Publicly Available Specification

ISO/PAS 5929

First edition
2025-08

Corrosion of metals and alloys — Test and evaluation method for the corrosion of steel bar embedded in concrete structure exposed to total corrosion zones in marine environments

Corrosion des métaux et alliages — Méthode d'essai et d'évaluation de la corrosion des barres en acier encastrées dans des structures en béton exposées à des zones de corrosion totale dans des environnements marins

Reference number
ISO/PAS 5929:2025(en)

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Published in Switzerland

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

Reinforced concrete structures worldwide face increasing durability deterioration, primarily driven by environmental factors. In the marine environment, chloride-induced steel corrosion causes significant structural damage. This phenomenon occurs across multiple exposure zones defined by elevation: atmospheric, splash, tidal, immersion, and buried zones. Coastal infrastructure (e.g. docks, bridges, piers) typically spans several such zones simultaneously.

Existing corrosion testing methods focus on single-directional chloride penetration within isolated zones like the splash zone. While moisture fluctuations here accelerate corrosion, such unidirectional models fail to replicate real-world multi-zone interactions. This oversight leads to incomplete corrosion resistance assessments during material selection.

This document establishes a testing methodology that vertically and horizontally simulates chloride migration along steel bars. By simulating worst-case conditions in all corrosion zones, the method facilitates accurate corrosion distribution mapping (particularly chloride ingress), data-driven material selection for extended service life, cost-effective design that avoids overprotection (e.g. excessive component thickness) and accurate protection and repair along the length of concrete piers and columns. 3D scanning supplements traditional measurements and enables non-destructive 3D corrosion mapping without structural compromise.

This document proposes a device and a procedure to test the corrosion of steel bars in marine environments at all corrosion zones. The method describes the dimensions, standard configuration methods and test standard processes of standard components. The method should simulate the impact of different chloride salt environments along the length of steel bars in reinforced concrete components. However, the actual environment and test conditions differ widely, and this document cannot cover all possible scenarios. The objectives of testing can be achieved according to the parameters set out in this document. However, other methods exist, and users can choose test parameters based on their own situation.

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Corrosion of metals and alloys — Test and evaluation method for the corrosion of steel bar embedded in concrete structure exposed to total corrosion zones in marine environments

1 Scope

This document specifies the apparatus, materials, specimen preparation, procedures, results and reports for testing the corrosion test of steel bars. This document includes an evaluation method.

This document applies to reinforced concrete structures exposed simultaneously to atmospheric, splash, tidal, immersion, and buried zones in marine environments.

NOTE Annex A provides test apparatus examples. Annex B illustrates test results.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1920-4, *Testing of concrete — Part 4: Strength of hardened concrete*

ISO 6935-2, *Steel for the reinforcement of concrete — Part 2: Ribbed bars*

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

ISO 22965-1, *Concrete — Part 1: Methods of specifying and guidance for the specifier*

ISO 22965-2, *Concrete — Part 2: Specification of constituent materials, production of concrete and compliance of concrete*

EN 197-1, *Cement — Part 1: Composition, specifications, and conformity criteria for common cements*

ISO 8044, *Corrosion of metals and alloys — Vocabulary*

ISO 21062, *Corrosion of metals and alloys — Determination of the corrosion rates of embedded steel reinforcement in concrete exposed to simulated marine environments*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8044 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
simulated marine environmental chamber
sealed enclosure simulating all marine corrosion zones through controlled parameters

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3.2
environmental parameter control chamber
auxiliary chamber regulating temperature, humidity, and chloride concentration

4 Apparatus

4.1 Simulated marine environmental chamber

The simulated marine environmental chamber shall be designed to simulate a marine environment with all corrosion zones at different depths and heights, including the atmospheric zone, splash zone, tidal zone, immersion zone and buried zone. The environmental parameters shall be set, monitored and adjusted.

The size and quantity of the test cells shall be chosen based on the duration and purpose of the test and the number of specimens. For example, if the data is to be obtained within half a year through the accelerated test method, the scale ratio can be larger (i.e. the component size can be smaller) and the thickness of the concrete protective layer is not more than 15 cm. Devices shall be placed in the simulated marine environmental chamber to monitor and record the temperature, humidity, salt spray concentration, solution chloride concentration, pH value and liquid level in real time.

Test temperature shall be selected depending on the user's conditions and recorded during testing.

A typical design of simulated marine environmental chamber is shown in Annex A.

4.2 Environmental parameter control chamber

The environmental parameter control chamber shall contain equipment for controlling the indoor environmental parameters of the simulated marine environmental chamber. The chamber shall be designed so that test personnel can enter and exit at any time. Necessary electrical and fire-fighting devices shall be installed as required.

4.3 Atmospheric zone: Spraying device

The ambient temperature and humidity should be taken into account in the atmospheric zone. A constant temperature and humidity can be chosen or a temperature and humidity cycle can be set considering the temperature and humidity changes in the day and night, according to the test requirements.

An alternative method can be used, such as the salt spray device (Figure 1) in an atmospheric area. An ultrasonic atomizer shall be set in the environmental parameter control chamber, and the chloride solution spray device shall be set in the simulated marine environmental chamber.

The salt spray concentration, mist particle size and amount of sedimentation should be considered to ensure that the device can produce a fine mist or small droplets that fall on the test object evenly.

The concentration of chloride solution can be 3 % ± 0,2 %.

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