BS EN ISO 8565:2011

BSI Standards Publication

Metals and alloys — Atmospheric corrosion testing — General requirements (ISO 8565:2011)

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National foreword

This British Standard is the UK implementation of EN ISO 8565:2011. It supersedes BS EN ISO 8565:1995 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/NFE/8, Corrosion of metals and alloys.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN ISO 8565:2011) has been prepared by Technical Committee ISO/TC 156 "Corrosion of metals and alloys" in collaboration with Technical Committee CEN/TC 262 “Metallic and other inorganic coatings” the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2012, and conflicting national standards shall be withdrawn at the latest by January 2012.

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The text of ISO 8565:2011 has been approved by CEN as a EN ISO 8565:2011 without any modification.

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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.

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

This second edition cancels and replaces the first edition (ISO 8565:1992), which has been technically revised.

Introduction

Corrosion testing under atmospheric exposure conditions is carried out in order

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

— to evaluate the type of corrosion of particular metals, and

— to obtain data for corrosivity determination and estimation.

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”.

INTERNATIONAL STANDARD ISO 8565:2011(E)

Metals and alloys — Atmospheric corrosion testing — General requirements

1 Scope

This International Standard establishes general requirements for stationary corrosion testing of metals and metallic and other inorganic coatings under atmospheric conditions carried out in the open air or under shelters. It can also be applied for testing of complex specimens and assemblies of metallic materials.

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 4226, *Air quality — General aspects — Units of measurement*

ISO 8044, *Corrosion of metals and alloys — Basic terms and definitions*

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

ISO 9169, *Air quality — Definition and determination of performance characteristics of an automatic measuring system*

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

ISO 9225, *Corrosion of metals and alloys — Corrosivity of atmospheres — Measurement of environmental parameters affecting corrosivity of atmospheres*

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

ISO 10289, *Methods for corrosion testing of metallic and other inorganic coatings on metallic substrates — Rating of test specimens and manufactured articles subjected to corrosion tests*

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 of different size 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 $\times$ 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 minimum 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 only corrosion of the outside surface is of interest.

Complex specimens, such as assemblies, may contain crevices, water traps, welded joints and dissimilar 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 welded joints

Atmospheric corrosion tests on welded joints are intended to reveal any tendency for preferential corrosion in the weld 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 (preferred position), or perpendicular.

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.

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

The test specimens may be marked 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.

Methods suggested for marking are different. The test specimens may be marked with appropriate numbers by stamping. For metallic coatings, the preferred method is positional notch coding before the protective coating is applied. Other marking procedures can be used, provided that the requirements of legibility and durability are met.

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 exposure 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

3.6.1 General

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

3.6.2 Control specimens

Control specimens 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.

3.6.3 Reference specimens

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

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.

3.8 Specimen data records

For each series of test specimens, records of data are needed for the assessment of the corrosion effects (see Clause 8). These records may 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 physical-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 and other inorganic 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:

- specification of basic metal and/or metallic coating,
- 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, and

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 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 be 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. Placing test frames on well-drained ground or on gravel, concrete or paved foundations can limit this influence.

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.

Test sites are located in areas with corrosivity according to the classification system specified in ISO 9223 (broadly characterized as the type of atmosphere: rural, urban, industrial, marine) taking into account the climatic conditions of the region.

Test sites can be located 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 sites near to or at a meteorological station. The location of the test site should be selected both 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. Additional protection may be provided by protective means (coatings for metal surfaces, 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. Fixing elements may be made from inert and durable materials. 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 minimum height shall be chosen to prevent both splashing by rainwater and burial in snow-drifts and should be not less than 0,5 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

Covers protect the test specimens against rain and provide some shielding of the specimens against solar radiation and deposition of particulates.

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 off. The roof should normally ensure protection against rain and also water dripping from the roof and water splashing from the ground. 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

Sheds protect test specimens against rain, solar radiation and wind. The concentration of the polluting gases and deposition of particulates depends on changes of air flow outside, affected by the design of the shed. The shed shall be placed on an open space in the test site.

The design of the sheds can be similar to the design of common 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 shall be painted white. The floor of the shed shall be at least 0,5 m above ground level.

The internal dimensions of the 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.

5 Test site characterization

In order to evaluate the results of the corrosion measurements, it is necessary to characterize the atmospheric conditions at the test sites. This characterization shall include the factors listed in Annex A. This characterization shall be done by direct measurements of the corrosion rate of standard specimens according to ISO 9226, together with measurement of the environmental parameters at the site or collection of the environmental data from other sources. Environmental data shall be measured or recorded regulary according to Annex A and ISO 9225. The exposure of standard specimens according to ISO 9226 triannualy could be sufficient.

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

The corrosion effect of environmental factors is complex and influenced by many factors and their combinations. Measurement of the dominating factors is prescribed as mandatory (see Annex A). Measurement of other parameters is informative only (see Annex A).

The environmental data for the characterization of the atmosphere are as follows:

— air temperature, in degrees Celsius;

— relative atmospheric humidity, in percentage;

— amount of precipitation, in millimetres;

— solar radiation, in megajoules per square metre;

— sulfur dioxide (SO_2) concentration or deposition rate according to ISO 9225, in micrograms per cubic metre or miligrams per square metre per day;

— chloride (Cl^-) deposition rate according to ISO 9225, in milligrams per square metre per day, mandatory for marine test sites;

— nitrogen dioxide (NO_2) concentration, in micrograms per cubic metre;

— nitric acid (HNO_3) concentration, in micrograms per cubic metre;

— ozone (O_3) concentration, in micrograms per cubic metre;

— hydrogen ions in precipitation, measured as pH.

The recommended frequency of monitoring and mode of reporting these factors is given in Annex A.

Indirect information about solar radiation can be obtained from a report about the duration of sunshine. Other factors such as duration of precipitation, actual time of wetness, direction and speed of winds, amount of other gases like NH_3, and particulate contaminants, can be collected or measured depending on the specific requirements of the test.

The characterization of the test site atmosphere shall be performed according to ISO 4226 and ISO 9169. Deposition measurements shall be performed according to ISO 9225.

6 Operating conditions

The test specimens shall be placed as follows:

— for open-air exposure, the surface of test specimens, in general, faces south in the northern hemisphere and north in the southern hemisphere, but the direction of other corroding sources (such as the ocean) can be taken into consideration;

— for sheltered exposure, the test specimens are exposed at the preferred inclinations of 0°, 30°, 45°, 60° or 90° to the horizontal, unless otherwise specified or agreed;

— the triplicate specimens are usually placed in a column on the rack.

Other operation requirements are given in 4.4.1, 4.4.2 and 4.4.3.

7 Test procedure

7.1 Duration of tests

The total period and the season of exposure depend on the type of test specimen and the purpose of the test. Due to the rate of the atmospheric corrosion process, it is recommended that test exposures be on a schedule, such as 1 year, 2 years, 5 years, 10 years, 15 years or 20 years, depending on the corrosion resistance of the metal or coating being tested.

It should be noted that, especially for short-term testing, the results might depend on the season when exposure is initiated. Therefore, it is recommended that exposures be commenced in the period of highest corrosivity (usually autumn or spring and immediately preceding the rainy season in tropical zones).

7.2 Periodic visual examinations

Specimens shall be examined periodically and notes and photographic records shall be made of any significant changes in appearance or development of unusual features. Observations shall be made on the condition of both the skyward or groundward sides of the specimens in order to observe any differences in corrosion effect.

Records shall include notes on the colour, texture and uniformity of any corrosion products and whether these are adherent or display a tendency to flake off the surface as the specimen ages.

Specimens should be checked to confirm that identity markings are still legible (see 3.4). Periodic examination is also of benefit in relation to site security, instrument service and regular attention to site facilities.

7.3 Evaluation of results

According to the aim of testing and the tested materials, suitable evaluation procedures are used. The evaluation is carried out by visual examination, measurement of mass gain and/or loss, metallographic examination, change in mechanical properties or performance characteristics of materials (e.g. reflectivity). For sheltered exposure, measurements of mass gain are important.

Corrosion effects shall be evaluated at the time intervals established in the test programme as described in 7.1, and by comparison with the control specimens when appropriate. The evaluation of the test specimens shall be carried out within 3 months of completion of the exposure period. During this time, the test specimens shall be stored according to the requirements of 3.7. For metallic and other inorganic coatings, exposure test specimens shall be rated according to the methods given in ISO 10289.

Photographic records of the specimens shall be made according to 7.2 and at the end of the exposure.

Metallic test specimens shall be cleaned of dust and dirt prior to mass-loss evaluation. Removal of corrosion products shall be performed according to the methods specified in ISO 8407.

8 Test report

The test report shall contain the following information:

a) a reference to this International Standard (ISO 8565:2011);

b) data on the test specimens, including the inclination and direction of the specimens' exposure (drawings or sketches of irregularly shaped specimens and assemblies are recommended);

c) test site characterization (see Clause 5);

d) the number of reference specimens and test specimens;

e) the dates of exposure, removal and assessment;

f) the original properties and preparation of the test specimens (see 3.8);

g) a separate qualitative description of changes in surface appearance for each evaluation;

h) the quantitative results of assessment of corrosion by means of mass gain, mass loss, metallographic observations, changes in physical properties, depths, density and distribution of pits or other methods of evaluation.

The test report shall also discuss any problems that may have influenced the test results. It is recommended to include photographic records of the test specimens before, during (see 7.2) and at the end of the exposure (see 7.3) in the test report.

The test report may conclude with a summary of the main results.

Annex A
(normative)

Environmental factors characterizing atmospheric exposure conditions

A.1 Mandatory environmental factors

Environmental factor	Unit	Type and number of measurements	Expression of results
Air temperature	°C	Continuous or at least four times per day with 6 h difference	Average per month and per year
Relative humidity	%	Continuous or at least four times per day with 6 h difference	Average per month and per year
Precipitations	mm	Monthly	Monthly sum or yearly sum
Concentration of SO_2 or SO_2 deposition rate	$\mu g/m^3$ $mg/(m^2 \cdot d)$	Continuous — monthly	Average per month and per year
Chloride deposition rate (marine atmospheres)	$mg/(m^2 \cdot d)$	Continuous — monthly	Average per month and per year
NOTE The frequency of measurements with diffusive samplers may be bi-monthly or even tri-monthly, but not less frequent.			

A.2 Informative environmental factors

Environmental factor	Unit	Type and number of measurements	Expression of results
Solar radiation	MJ/m^2	Continuous — monthly	Yearly sum
Concentration of NO_2	$\mu g/m^3$	Continuous — monthly	Average per month and per year
Concentration of O_3	$\mu g/m^3$	Continuous — monthly	Average per month and per year
Concentration of HNO_3	$\mu g/m^3$	Continuous — monthly	Average per month and per year
Hydrogen ions in precipitations (pH)	—	Monthly	Average per year
Particulate deposition	mg/m^2	Monthly	Average per year
PM_{10}	mg/m^3	Continuous — monthly	Average per year
NOTE 1 The frequency of measurements with diffusive samplers can be bi-monthly or even tri-monthly, but not less frequent. NOTE 2 Measurement of particulate deposition is recommended in industrial atmospheres. Analytical evaluation of anions in particulate matter (i.e. sulfates, chlorides) defines the possible stimulating effect of particulate matter. NOTE 3 Measurement of pollution components indicated as informative, such as HNO_3 and others, can be recommended in urban and industrial atmospheres or for characterization of multi-pollutant environmental conditions. Other pollutants in specific environments can be measured (e.g. NH_3). NOTE 4 The pH value is measured in monthly sum of precipitation.			

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