
International Standard



4543

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Metallic and other non-organic coatings — General rules for corrosion tests applicable for storage conditions

Revêtements métalliques et autres revêtements non organiques — Directives générales pour les essais de corrosion applicables aux conditions de stockage

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4543 was developed by Technical Committee ISO/TC 107, *Metallic and other non-organic coatings*, and was circulated to the member bodies in November 1978.

It has been approved by the member bodies of the following countries:

Australia	India	South Africa, Rep. of
Bulgaria	Italy	Spain
Czechoslovakia	Japan	Sweden
Egypt, Arab Rep. of	Netherlands	Switzerland
France	New Zealand	Turkey
Germany, F. R.	Poland	USA
Hungary	Romania	USSR

The member body of the following country expressed disapproval of the document on technical grounds :

United Kingdom

Metallic and other non-organic coatings — General rules for corrosion tests applicable for storage conditions

0 Introduction

Corrosion testing under storage conditions is carried out in order to :

- a) assess the corrosion resistance of different protective coatings to environments encountered under particular storage conditions;
- b) compare the corrosion resistance of two or more protective coatings;
- c) determine the type and optimum thickness of a protective coating and type of protective wrapping;
- d) evaluate the relationship between the results of testing under laboratory and storage conditions.

It involves exposure of coated test specimens to the action of corrosive factors encountered in storage and periodic observation of the test specimens.

The aggressiveness of corrosion in storage rooms depends upon the humidity and temperature of the atmosphere and upon the action of other environmental factors which may either be constant or may vary periodically or accidentally in a particular microclimate.

1 Scope and field of application

This International Standard gives guidance on methods of corrosion testing of protective metallic, conversion and other non-organic coatings, with or without additive protection, in heated and unheated storage rooms in all microclimates with or without control of climatic parameters.

Specimens and articles may be tested separately or in bulk, and with or without protective wrappings.

2 Test specimens

2.1 Type

The following types of test specimen may be used :

- specially prepared specimens covered with the protective coating to be tested;

- coated production articles or parts thereof.

Depending on the purpose of the examinations, specimens may be tested with or without wrappings and with or without temporary protective films.

2.2 Shape and dimensions

To minimize edge effects and to obtain representative corrosion, the surface area of the test specimens should be as large as possible and in any case not less than 50 cm² (5 cm × 10 cm).

If the coated articles used are smaller than 50 cm² in area, specimens of the same kind may be combined to total the required minimum surface area, but the results obtained will not necessarily be strictly comparable with those obtained on specially prepared test specimens of the specified minimum area.

2.3 Preparation

Clean the test specimens thoroughly before exposure to remove any contaminants that may affect the performance of the coating system being tested. The cleaning method to be employed depends upon the nature of the surface and the contaminants, but shall not include the use of any abrasives or solvents which may attack the surfaces of the test specimens.

However, if testing coatings with additional temporary protective films, do not clean the surface.

2.4 Handling

The handling of test specimens prepared for testing (installation on racks, hanging, etc.) shall be carried out with clean, cotton-gloved hands.

2.5 Marking

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

Test specimens may be marked by one of the following methods :

- a) positional notch coding before the protective coating is applied (preferred method);
- b) stamping appropriate numbers (with a numbering stamp);
- c) hanging on the test specimen a number plate made of a corrosion-resistant material, hanging free of the specimen and attached by means of a loose-fitting, non-metallic thread, for example nylon thread;
- d) painting with suitably durable paints on the reverse side of the test specimen.

Numbers should preferably be marked on the front (test) side of the test specimens, at their bottom edge. The holes on which number plates are hung should be situated near the bottom edge of the specimen so that the plate itself cannot come into direct contact with either the test specimen to which the plate is attached or with neighbouring test specimens after they have been positioned in the frame.

Mark test specimens with figures and letters so that the following information is indicated :

- a) the type of coating;
- b) the type of wrapping or packaging;
- c) the type of temporary protective coating, if any;
- d) a serial number;
- e) the place and conditions of storage.

The markings should be minimized, preferably by using a simple code that enables them to be associated with the information required (see clause 5).

2.6 Number

Select the number of test specimens in any one series of tests according to the type of specimen, the number required to evaluate a particular physical property and the number expected to be removed for examination during the period of exposure. The number of test specimens of each type used for a given evaluation should not be less than three for test specimens having a surface area of at least 50 cm². If the specimens have smaller surface areas, take a correspondingly greater number of test specimens.

2.7 Standard specimens

It is desirable that standard test specimens of solid metals, for example zinc, copper or low alloy steel, should be included alongside the test specimens of the coating system being examined, in order to be able to assess the prevailing corrosive conditions. Therefore, such metals should be chosen from those for which data concerning performance in a variety of storage rooms have been established. The standard test specimens should be stored under the conditions specified in 2.8.

2.8 Storage

Store the test specimens before exposure in a clean, dry atmosphere in an air-conditioned, temperature-controlled room with a relative humidity of 50 % or less, or sealed in a desiccator, or by sealing the specimens into evacuated plastics bags containing a desiccant.

3 Operating conditions

3.1 Corrosion environment

Select the test conditions bearing in mind that the data obtained for a given set of test specimens should correspond with, or be similar to, the actual conditions of use or storage of metals, coatings or articles. Before exposure, assess the corrosion factors indigenous to the storage room where testing is to be carried out.

The factors affecting corrosion vary with the nature of the material being tested and may include any or all of the following :

- a) atmospheric humidity and its fluctuations;
- b) air temperature and its fluctuations;
- c) atmospheric pollution, both chemical (such as the presence of gases and vapours) and physical (such as dust, smoke and foreign matter);
- d) value of, and the fluctuations in, the temperature of the test specimens;
- e) quality of surface cleaning of the test specimens;
- f) exposure to biological species;
- g) corrosive properties of the materials in direct contact with the surface of the specimen;
- h) type and quality of the packaging and its impermeousness.

The recommended methods and frequency of monitoring these factors are given in the annex.

3.2 Storage room and method of exposure

3.2.1 Location

The test specimens should be placed in particular areas of the storage room, for example on shelves. It is advisable to separate off the exposure site in order to avoid damaging the test specimens, but without affecting the environmental conditions.

The location of the test specimens should be such that none of them will be unduly influenced by local heat sources, vents, circulating fans, etc.

The exposure site should be chosen so that it provides the storage conditions to be evaluated.

Storage room floors should be covered with a dust absorbing substance.

3.2.2 Shelves, racks and frames

The structure of the shelves, racks and frames is not specified, but the following requirements should be observed.

Wrapped test specimens should be placed on shelves and frames, while bare specimens should be fixed in frames and placed in racks to enable a larger number of test specimens to be exposed.

The construction of the shelves, racks and frames should :

- a) be made of corrosion-resistant material that has no corrosive action on the test specimens;
- b) if made of wood, have a moisture content of not more than 15 % and not emit vapours of corrosive organic compounds;
- c) be secured so as to prevent undesirable displacement and movement of the test specimens;
- d) be designed in such a way that, unless otherwise specified, the test specimens placed on them are as far away from the floor as possible and not less than 0,5 m from the roof;
- e) if made of wood, be designed so as to minimize the effect of wood preservatives on metals and temporary protectives.

3.2.3 Measuring instruments

Instruments should be positioned and operated in accordance with their service and maintenance instructions. If testing packaged specimens, it is advisable to measure the internal and external humidities, particularly for boxes.

The following measuring instruments may be used to record the exposure conditions :

- a) hygromograph, to record the temperature and the absolute and relative humidities;
- b) instruments to determine and record the sulphur dioxide content and the degree of pollution of the atmosphere by dust and chloride ions.

3.2.4 Exposure of test specimens in storage rooms

The test specimens should be exposed under actual conditions of storage that will be experienced.

If the test specimens are production articles coated with protective agents and/or are wrapped or packaged, position them in accordance with the generally accepted manner of storing such articles.

Place the test specimens in such a way that :

- a) contact does not occur either between individual test specimens or between the test specimens and any material that would affect their corrosion under the test conditions; this may be achieved by fixing the test specimens to the rack(s) or to the frame(s) by means of suitable holders, hooks or clamps, made of non-metallic materials, resistant to atmospheric corrosion and that do not corrode the test specimens, and so that the area of contact between the test specimens and their holders is as small as possible;
- b) there is easy access to the surfaces of the test specimens;
- c) they are easy to remove;
- d) they are protected from falling out (for example by the action of wind), accidental contamination or damage;
- e) they are all exposed to the same conditions with uniform access of air from all directions.

4 Test procedure

4.1 Positioning of test specimens

Draw up a scheme for the positioning of test specimens on the racks, indicating the positions of particular specimens.

If the test programme calls for periodic removal of certain sets of test specimens of the same kind, place these test specimens in the order of their removal.

Place test specimens undergoing periodic visual or functional assessment in such a way that a set of the same specimens forms a separate entity.

If testing is carried out in different storage rooms, maintain the exposure conditions as similar as possible in order to obtain, as far as possible, comparable results, particularly insofar as the positioning of test specimens, and the dimensions and design of shelves, racks and frames, are concerned. If testing metals, coatings and articles, the results of which are to be compared with the result of testing carried out at other times, place comparative standard specimens similarly to the test specimens so as to enable the corrosion resistance of the test specimens and standard specimens to be compared.

4.2 Duration of tests

The total test duration depends on the type of test specimen and the purpose of examination. In principle, continue testing until the first signs of corrosion appear. If the test specimens are to be removed periodically, the time interval between removals is governed by the number of test specimens and the purpose of testing. Assessment should be carried out at regular intervals, the frequency depending upon the corrosion resistance of the coating being tested. The recommended periods are : 1 week, 2 weeks, 2, 3, 6, 12, 18, 24, 36, 48 and 60 months.

4.3 Evaluation of results

If possible, evaluate the degree of corrosion in the storage room where the test specimens were exposed. If it is necessary to carry out the evaluation elsewhere, protect the test specimens from mechanical damage, water and unintentional finger marks. Avoid the rapid transfer of cold test specimens to warm and humid environments.

If it is necessary to transfer the specimens to other places to make an assessment, protect them so that no corrosion changes occur during the transfer. The method of evaluation should always be in accordance with the aim and programme of testing.

Unless otherwise specified, evaluate the corrosion changes at the time intervals specified in 4.2. It is recommended that, in the first month of testing, assessment be made every week or every two weeks of exposure. After completing the exposure, evaluate the results within 1 month. During this time, store the test specimens as specified in 2.8.

The criteria of evaluation of the corrosion results shall be in agreement with the aim and programme of testing. In the case of metallic coatings, follow the recommendations given in the relevant International Standard, unless otherwise specified.

4.4 Control of environmental factors

Before exposure, carry out a general assessment of the corrosion factors and of their type and intensity occurring in the storage rooms. During testing, monitor and record the external environmental factors listed in the annex.

4.5 Expression of results

Report the detailed results of observations and evaluations of corrosion changes of each test specimen on suitable cards.

The cards should include the following information :

- a) the number or reference of the test specimen;
- b) the date of exposure;
- c) a description of the appearance of the test specimen surface before testing;
- d) the dates of assessment;
- e) a detailed description of changes in surface appearance, loss or gain of mass or of other physical properties, separately for each evaluation, possibly with photographs of the test specimens before, during and after testing;
- f) the quantitative results of assessment of corrosion changes by visual or other methods of evaluation, using standards, photographs and patterns;
- g) an evaluation of the packaging or wrapping.

5 Test report

The test report should contain the following information :

- a) the scope of the test;
- b) data concerning specially prepared test specimens (see 2.5) :
 - 1) specification of the basis material (substrate);
 - 2) specification of the coating and coating materials, especially the actual coating thickness;
 - 3) method of preparing and cleaning the surface before coating;
 - 4) method of application of the coating;
 - 5) method of preparing the surface after coating;
 - 6) basic properties of the coating, including the test methods by which its properties, for example porosity, hardness and ductility, were evaluated;
 - 7) materials used for wrapping or packaging and the manner of applying them;
- c) data concerning production articles or parts thereof :
 - 1) basic technical documentation, for example drawings, with specifications of materials and coatings (including type of coating, especially the actual coating thickness);
 - 2) technical data on the properties to be tested, with the test methods by which they are to be evaluated, and including the initial values before exposure;
 - 3) the method by which the surface was prepared and cleaned before the protective coating was applied;
 - 4) the method of packaging, for example a sketch specifying the materials employed;
- d) data on the testing conditions :
 - 1) place of exposure;
 - 2) method of placing or fixing the test specimens during testing;
 - 3) duration of test, for example dates of starting and completion;
 - 4) results of measuring the external corrosion factors (see the annex);
- e) the dates and results of evaluation of the corrosion changes for particular test specimens, in accordance with 4.5, including both descriptive data and numerical assessment, possibly with additional remarks on the conduct of the test and photographs of the test specimens and packaging.

Annex

Types and numerical values of factors characterizing storage conditions

Measured value	Unit	Type and number of measurements	Expression of results
Air temperature	°C	Continuous measurement	Average per day, month and year
Relative humidity and its variation	%		Minimum and maximum values
Absolute humidity and its variation	g/m ³		Minimum and maximum values
Air contamination* – concentration : of SO ₂ of Cl ⁻ – cumulative deposit per day : of SO ₂ of Cl ⁻	mg SO ₂ /m ³ mg Cl ⁻ /m ³ mg SO ₂ /m ² mg Cl ⁻ /m ²	At least once per week	Average per month and year
		Continuous	Total per month and year
Dust contamination (by solid particles)	g/m ²		Chemical composition and sum in month
Biological factors	–	Periodical observations	Presence or absence

* If any exists : required only for a full test programme.

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