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Corrosion of metals and alloys — Guidelines for exposing and evaluating metals and alloys in surface sea water

Corrosion des métaux et alliages — Lignes directrices pour l'exposition et l'évaluation des métaux et alliages à la surface de l'eau de mer

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.

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Corrosion of metals and alloys — Guidelines for exposing and evaluating metals and alloys in surface sea water

1 Scope

1.1 This International Standard gives guidance on the conditions and procedures to be followed when conducting exposures of metals and alloys to surface sea water such that meaningful comparisons may be made for different locations. This International Standard applies to exposure areas from above water level which are wet for a significant period (splash and tidal zones) down to a depth at which the composition of the sea water is similar to that at the surface.

1.2 This practice gives guidance on procedures for the evaluation of the effects of sea water on metals and alloys.

1.3 Because of the variability and complexity of sea water, exposures over a minimum period of one year are considered necessary to minimize the influence of these variable factors.

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

ISO 11463:1995, *Corrosion of metals and alloys — Evaluation of pitting corrosion.*

3 Control specimens

It is prudent, because of the inherent variability in processing conditions, that control specimens be used in corrosion tests. Two kinds of control specimens are needed as follows.

A specimen for which performance is well established in the given environment and which actually does corrode (for example, mild steel). Its corrosion rate will help to determine the length of the test period.

A specimen that is known to be normally resistant in the given environment (for example, copper). The purpose of this specimen is to make sure that no unusual conditions, such as chemical pollution, were encountered during the test period. In the case of evaluations of aluminium alloys, care should be exercised in the location of these copper specimens (see 6.2).

4 Test sites

4.1 Test sites shall be chosen at locations representative of natural seawater environments where the metals or alloys to be tested may be used. Ideally, a natural seawater test site shall be in a protected location where all necessary conditions required for such tests (splash, tidal and full immersion) may be encountered. Unless the intent is to determine the corrosion due to pollution, the site shall have clean, uncontaminated sea water. Reference shall be made to tropical versus other conditions, and seasonal variations in temperature and in deposition of marine growth on the test panels with a defined “fouling season”. Climatic and atmospheric characteristics may also be important in selecting a site where tidal or splash and spray exposures may be conducted.

4.2 Observations of critical water parameters shall be made and reported; depending on the experiment, these typically include water temperature, salinity, conductivity, pH, oxygen content, other compositional parameters (e.g. ammonia, hydrogen, sulfides, carbon dioxide, heavy metals) and tidal flow (velocity). The periodicity of measurement of water parameters will be a function of the length of exposure and the expected time variation in these parameters. A mean value of the seawater conditions on a monthly basis is normal.

5 Exposure racks

5.1 Test racks shall be constructed of a material that will remain intact for the entire proposed period of exposure. Monel nickel-copper alloy 400 (UNS No. N04400) has been found to be an excellent material for racks, but is not recommended for holding aluminium specimens. Coated aluminium racks (6061-T6 or 5086-H32) also have given satisfactory service when used with strip insulators (such as polyethylene) and nylon bolts and nuts to mount the specimens. Nonmetallic racks may be used, provided that they have no effect on the corrosion of the specimens. Reinforced plastic racks may be used. Treated wood is not appropriate for test racks as the preservative may leach out and affect corrosion of the test materials.

5.2 Specimens shall be mounted in the racks so that they are supported by porcelain or plastic insulators and do not make electrical contact with each other or with the supporting racks. Rack charts shall be maintained showing the positions of all specimens and exposure data.

5.3 Spacing of the mounted specimens can be important, therefore it is desirable to have sufficient space between surfaces of test specimens to ensure that adequate water flows between them and that with long exposures the accumulated fouling will not block off the surface to the presence of the seawater environment.

5.4 Racks may be suspended by such materials as nylon, polyester or polypropylene rope depending on prevailing conditions. Steel wire rope shall not be used.

5.5 Exposure racks shall be suspended so that attached specimens will be oriented vertically and subjected to the full effects of the sea water but free of galvanic contact with other specimens and with minimal sedimentation of silt and debris on the specimen.

6 Specimens

6.1 When the material to be tested is in sheet form, a nominal specimen size of 100 mm by 300 mm is recommended. Specimens may be larger or smaller to suit a particular test.

6.2 If testing of materials in odd shapes (bolts, nuts, pipes, etc.) is desired, it is essential that a means of supporting them in the test racks be devised. It is important that the specimens be electrically insulated from their respective supports and from each other to prevent formation of galvanic corrosion cells unless this is part of the study. In some instances it is not sufficient to isolate specimens electrically to prevent corrosion of one material. For example, it is essential to exercise great care with aluminium specimens or racks so that they will not be

contaminated by copper, which will cause accelerated corrosion of the aluminium. A galvanic couple is not necessary to accelerate the corrosion of aluminium by copper. Copper or alloys containing copper physically located in the vicinity of aluminium may corrode sufficiently so that accelerated corrosion of the aluminium may be caused by copper deposition on the aluminium (see clause 3).

6.3 The total number of test specimens required shall be determined from a knowledge of the duration of the test and the planned removals of the specimens for intermediate evaluations. There is seldom reason to remove and evaluate specimens exposed less than 6 months. For reliable results, a sufficient number of replicate specimens should be used for removal at each exposure period. Triplicate specimens for each exposure period will usually satisfy this requirement. A suitable removal schedule might be 0,5 y, 1 y, 2 y, 5 y, 10 y and 20 y. In case of uncertainty as to an alloy's corrosion resistance, shorter intervals might be appropriate and corrosion rate data may be used to establish more appropriate exposure periods. In addition, yearly inspections shall be made to ensure that the specimens are intact.

6.4 Unexposed replicate specimens shall be considered for use where comparisons of exposed and unexposed material will be made such as for corrosion effects on mechanical properties or appearance.

7 Preparation of specimens

7.1 Specimens shall be marked in a manner that will ensure identification for the life of the test. One good method is to use a series of notches or drilled holes arranged according to some desired code. Another method is to attach a corrosion-resistant metal tag by means of an insulating cord and a suitably located hole. An example of materials that can be used for such tags are alloy 625 (UNS No. N06625), alloy C 276 (UNS No. 10276) or alloy 400 (UNS No. N0400) (except for aluminium alloys) or titanium. Numbers stamped on relatively corrosion-resistant materials may be suitable for some tests.

7.2 Oil, grease and dirt shall be removed by degreasing with a solvent cleaner and scrubbing to remove insoluble soils (see ISO 8407). Any mill scale shall be removed from all test specimens unless it is specifically desired to perform the test with the mill scale intact. Pickling with inhibited acid or sandblasting are acceptable descaling methods. If acid pickling is used, care shall be taken to stop the pickling action as soon as the mill scale has been removed. It is recommended that the finish be as close as possible to the condition in which the material will be used. To facilitate examination of exposed specimens, it is important that a uniform finish be applied to the surface, i.e. there should be no pits or other depressions which might look like corrosion attack. To facilitate meaningful examination of exposed specimens it is important that any irregularities on the specimen surfaces be noted initially so that these areas will not be confused with pits or other corrosion at the completion of the experiments. When a specific surface finish, such as pickled, scaled, as welded, sandblasted or ground is to be evaluated, the finish on the test specimens should be in accordance with test requirements. Thus, two types of test are involved here:

1) an alloy evaluation test with the surface finish as close as possible to the condition in which the material will be used;

2) a surface finish test.

7.3 Specimens shall be weighed to the precision desired by the investigator, usually ± 1 mg. Records shall be kept of the mass, physical dimensions and appearance of each specimen, including surfaces and edges, at the beginning of the test. Changes in the physical appearance and any corrosion losses of the specimen due to exposure can then be determined.

7.4 Special specimen configurations for evaluating localized corrosion, such as intergranular attack, stress corrosion cracking, pitting and crevice corrosion, may be required.

8 Evaluation of test specimens

8.1 Remove specimens from exposure at the scheduled times or other appropriate times.

8.2 Without scratching the specimens, scrape off marine growth and barnacles.

8.2.1 Plastic or wooden scrapers shall be used to remove barnacles.

8.2.2 Clean the panels in accordance with ISO 8407 and then reweigh to an appropriate degree of precision. For certain tests, it may be of interest to preserve corrosion products for laboratory evaluation. Photographs before and after cleaning are usually valuable documentation.

8.3 Determine the mass loss of each specimen from the pre- and post-exposure weighings and convert the results to a corrosion rate (see ISO 8407) or plot as mass loss per unit area versus exposure time. Where the corrosion is highly localized (as in pitting or crevice attack) and the loss in mass is low, mass loss results may be misleading. In these cases, the tensile properties of the exposed specimens can be determined and compared with the tensile properties of unexposed replicate specimens.

8.4 Measure the depth of attack and describe in detail with attention to changes at the edges as well as the surface of the specimen. Take care during the evaluation of specimens to recognize any other specific forms of attack, such as stress corrosion cracking and dealloying. These other forms of attack may be evaluated separately using other ISO standards such as ISO 11463.

8.5 A comparison of the corrosion data from the test specimens with corrosion data from the control specimens will determine the relative merit of the material in question.

9 Test report

The test report shall include detailed descriptions of the exposed specimens, pertinent data on exposure conditions and any deposits formed and results of the corrosion evaluation.

Data for the exposed specimens shall include physical dimensions, chemical composition, metallurgical history, surface preparation and after-exposure cleaning methods.

Details of exposure conditions shall include location, dates and periods of exposure, and a description of the seawater conditions prevailing during the exposure period. A more detailed compilation might be justified for certain tests. For example, in the case of pitting, assessment of the results shall follow the reporting outlined in ISO 11463.

The results of the tests should be expressed as corrosion rate, such as penetration per unit time (for example, mm/y or µm/y) or loss in thickness over the exposure period, or plotted as mass loss per unit area versus exposure time. The corrosion rates will be the average of both surfaces and edges of a panel.

Any changes in the physical appearance of the specimens during the exposure period shall be noted. If the corrosive attack is nonuniform (that is, if pitting or crevice attack is predominant) the corrosion rate data can be misleading.

If the tensile properties of the specimens are measured after exposure, any tensile strength loss should be reported as a percentage loss compared to both the original and control tensile properties of unexposed material.

Any time that the specimens are disturbed during the exposure period, such as by contact with floating debris, the date and nature of the occurrence shall be reported.

ICS 77.060

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