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Metals and alloys — Atmospheric corrosion testing — General requirements for field tests

Métaux et alliages — Essais de corrosion atmosphérique — Prescriptions générales de l'essai in situ

Reference number
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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.

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.

International Standard ISO 8565 was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*.

It cancels and replaces ISO 4542:1981, *Metallic and other non-organic coatings — General rules for stationary outdoor exposure corrosion tests*.

Annex A forms an integral part of this International Standard.

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Introduction

Corrosion testing under atmospheric exposure conditions is carried out in order to

— obtain data on the corrosion resistance of metals, alloys[1] and other inorganic metallic coatings[1] in atmospheric environments;

— evaluate the relationship between the results under given laboratory conditions and in an atmospheric environment;

— evaluate the type of corrosion of particular metals.

It involves exposure of the specimens to the action of atmospheric environments at the test sites and periodic checking of the test specimens. It does not cover service corrosion testing.

The corrosion rate of the specified metal depends on the environment of the atmospheric corrosion test site. The relationship between corrosion rates for metals and atmospheric variables is complex. Therefore the results of field tests cannot be used to predict service performance exactly, but do provide an approximate guidance to service performance.

1) Hereinafter referred to as "metals".

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Metals and alloys — Atmospheric corrosion testing — General requirements for field tests

1 Scope

This International Standard establishes general requirements for stationary corrosion testing of metals and metallic coatings under atmospheric conditions carried out in the open air or under shelters.

It may also be applied for indoor testing.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 4221:1980, *Air quality — Determination of mass concentration of sulphur dioxide in ambient air — Thorin spectrophotometric method.*

ISO 4226:1980, *Air quality — General aspects — Units of measurement.*

ISO 4540:1980, *Metallic coatings — Coatings cathodic to the substrate — Rating of electroplated test specimens subjected to corrosion tests.*

ISO 4543:1981, *Metallic and other non-organic coatings — General rules for corrosion tests applicable for storage conditions.*

ISO 6879:1983, *Air quality — Performance characteristics and related concepts for air quality measuring methods.*

ISO 8403:1991, *Metallic coatings — Coatings anodic to the substrate — Rating of test specimens subjected to corrosion tests.*

ISO 8407:1991, *Corrosion of metals and alloys — Removal of corrosion products from corrosion test specimens.*

ISO 9225:—[2], *Corrosion of metals and alloys — Corrosivity of atmospheres — Measurement of pollution.*

ISO 9226:—[2], *Corrosion of metals and alloys — Corrosivity of atmospheres — Determination of corrosion rate of standard specimens for the evaluation of corrosivity.*

3 Requirements for test specimens

3.1 Types of specimen

3.1.1 Flat sheet specimens

Rectangular specimens in the form of flat sheets are the preferred type as they can be readily weighed and measured and their simple shape facilitates attachment to test frames. A convenient specimen size is 150 mm × 100 mm. Specimens may be larger provided that they can be accurately evaluated. The specimen thickness shall be adequate to ensure that the specimens will survive the intended test period. The specimen thickness shall also take into account the possibility of mechanical effects and of intergranular corrosion in some materials. The most convenient thickness is 1 mm to 3 mm.

For specimens with metallic coatings the surface area of the test specimens should be as large as possible, in any case not less than 50 cm^2 (5 cm × 10 cm). If the coated articles used are smaller than 50 cm^2 in area, specimens of the same kind may be combined to total the required mini-

2) To be published.

mum surface area. However, the results obtained will not necessarily be comparable with those obtained on specially prepared test specimens of the specified minimum area.

3.1.2 Irregularly shaped specimens

Other specimen shapes such as bolts, tubes, rods, angles and even assemblies may be tested if necessary.

The ends of tube specimens shall be sealed if corrosion of the outside surface only is of interest.

Complex specimens, such as assemblies, may contain crevices, water traps, weldments and dissimular metals. It is therefore important to take account of the effects of these on the corrosion resistance of the assembly. Care should also be taken to position the assembly to simulate its intended use.

3.1.3 Specimens with weldments

Atmospheric corrosion tests on weldments are intended to reveal any tendency for preferential corrosion in the weldment zone arising from metallurgical or compositional differences between the weld metal and the parent material. The joints shall preferably be placed in the centre of the test specimen, parallel to its long side; or perpendicular, if required by technical specifications.

3.2 Specimen preparation

Because atmospheric corrosion tests may extend over many years, it is important to ensure that specimens are clearly identified and records of data are carefully kept. It is normally necessary to cut specimens from larger pieces of the metal to be tested and to carry out deburring. These operations involve the risk of surface damage to the specimens and, with some metals, may lead to significant changes in metallurgical condition (for example work-hardening of sheared or cut edges). Surface damage can be avoided with care, whilst work-hardened edges should be removed by machining, unless the effects of this condition are being specifically evaluated. Similar damage may be caused by other operations such as flame-cutting, sawing and grinding. When the results of the test are to be compared with service performance, it is recommended that specimens be exposed with surfaces identical or similar to those which would apply in service. For all other purposes, a well-defined surface preparation is needed.

Surface preparation may involve a combination of a degreasing stage using organic solvents or alkaline degreasing fluids and a mechanical or chemical descaling treatment for surfaces bearing mill scale, heat-treatment scale or rust. Suitable descaling treatments for a wide range of metals are given in ISO 8407:1991, tables 1 and 2.

For metallic and inorganic coatings, it is absolutely necessary to avoid cleaning methods which may attack the surface of test specimens.

3.3 Handling

After final surface cleaning before exposure, it is important that limited handling occurs. In general, it is necessary to use clean gloves in the final handling operations.

3.4 Marking of specimens

Mark the test specimens in such a way that no confusion during the exposure is possible. Marking shall be legible and durable over the whole period of exposure and shall be made on those areas of the test specimens that are not subjected to visual assessment and have no functional purpose.

The test specimens may be marked with appropriate numbers by stamping. For metals, notched specimens or drilled holes can be used. Other marking procedures can be used, provided that the requirements of legibility and durability are met.

Methods suggested for marking are different. For metallic coatings the preferred method is positional notch coding before the protective coating is applied.

The area affected by marking shall be minimized. The establishment of a reliable map of specimen identity, exposure data and location on the exposure frame is recommended.

3.5 Number of specimens

The number of test specimens of each type used in a given evaluation shall not be less than three for each exposure time interval.

Three specimens should suffice for simple comparative test programmes. However, for more complex programmes, more specimens will be needed, according to the statistical requirements.

3.6 Control and reference specimens

It is desirable that extra specimens be included in the test programme, in order to fulfil various requirements of control and reference.

3.6.1 Control specimens

These are replicates of exposed test specimens which are stored under non-corrosive conditions (see 3.7). They may be used to determine changes

in physical and mechanical properties as a result of exposure of the specimens.

3.6.2 Reference specimens

When testing new or modified materials, samples of the original (known) material are used for comparison purposes and exposed together with the test samples.

3.7 Storage

During storage of the test specimens before exposure, and during storage of control specimens, care shall be taken to avoid mechanical damage and contact with other specimens. A room with a controlled temperature and a relative humidity of 65 % or less shall be used for storage purposes. Particularly sensitive specimens shall be stored in a desiccator or sealed in plastic bags with desiccant. (See ISO 4543.)

3.8 Specimen data records

For each series of test specimens, record the data which are needed for the assessment of the corrosion effects (see clause 8). These records shall include the following:

a) in the case of uncoated metal samples

- chemical composition,
- mass,
- shape and size,
- surface finish characteristics,
- heat treatment,
- basic physical properties (mechanical, electrical or physico-chemical) and surface roughness,
- initial state of specimen surface before testing (for metals which may change their structure during long-term exposure under atmospheric conditions),
- method of preparation of the test panels,
- test method for the metal surface treatment,
- specification of the metal according to relevant standards or trade marks,
- specification of the test methods by which the individual properties were evaluated,
- specification of the intermediate product from which the test panels were produced;

b) in the case of metallic coatings

- specification of the basis metal (substrate),
- method of preparing the surface before coating,
- specification of the coating application and coating materials,
- coating thickness,
- basic properties of the coating, including the test methods by which its properties were evaluated (e.g. porosity, hardness, ductility, etc.);

c) in the case of manufactured articles or their parts

- basic technical data on the properties to be tested, with test methods by which they are evaluated (e.g. thickness, porosity, hardness, ductility, etc.) and the initial values before starting the test.

Visual and, if necessary, photographic records of the specimen condition before testing shall be made and carefully retained.

4 Atmospheric corrosion test sites

4.1 Category of location

It is recommended that the atmospheric corrosion test sites provide facilities for both

a) open-air exposure, i.e. direct exposure to all atmospheric conditions and atmospheric contaminants,

or

b) sheltered exposure, i.e. exposure with protection from atmospheric precipitation and solar radiation either under a cover or in a partly closed space, such as shutter sheds, where the test specimens are also protected by shuttered side walls.

Due to the possibility of carrying out sheltered exposure in different ways, it is essential that comprehensive details of the shelter and the manner of exposing specimens are given. The results obtained under different shelters cannot be readily compared.

4.2 Test site requirements

Test sites shall be selected so that the testing area will normally be exposed to the full effects of the weather. The presence of buildings, structures, trees and certain geographical features, rivers, lakes, hills or hollows may cause unintended shelter or exposure to wind, sources of pollution or sunlight.

Unless the effects from man-made or natural features are to be an intended part of the programme, such features in the vicinity of the test site should be avoided; otherwise their presence shall be reported. Similarly, the presence of low-growing shrubs and other plants may affect the temperature and humidity distribution over a given test site and therefore these should be absent or controlled to a maximum height of 0,2 m or by placing test frames on well-drained ground or on gravel, concrete or paved foundations.

If chemicals are used to control plant growth in the vicinity of the specimen racks, care shall be exercised to keep such chemicals from coming into contact with any of the specimens and safety precautions shall be taken.

If atmospheric corrosion tests are to be conducted under sheltered conditions, appropriate provisions for this shall be made whilst avoiding any unwanted effects on neighbouring specimens that are intended to be fully exposed to the weather.

4.3 Test site locations

Test sites shall be located to represent the environments where the materials are likely to be used.

Two kinds of test sites can be distinguished:

a) permanent test sites which are located in areas broadly classified as industrial, rural, urban and marine, taking into account the representative areas of climatic conditions of the region;

b) temporary test sites, located for a predetermined period of time only, in places of specific corrosion interest.

The location of the test site shall permit periodic observations of the test specimens and recording or evaluation of the environmental factors specified in clause 6. It is advantageous to locate atmospheric exposure test stations near to or at a meteorological station. The location of the test site should be selected mainly from the point of view of the environment as well as ease of examination.

4.4 Site security

Atmospheric corrosion test sites shall be designed to provide adequate security against theft, damage or other forms of interference.

Care should be taken that security fencing does not affect the testing, for example by causing some specimens to be in shadow more than others or buried by snow drifts.

4.4.1 Exposure frames

The function of the exposure frames is to maintain test specimens securely in position without undergoing significant deterioration or influencing the corrosion of the test specimens attached to them. The frames may be designed to provide full or partial exposure to the weather.

Metal sections or wood may be used, provided that they have adequate strength and durability. If necessary, additional protection can be provided by paint coatings over suitably prepared and primed metal surfaces. Frames may also be constructed from suitably protected and maintained wood.

The practical realization of the following design requirements will depend upon the locally available resources and materials.

Frames shall be designed to expose as large an area as possible of both the upper and undersides of the specimens. The purpose of this is to enable differences in skyward or groundward exposures to be evaluated if this is a test requirement. In addition, the structural components of the frame shall not shelter the specimens.

The method of attaching specimens to the test frame shall prevent neighbouring specimens from touching, sheltering or influencing one another and shall also provide complete electrical insulation between the specimens and the test frame. Grooved porcelain electrical insulators with fixing holes, or similar devices in inert and durable plastics materials, are suitable. Alternatively, bolts or screws, fitted with electrically insulating sleeves and washers, may be used. The area of contact between the test specimens and their holders shall be as small as possible.

The test frames shall also be designed to enable specimens to be exposed at an angle of 45° from horizontal (30° are permissible) skyward-facing, or in other orientations required by the test programme.

The design of the frame shall be such that test specimens are not affected by water which runs off the test frame or other specimens, or by splash water from the ground. The installation of test frames on a site may also cause localized drifting of snow,

and therefore a minimum specimen exposure height above ground level may be necessary. This minimum height shall be chosen to prevent both splashing by rain water and burial in snow drifts and should be not less than 0,75 m.

The load-bearing capacity of the frames shall allow for the maximum static loading from full specimen capacity and from imposed wind and snow loadings. Frames shall be firmly anchored to the ground and specimens shall not move or become detached in high winds.

It is very convenient for practical purposes to standardize the specimen dimensions or to arrange for a limited range of standard sizes. This simplifies both the design of the test frames and the method of specimen attachment.

To allow accumulation of atmospheric corrosion products and pollutants and to prevent their removal by rain, it may be necessary to perform tests under sheltered exposure. The extent of exposure to atmospheric agents will determine the detailed design of the sheltered exposure racks.

4.4.2 Covers for sheltered exposure

When testing specimens under covers, such as shielding under umbrella roofs, the test specimens should also be placed on racks or frames.

Normal roofing materials may be used for constructing umbrella roofs. The roof shall be inclined to enable water to drain and should normally ensure protection against rain, water dripping from the roof and water splashing from the ground. The roof shall also provide some degree of shielding of the specimens against solar radiation. The maximum height of the roof above the ground and its extension beyond the specimen rack edges shall be not more than 3 m.

4.4.3 Sheds for enclosed exposure

The design of the shutter sheds shall be the same as the design of standard meteorological sheds, which should ensure protection against atmospheric precipitation, solar radiation and wind, but should allow the air flow from outside to be maintained. The exterior surfaces of the shed walls and doors shall be painted white.

The shutters shall be of the Venetian blind type, fixed and stable, so that air exchange is possible between the inside of the shed and the outside atmosphere and so that rain or snow can only rarely penetrate to the interior of the shed. The floor of the shed shall be at least 0,5 m above ground level.

The internal dimensions of the shutter shed shall be chosen to suit the number of test specimens to be placed on racks or shelves inside the shed. The design of the racks and shelves and the positioning of specimens shall ensure free air circulation between the test specimens and prevent the formation of specific microclimatic conditions at particular remote spaces in the shed.

The shutter shed shall be placed on an open space in the test station. If more than one shed is placed at the same test site, the distance between them shall be such that the presence of one shed does not affect the climatic conditions inside another shed. It is recommended that the minimal distance between sheds be equal to twice the height of the shed.

5 Test site characterization

In order to further evaluate the results of the corrosion measurements, it is necessary to characterize the atmospheric conditions at the test sites. This characterization should be done by direct measurements of the corrosion rate of standard specimens according to ISO 9226 and, in the case of the permanent test sites, by measurement or collection of atmospheric data from other sources.

If other sources of atmospheric data are used, both the source and its approximate distance from the test site shall be stated.

The environmental data required for the characterization of the atmosphere are

- air temperature, in degrees Celsius;
- relative atmospheric humidity, as a percentage;
- amount of precipitation, in millimetres per day;
- intensity and duration of solar radiation;
- sulfur dioxide deposition rate according to ISO 9225, in milligrams per square metre per day, or concentration in milligrams per cubic metre;
- chloride deposition rate according to ISO 9225, in milligrams per square metre per day, usually only for marine test sites.

The recommended frequency of monitoring these factors is given in annex A.

Other factors such as duration of precipitation, actual time of wetness, direction and speed of winds, pH value of rain, amount of gases and particulate contaminants, can be collected or measured depending on the specific requirements of the test.

The corrosion rate of standard specimens shall be measured, after removal of the corrosion product, according to ISO 8407.