Reference number
ISO 10062:2022(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

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

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 262, *Metallic and other inorganic coatings,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 10062:2006), which has been technically revised.

The main changes compared to the previous edition are as follows:

- simplified method has been deleted due to safety issues for operator;
- warnings about each gas have been added in 5.1.2;
- Annex A has been changed to normative annex;
- the installation environment has been added to Annex A.

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

Products with, for example, sensitive electrical functions, can, during storage or operation in indoor locations, be affected by atmospheric corrosion dependent on climatic factors such as temperature, relative humidity, air velocity and rate of change caused by temperature and humidity. Additionally, gaseous pollutants can seriously affect the rate of corrosion, as well as the occurrence of different corrosion mechanisms. Contaminants on the surface, such as salt, dust, oil and compounds liberated from plastics, can also affect the rate and mechanism of corrosion.

Different corrosion-promoting gaseous pollutants dominate in different field environments:

- sulfur dioxide and nitrogen oxides in atmospheres influenced by combustion of fossil fuels and in traffic environments,
- hydrogen sulfide in atmospheres in the vicinity of petrochemical and steel industry, decaying organic matter, stagnant waters and animal shelters, and
- hydrogen sulfide and chlorine compounds in the vicinity of pulp and paper industry; if chlorine is used for bleaching.

Those gaseous pollutants are known to act as single corrosion-promoting factors. However, in atmospheres where more than one gaseous pollutant is present, synergistic effects can be initiated. As a result, a considerable increase in the corrosion rate can occur, compared to the case when the different gaseous pollutants act as single corrosion-promoting factors.

This document is intended to

a) specify a general method using atmospheres polluted by one or more gases at very low volume fractions $\leq 10^{-6}$ under specified conditions of temperature and relative humidity, so as to avoid condensation phenomena during the test,

b) specify the test apparatus and procedure required to achieve the best possible reproducibility, and

c) assess performance under test conditions which accelerate corrosion; as knowledge of operating conditions proceeds, more suitable pollutants or pollutant mixtures can be used.

This document is not intended to be used for comparative testing as a means of ranking different materials relative to each other with respect to corrosion resistance or as a means of predicting long-term corrosion resistance of the tested material.

Corrosion tests in artificial atmosphere at very low concentrations of polluting gas(es)

1 Scope

This document specifies tests which are intended to determine the influence of one or more flowing polluting gas(es) at volume fractions less than or equal to 10^{-6} on test samples and/or articles of metals and alloys with or without corrosion protection under determined conditions of temperature and relative humidity.

This document is applicable to

a) metals and their alloys,

b) metallic coatings (anodic and cathodic),

c) metals with conversion coatings,

d) metals with anodic oxide coatings, and

e) metals with organic coatings.

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 554, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 558, *Conditioning and testing — Standard atmospheres — Definitions*

3 Terms and definitions

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

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

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

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

3.1
exposure time
interval of time elapsed between the moment when the specimens are introduced into the test chamber and the end of the test

3.2
test duration
interval of time during which the specimens are exposed to polluting gases

4 Apparatus

WARNING — Safety rules for personnel: Handling of the gases used for testing can be hazardous and shall be done by skilled personnel trained to handle such gases. The test equipment shall be

used and maintained by skilled personnel, not only so that the tests can be performed correctly, but also because of the hazards to health and safety that are involved.

Special attention shall be paid to equipment design and the choice of construction materials, in order that the conditions (less than ±1 °C for temperature and less than ±3 % for relative humidity) are uniformly consistent throughout the working space, able to ensure no condensation in the test chamber and are repeatable.

The apparatus shall enable the use, singly or in mixtures, of polluting gas(es) such as SO_2, H_2S, Cl_2 and NO_2 up to at least the concentration required, for each gas, by the test method.

The important parameters are

a) the materials used for the test chamber and the gas handling system,

b) the geometry of the test chamber,

c) the rate and pattern of the gas flow,

d) the homogeneity of gas mixing, and

e) the incident illumination (see A.1.6).

The apparatus shall be constructed according to Annex A and shall meet its requirements.

A typical apparatus for polluting-gas corrosion tests is also shown in Annex B (see Figure B.1).

5 Test methods

5.1 Test severity

5.1.1 General

The test severity, to be given in the relevant specification, is specified by

- the type, concentration and flow rate of polluting gas,
- the temperature,
- the relative humidity, and
- the test duration.

5.1.2 Suggested test methods

The method, shown in Table 1, to be used depends upon the purposes of the test, the nature of the metals and alloys and the type of protection to be tested.

WARNING — Sulfur dioxide (SO_2, CAS Registry Number®[1] 7446-09-5) is toxic, corrosive and irritating. Refer to the safety data sheet for details. Handling of sulfur dioxide shall be restricted to skilled personnel or conducted under their control. The apparatus shall be used and maintained by skilled personnel, not only so that the procedures can be performed correctly, but also because of the hazards to health and safety that are involved.

WARNING — Hydrogen sulfide (H_2S, CAS 7783-06-4) is a flammable gas, toxic, corrosive, irritating and very toxic to aquatic life. Refer to the safety data sheet for details. Handling of hydrogen sulfide shall be restricted to skilled personnel or conducted under their control. The

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[1] CAS Registry Number® is a trademark of CAS corporation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

apparatus shall be used and maintained by skilled personnel, not only so that the procedures can be performed correctly, but also because of the hazards to health and safety that are involved.

WARNING — Chlorine (Cl_2, CAS 7782-50-5) is oxidizing gas, toxic, corrosive and irritating. Refer to the safety data sheet for details. Handling of chlorine shall be restricted to skilled personnel or conducted under their control. The apparatus shall be used and maintained by skilled personnel, not only so that the procedures can be performed correctly, but also because of the hazards to health and safety that are involved.

WARNING — Nitrogen dioxide (NO_2, CAS 10102-44-0) is oxidizing gas, toxic, corrosive and irritating. Refer to the safety data sheet for details. Handling of nitrogen oxide shall be restricted to skilled personnel or conducted under their control. The apparatus shall be used and maintained by skilled personnel, not only so that the procedures can be performed correctly, but also because of the hazards to health and safety that are involved.

Table 1 — Test conditions

	Method A	Method B	Method C	Method D	Method E	Method F
SO_2 (10^{-6} vol/vol)	0,5 ± 0,1	—	—	0,5 ± 0,1	0,20 ± 0,05	0,5 ± 0,1
H_2S (10^{-6} vol/vol)	—	0,10 ± 0,02	—	0,10 ± 0,02	—	0,10 ± 0,02
Cl_2 (10^{-6} vol/vol)	—	—	0,02 ± 0,005	—	—	0,02 ± 0,005
NO_2 (10^{-6} vol/vol)	—	—	—	—	0,5 ± 0,1	—
Temperature (°C) and relative humidity (%) [a]	(40 ± 1) °C and (80 ± 5) %, or (25 ± 1) °C and (75 ± 3) %					

[a] The condition of (40 ± 1) °C and (80 ± 5) % is more aggressive than the condition of (25 ± 1) °C and (75 ± 3) %. Either of them shall be optionally selected and shall be stated in the test report.

NOTE 1 Since the corrosivity is different for methods A, B, C, D, E and F the result obtained by these methods are not comparable.

NOTE 2 Other methods can be added in the future if required (e.g. increase in the relative humidity).

5.1.3 Test duration

The test duration for each test method depends upon the purposes of the test, the nature of the metals and alloys and the means of protection tested.

5.2 Treatment of the specimens prior to testing (see Clause 6)

The relevant specification may require a preconditioning of specimens, for example, chemical or mechanical cleaning of the surface.

5.3 Examination of the specimens prior to testing

Measurements shall be carried out as required by the relevant specification (see ISO 7384).

5.4 Filling of the test chamber

The filling of the chamber by the specimens shall satisfy the following conditions:

- the total surface of the test specimens shall not exceed the critical level at which the concentrations of polluting gases would decrease by more than 10 % during the passage through the working space;
- the specimens shall be placed in the working space, as specified in the relevant specification.

Care shall be taken that the specimens are placed so that they do not come into contact with one another or with the walls of the chamber, and that they do not shield one another from the test atmosphere.

The specimens shall be distributed uniformly in the working space.

5.5 Procedure

5.5.1 Exposure time

The exposure time shall correspond to t_1 to t_3 (see Figure 1).

5.5.2 Test duration

The test duration shall correspond to t_2 to t_3 (see Figure 1).

5.5.3 Test procedure

The conditions of the specimens and the test chamber shall be such that condensation does not occur on the specimens when they are introduced into the test chamber.

The temperature and relative humidity inside the chamber shall be adjusted according to the specified method (see 5.1.2 and A.1.4).

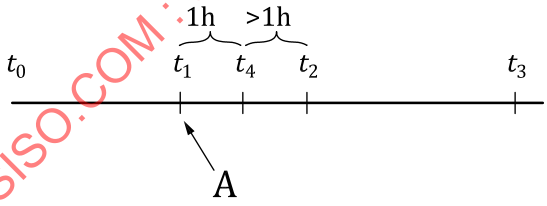
After introducing the specimens, a waiting period of 1 h should be allowed for the temperature and the relative humidity to stabilize before the polluting gas(es) is/are introduced into the test chamber.

The polluting gas(es) shall be introduced simultaneously into the damp air flow and their concentrations shall be adjusted to the value specified by the test method; during this adjustment, the maximum specified concentrations should not be exceeded (see 5.1).

The concentration of polluting gas(es) shall be stabilized in less than 1 h.

The test duration shall be measured as indicated in 5.5.2.

At the end of the test, the injection of polluting gas(es) shall be stopped and the specimens shall be maintained in the flow of the damp atmosphere without polluting gas(es) for 2 h.



Key

A	introduction of specimens
t_0	time to start to adjust the temperature and the relative humidity
t_1	time to reach the specified temperature and the relative humidity and start the exposure time
t_2	time to start the test duration
t_3	time to stop the test duration and the exposure time
t_4	time to introduce polluting gas(es)

NOTE 1 t_0 to t_1 is the temperature and the relative humidity adjustment.

NOTE 2 t_1 to t_4 is the waiting period of 1 h to recover the temperature and the relative humidity.

NOTE 3 t_4 to t_2 is the gas-concentration adjustment less than 1 h.

NOTE 4 t_2 to t_3 is the test duration.

NOTE 5 t_1 to t_3 is the exposure time.

Figure 1 — Test procedure

5.6 Monitoring of test behaviour

In order to monitor the chamber performance for each test, appropriate metal control coupons (copper or silver) should be exposed simultaneously with the specimens in the working space of the test chamber, and the corrosive effects on these coupons should be assessed (e.g. nickel, and gold on copper).

5.7 Post-test storage

The specimens shall be removed from the chamber and stored under standard conditions as specified in ISO 554 and ISO 558. The reaction of specimens during storage after testing shall be considered.

6 Information to be given in the relevant specification

The following information shall be given in the relevant specification:

a) a reference to relevant specification with publication date;

b) conditions and duration of the test;

c) treatment of the specimens prior to testing if required;

d) a report on the examination of the specimens prior to testing;

e) assessment of corrosion effects and a report on the visual examination during and after testing.

7 Expression of results

There are many criteria for the evaluation of the corrosion resistance of metals and alloys with and without corrosion protection, for example:

a) change in the specimen appearance during the test;

b) time elapsed before the first local sign of corrosion of base metal or coating appears;

c) number, depth and distribution of corrosion defects;

d) change in mass (see ISO 8407);

e) changes in dimensions (especially thickness);

f) change in mechanical, electrical, optical and other properties.

8 Test report

The test report shall contain the following information:

a) the purpose of the test;

b) a reference to this document, i.e. ISO 10062:2022 and the test method used (A, B, C, D, E or F) together with option of temperature and humidity;

c) designation and description of the test specimens and control coupons, if used (chemical composition, shape and dimensions, method of treatment: chemical, thermal and mechanical, type or coating and its thickness);

d) known characteristics of the specimens tested;

e) exposure period;

f) duration of the test;

g) method of placing and material for fastening the test specimens during the test;

h) the results of evaluation of corrosion changes for the tested specimen surfaces, including both descriptive and numerical assessment, possibly with photographs of the test specimens;

i) comparison of control coupons with previous exposures;

j) any deviations from procedure;

k) any unusual features observed;

l) the dates of the test.

If the necessary measurements cannot be made within the specified time, the period of storage under recovery conditions may be extended. This extension shall be mentioned in the test report.

Other data may be included in the test report depending on the purpose of the test, as well as on the criteria chosen for expressing the results.

Annex A
(normative)

Specifications for apparatus for corrosion tests in artificial atmosphere

A.1 Test chamber

A.1.1 Materials

Precaution shall be taken to compensate for

— adsorption and desorption of gases and steam, and

— corrosion of the test chamber by the test atmosphere.

This requires that

— the internal walls and parts of the chamber shall be made of inert material [e.g. glass or polytetrafluoroethylene (PTFE)],

— any windows(s) shall be of PTFE or glass,

— pipes, valves and taps in contact with the polluting gas(es) should preferably be made of inert material, and

— gaskets and seals shall be made of inert materials (e.g. fluoro-elastomers).

Other materials may be used, but adsorption or desorption phenomena shall be taken into account.

A.1.2 Design

The chamber shall be designed to avoid condensation at any point and to allow easy and thorough cleaning of inner walls and fittings.

The volume of the chamber shall be not less than 0,1 m^3.

In the working space, the uniformity of the temperature shall be better than ±1 °C and the uniformity of the relative humidity shall be better than ±3 %.

A.1.3 Pressure seals

The test chamber shall be fitted with suitable gasket seals to allow the test conditions to be maintained and monitored.

A.1.4 Test atmosphere

The flow rate within the chamber shall be controlled. The test atmosphere shall flow through the chamber in such a manner as to ensure uniform test conditions in the working space.

This flow rate shall be sufficient to ensure at least three exchanges per hour of the atmosphere in the test chamber.

NOTE The mass transfer characteristics for the transport of pollutants to the surface of the test specimens vary with volume flow rate of test atmosphere through the test chamber, but also with the geometry of the test chamber. Because of that, deviation in corrosion rate can therefore result if two test chambers with different geometries are used, even if the exchange rate of the test atmosphere is the same in the two test chambers.

The test atmosphere is preferably injected through opening(s) in the bottom of the chamber and extracted through opening(s) in the top of the chamber. Suitable baffles shall be placed in front of the opening(s), to ensure the required uniform test conditions in the working space.

The test atmosphere extracted from the chamber shall be collected in such a manner as to conform with safety precautions.

A.1.5 Sampling points

Sampling points for the analysis of the atmosphere during the test (see Clause A.3) are placed close to the injection points and the outlet points, in the working space. Checks should be made to ensure that the concentration of polluting gas(es) does(do) not decrease by more than 10 % during the passage through the working space.

Condensation or adsorption in the lines used to monitor the test atmosphere shall be avoided as far as possible, as this would impair the measurements.

A.1.6 Illuminance level

The test chamber shall not be exposed to direct sunlight and the level of illumination (due to daylight or to incandescent or fluorescent lamps) measured inside the test chamber at any point on the exposed surface shall not exceed 300 lx.

A.1.7 Installation

The test chamber shall be installed in a room free from dust, draughts, corrosive gas and direct solar radiation, at a room temperature of (23 ± 5) °C and at a relative humidity of less than 75 %.

A.2 Generation of the test atmosphere

A.2.1 General

The test atmosphere is obtained by continuously introducing the necessary quantity of polluting gas(es) into a damp air flow to obtain the required concentration(s). The mixing of gases usually requires a mixing tube or chamber.

The dry polluting gas(es) and the damp air shall be mixed together before injection into the working space.

A.2.2 Damp-atmosphere generation

The damp atmosphere shall be within the tolerances for the specified temperature and relative humidity when it is injected into the test chamber. Water droplets or aerosols shall not be injected into the test chamber. The air used may be taken from pressurized cylinders or delivered by a dry pump after filtration and purification by activated charcoal or molecular sieve (size 5 a) and a particulate filter.

A.2.3 Polluting gas(es)

The required concentrations of the polluting gas(es) can be obtained from pressurized cylinders containing mixtures of the pure polluting gas and an inert gas such as nitrogen. Permeation tubes filled