
**Corrosion of metals and alloys — Alternate
immersion test in salt solution**

*Corrosion des métaux et alliages — Essai en immersions alternées
en solution saline*

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ISO 11130:1999

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 11130 was prepared by Technical committee ISO/TC 156, *Corrosion of metals and alloys*.

Annexes A and B of this International Standard are for information only.

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Introduction

Corrosion of metals is influenced by factors which may vary significantly with environmental conditions. Therefore, corrosion resistance determined for metals during alternate immersion testing described in this International Standard may vary greatly with the test solution selected, the temperature during immersion and the temperature and humidity during the drying periods of test.

Consequently, the result of an alternate immersion corrosion test should not be taken as indicative of the corrosion resistance of metal tested in all the different service environments in which the metal may be used.

Nevertheless, results obtained by the method described in this International Standard may indicate the relative corrosion resistance of different metals under in-service conditions, particularly when the service environment is similar to the test solution selected. The method may also be used to test metals under an applied tensile stress.

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Corrosion of metals and alloys — Alternate immersion test in salt solution

1 Scope

The purpose of this International Standard is to define a method of assessing the corrosion resistance of metals by an alternate immersion test in salt solution, with or without applied stress.

The test is particularly suitable for quality control during the manufacture of metals including aluminium alloys and ferrous materials, and also for assessment purposes during alloy development.

Depending upon the chemical composition of the test solution, the test may be used to simulate the corrosive effects of marine splash zones, de-icing fluids and acid salt environments.

The term "metal" as used in this International Standard includes metallic materials with or without corrosion protection.

The alternate immersion test applies to:

- metals and their alloys, <https://standards.iteh.ai/catalog/standards/sist/3b8b9121-c9a2-4b32-b484-81f333ef7e2f/iso-11130-1999>
- certain metallic coatings (anodic and cathodic with respect to the substrate);
- certain conversion coatings;
- certain anodic oxide coatings;
- organic coatings on metals.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1462:1973, *Metallic coatings — Coatings other than those anodic to the basis metal — Accelerated corrosion tests — Method for the evaluation of the results.*

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

ISO 7539-1:1987, *Corrosion of metals and alloys — Stress corrosion testing — Part 1: General guidance on testing procedures.*

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

3 Principle

The test consists of immersion of a test specimen, stressed (see ISO 7539-1) or unstressed, in a salt solution, followed by withdrawal and a period of drying.

The immersion/drying cycle is repeated at a given frequency for a given period. The extent of attack is then evaluated. For many materials, this provides a more severe corrosion test than simple continuous immersion.

4 Test solution

4.1 General

The test solution shall be prepared using reagent grade chemicals conforming to the prescribed specification. Otherwise, the solution used should be the one most appropriate to the intended service conditions. Subclause 4.2 gives details of a neutral salt solution that is suitable for simulating the corrosive effect of a marine environment.

Details of three other test solutions suitable for simulating salt-based de-icing liquid, acid salt conditions and ocean water are given in annex A.

4.2 Preparation

The neutral salt solution is prepared by dissolving a sufficient mass of sodium chloride in distilled or deionized water to give a concentration of 35 g/l \pm 1 g/l. The distilled or de-ionized water used shall have a conductivity not higher than 2 mS/m at 25 °C \pm 2°C.

The maximum allowable impurity content in the sodium chloride solution shall be as follows:

Impurity	Maximum permissible content % (m/m)	Remarks
Copper	0,001	Determined by atomic absorption spectrophotometry or other method of similar accuracy
Nickel	0,001	
Sodium iodide	0,1	Calculated for dry salt
Total	0,5	

Prior to use, check the pH of the salt solution by means of electrometric measurement at 25 °C \pm 2 °C or in routine checks, with a short-range pH paper which can be read in increments of 0,3 pH units or less. If the pH value determined is outside the range 6,0 to 7,0 adjustments shall be made by adding to the salt solution, diluted hydrochloric acid or sodium hydroxide of analytical grade.

The volume of the test solution should be defined by the specification of the product. If no specification is available, it is recommended that the volume should be not less than 3 l/dm² of test specimen area.

5 Apparatus

5.1 General

The apparatus shall include the following components:

- a suitable system designed for the automatic, continuous performance of complete cycles of alternate immersion and withdrawal of the test specimens. This system shall provide uninterrupted operation throughout the duration of the test (see 6.1). Each test specimen shall be connected to the system using suitable insulating material;
- one or more glass or plastic containers for the reagent. In the immersed position, only one kind of metal, alloy or coating shall be immersed in each container. Replicate specimens can share the same container.

NOTE 1 The system should be designed such that the time taken for full immersion or withdrawal of each specimen is no more than 2 min.

NOTE 2 Suitable apparatus for conducting alternate immersion tests is illustrated schematically in annex B.

5.2 Materials of construction

5.2.1 Materials of construction that come into contact with the test solution shall be such that they are not affected by the corrodent to the extent that they can cause contamination of the solution and change its corrosivity.

5.2.2 Use of inert plastics or glass is recommended where feasible.

5.2.3 Metallic materials of construction shall be selected from alloys that are corrosion resistant to the test environment or shall be protected with a suitable corrosion resistant coating that also satisfies the conditions given in 5.2.1.

5.3 Test specimen holders

5.3.1 Test specimen holders shall be designed to electrically insulate the test specimens from each other and from any other bare metal. When this is not possible, as in the case of certain stressing bolts or jigs, the bare metal in contact with the specimen should be isolated from the corrodent by suitable insulating materials. If a protective coating is used, it shall be of a type that will not leach inhibiting or accelerating ions or protective oils over the non-coated portions of the specimen. In particular, coatings containing chromates shall be avoided.

5.3.2 The shape and form of test specimen supports and holders shall be such that:

- they avoid, as much as possible, any interference of free contact of the test specimen with the salt solution;
- they do not obstruct air flow over the test specimen thereby retarding the drying rate;
- they do not retain a pool of solution in contact with the test specimen after withdrawal from the solution;
- drainage from one test specimen does not directly contact any other test specimen.

5.4 Air circulation

5.4.1 Air circulation is recognized as an important factor because it affects both the rate at which test specimens dry and the loss of water by evaporation. Optimum conditions for air circulation have not been established, but the recommendations described in 5.4.2 should be followed.

5.4.2 It is important to achieve moderate and uniform drying conditions. Mild circulation of air capable of drying specimens within about 40 min, even when coated with corrosion products and salt deposits, is recommended with the following precautionary considerations.

- Drying by forced air blasts on the test specimens is not recommended because of difficulty in maintaining uniform drying of large groups of test specimens.
- Stagnant air conditions should be avoided.
- The air temperature should be $27\text{ °C} \pm 1\text{ °C}$ unless otherwise specified.
- The relative humidity should be $45\% \pm 6\%$ unless otherwise specified.

6 Procedure

6.1 Test conditions

Generally, the test conditions are prescribed in the agreed specifications. If this is not the case, the exposures should involve 10 min immersion followed by withdrawal and 50 min drying. The cycle should be repeated continuously throughout the duration of the test unless prior failure occurs.

The solution temperature should be $25\text{ °C} \pm 2\text{ °C}$ unless otherwise specified.

Only one kind of metal, alloy or coating shall be immersed in the same container during a particular test.

NOTE Unless otherwise specified, the test duration shall be established on the basis of the susceptibility to corrosion of the metal in the test solution and the purpose of the test. Test duration in the range 20 d to 90 d is usually adequate for aluminium alloys and ferrous metals.

6.2 Test specimens

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The test should be performed with manufactured products or parts or with any other suitable test specimens.

In the absence of any specified geometry, rectangular specimens $90\text{ mm} \times 120\text{ mm} \times 1\text{ mm}$ are suggested.

A minimum of three test specimens should be used.

If the size of the test specimens is incompatible with the test apparatus, the specimens should be sectioned. The cut section should be protected by a suitable coating applied to an area of 5 mm around the cut. Under these circumstances, for comparison purposes, six specimens should be tested, three with and three without protection.

All greases should be carefully removed from the specimens by means of an appropriate method, for example either ultrasonic or manual cleaning using a soft, clean brush in a vessel filled with suitable organic solvent (e.g. hydrocarbon with a boiling point of $60\text{ °C} - 120\text{ °C}$). After cleaning, the specimens should be rinsed using clean solvent then dried.

If a plated or coated test specimen has to be cut, the cut surfaces shall be protected.

6.3 Test reagent

When in the immersed position, the test specimens must be completely covered by reagent to a minimum depth of 10 mm.

The level of reagent in the container shall be maintained by the addition of distilled water to replenish evaporation losses as required.

It is recommended that the solution be changed every 168 h or when the pH varies by more than 0,3 from the original pH, if this is sooner.

7 Calibration of the test facility

The test facility should be calibrated by tests on a standard material using test specimens with a simple geometry and uniform grain structure so that the results can be compared with published data. This calibration procedure should be repeated periodically to confirm the reproducibility of results.

8 Cleaning of test specimens

On completion of testing, test specimens should be removed from the apparatus and cleaned as thoroughly as possible, in order to prevent further corrosion, by rinsing with water to remove accumulated hygroscopic salt deposits, and drying.

9 Assessment of results

Many criteria may be used for the evaluation of results according to the particular requirements of the test, e.g.:

- a) the appearance after the test;
- b) the appearance following the removal of superficial corrosion products (see ISO 8407);
- c) the number and distribution of corrosion effects, i.e. pits, cracks, blisters, etc.; these may be assessed by methods such as those described in ISO 1462 or ISO 4540;
- d) metallographic examination may be needed to detect cracks in stressed samples;
- e) the time elapsed before the appearance of the first sign of corrosion;
- f) the change in mass (see ISO 8407);
- g) changes revealed by microscopic examination;
- h) changes in mechanical properties;
- i) the average and maximum depths of attack.

NOTE It is good engineering practice to specify the assessment criteria in the specification for a coating or a product to be tested.

10 Test report

10.1 The test report shall indicate the outcome of the test according to the evaluation criteria prescribed for the test. The results obtained for each test specimen should be reported and, when appropriate, the average for a group of replicate test specimens. The report may, if required, be accompanied by photographic records of the specimens.

10.2 The test report should provide information about the test procedure. This may vary according to the purpose of the test and to the test specification but, in general, the details likely to be included are as follows:

- a) reference to this International Standard, i.e. ISO 11130;
- b) the specification (or composition) of the material, and its heat treatment;
- c) details of any applied stress;
- d) the specification of the test cycle, especially the information about the time period of immersion and that of drying;