INTERNATIONAL STANDARD

ISO 21062

First edition
2020-05

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

Corrosion des métaux et alliages — Détermination des vitesses de corrosion de l'acier encastrés simulée de l'armature dans le béton exposé à l'environnement marin

Reference number
ISO 21062:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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 documents 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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.

Introduction

Structurally deficient concrete is caused by deterioration due to corrosion, mainly induced by chlorides from de-icing salts and marine exposure. The structural durability of concrete has become an issue of common concern to engineering.

The high humidity and high salt spray characteristics of the marine environment need higher durability structures. More specific requirements for the corrosion-resistant properties of reinforced steel bars, as well as the corresponding testing technology requirements, have been put forward.

In consideration of engineering practices, corrosion properties could be predicted on the basis of testing the corrosion rate via the comparative test of the steel bar specimen and a reference steel bar specimen. This document is consistent with the actual conditions of concrete structure exposure and can provide support for the development and selection of corrosion-resistant steel.

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

WARNING — This document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices.

1 Scope

This document specifies the apparatus, materials, specimen preparation, procedures, results and reports for comparing the corrosion rates of steel reinforcement bars in concrete in simulated marine and coastal environments.

This document is not applicable to galvanized steel reinforcement. It gives guidelines for material selection in corrosion design.

In order to illustrate the methodology, Annex A provides examples of experimental 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 1920-3, *Testing of concrete — Part 3: Making and curing test specimens*

ISO 1920-4, *Testing of concrete — Part 4: Strength of hardened concrete*

ISO 3673-1, *Plastics — Epoxy resins — Part 1: Designation*

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

ISO 8407:2009, *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*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

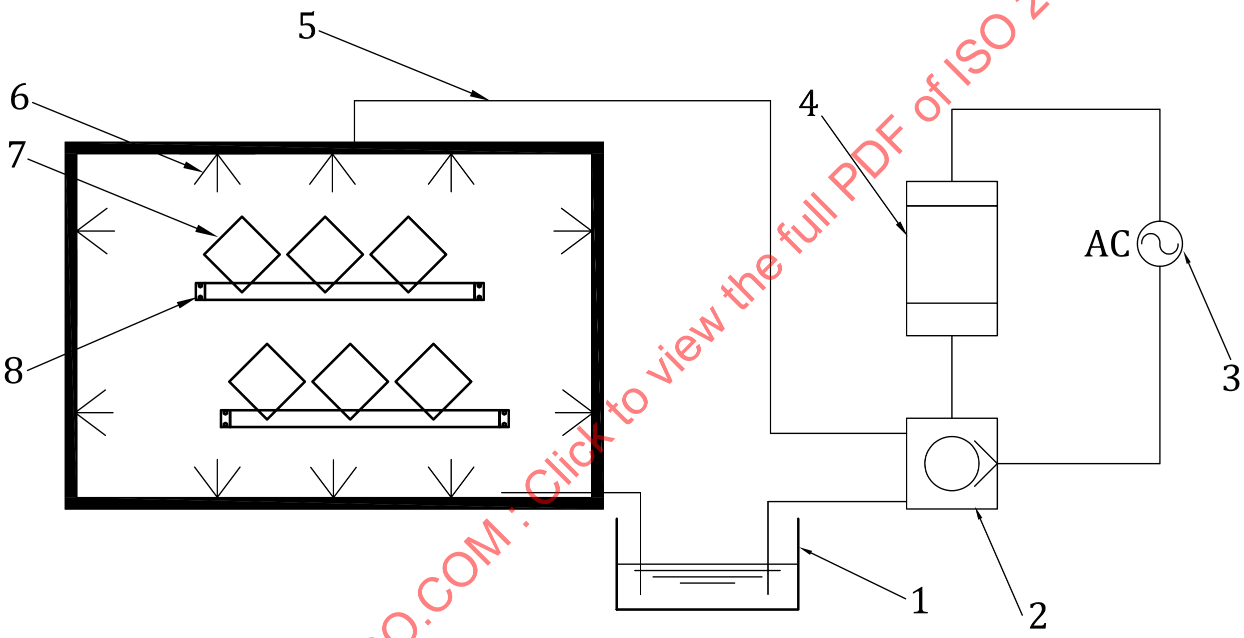
3.1
breaking of specimens
separation of specimens (which are steel reinforcement bars that have been encased in concrete) into fragments using a hammer or similar tools and then taking out the bars

4 Apparatus

4.1 Simulation chamber.

The simulation chamber shall be designed so that the test conditions can be obtained and controlled during the test. The simulation chamber shall be such that the conditions of homogeneity and distribution of the spray are met. A typical design of simulation chamber is shown in Figure 1. The placement of the concrete specimens is shown in Figure 2.

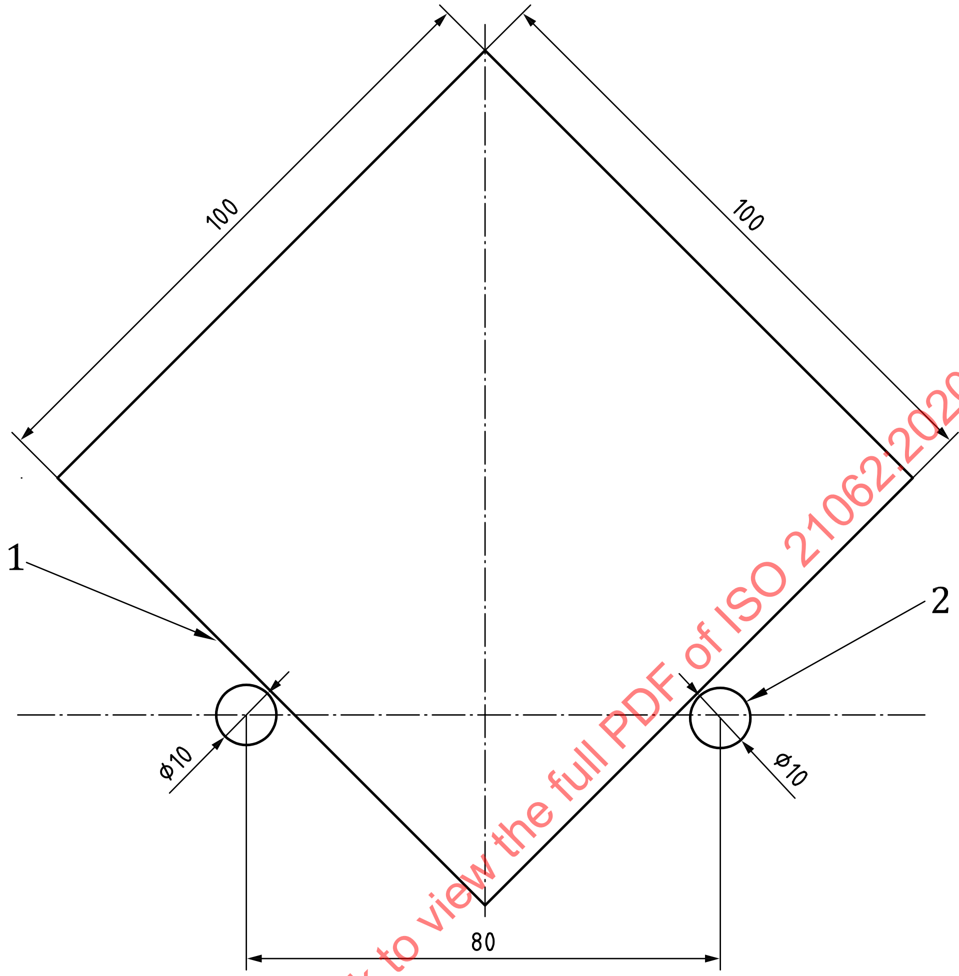
The test is conducted in a temperature range (approximately 5 °C to 30 °C). In special cases, other test temperature ranges may be adopted by agreement between the parties.



Key

1	vessel with spray solution	5	tube
2	pressurizing pump	6	nozzles
3	power	7	specimens
4	control unit	8	specimen holder

Figure 1 — Typical design of simulation chamber



Key

1 specimen

2 specimen holder

NOTE All materials, such as plastic or stainless steel, that can support the mass of the specimens and have certain corrosion resistance can be used as specimen holders.

Figure 2 — Placement of concrete specimens

4.2 Spraying device.

The spraying device for the salt solution installed in the simulation chamber shall be capable of producing a fine mist or small droplets falling on the test objects.

Salt (5.5) solution concentration: 3 % ± 0,2 %, initial pH 7 ± 0,5.

4.3 System for forced drying.

The simulation chamber shall be equipped with a system for forced air flow drying, as after spraying/wet stand-by all test objects should be dried and it shall be possible to regain environmental control within a reasonable time.

The specimens are sprinkled every 12 h for 60 min ± 5 min. Then the ventilation system is turned on for 2 h to dry the specimens.

5 Test materials

5.1 Reinforcing steel.

The reinforcing steel shall have a diameter of 16 mm to be consistent with the dimensions of Figure 3.

5.2 Benchmark bar.

The benchmark bar is numbered as 0# with a length of 395 mm ± 2 mm. It shall be selected in accordance with ISO 6935-2. B400DWR steel is recommended.

5.3 Test bars.

Test bars are numbered as 1#, 2# and 3#, with a length of 395 mm ± 2 mm.

5.4 Concrete.

B30 concrete shall be used in accordance with ISO 22965-1 and ISO 22965-2.

The standard cement used in this experiment shall conform to EN 197-1. CEM II/A Portland-composite cement is recommended with a strength class of 42.5. The aggregate shall be selected in accordance with ISO 22965-1 and ISO 22965-2. It is recommended to use approximately 5 mm to 10 mm gravels for coarse aggregate.

5.5 Industrial salt.

Industrial salt is used in the experiment.

Users can choose industrial salt according to their actual situation, as long as, in the process of testing, the selection and added amount of industrial salt shall be consistent for the series of tests.

The recommended quality indicators of industrial salt are NaCl ≥ 94,5 %, Ca^{2+}+Mg^{2+} ≤ 0,40 % and SO_4^{2-} ≤ 0,70 %.

6 Preparation of specimens

6.1 Reinforcing steel cleaning

The reinforcing steel (5.1) shall be thoroughly cleaned before testing. Cleaning shall eliminate all those traces (dirt, oil or other foreign matter) that could influence the test results. The cleaning method employed shall depend on the nature of the material, its surface and the contaminants. It shall not include the use of any abrasives or solvents that could attack the surface of the specimens.

It is recommended that reinforcing bars should be degreased and submerged in 10 % sulfuric acid at room temperature for approximately 10 min to 15 min. Then they should be washed using distilled water. After that, they should be soaked in n-hexane and then dried.

6.2 Reinforcing steel coating ends

Both ends of the reinforcing bars are coated with the epoxy, which shall conform to ISO 3673-1. The coating length is 25 mm ± 1 mm.

6.3 Adding industrial salt

Industrial salt (5.5) is added to the concrete (5.4) and as 2,5 % of the cement.

6.4 Making concrete specimens

The dimensions of the test specimens are 100 mm × 100 mm × 400 mm. No fewer than three specimens are used in each exposure period.

The three-dimensional positioning of the reinforcing bars is shown in Figure 3. The reinforcing bars are fixed inside the mould. A benchmark bar (5.2) numbered as 0# and three test bars (5.3) numbered as 1#, 2# and 3# are placed together in each specimen. Countries can adjust the thickness of the bars' protective layer according to their actual situation and the experiment purpose. The recommended thickness of the bars' protective layer is 15 mm. It takes 24 h for the concrete (5.4) to harden. Then, the wood boards used to hold the bars in place are removed from both ends, which are sealed with the cementitious grout. The bars should not be exposed. The specimens are numbered after 24 h. The bars shall be placed in the curing chamber for 28 d in accordance with the requirements of ISO 1920-3.

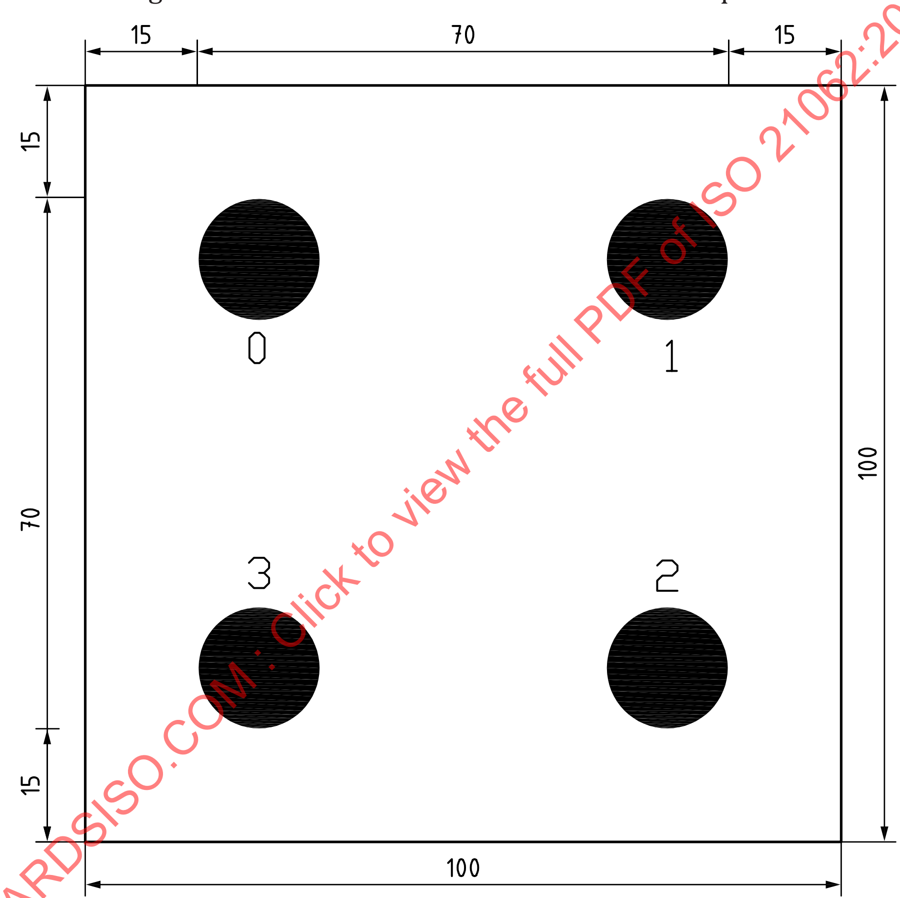


Figure 3 — Cross section of concrete specimen

7 Test procedure

7.1 Initial performance test

7.1.1 Mechanical properties and chemical compositions of reinforcing bars

The analysis of the chemical composition and the test of the mechanical properties of the bars shall be performed in accordance with ISO 6935-2.

7.1.2 Mass

The initial mass m_{io} of the bar is measured after the rust is removed according to 6.2. The accuracy of the measurement is 0,01 g.

7.1.3 Dimensions

After the bar is treated using the method described in 6.2, it shall be measured for its initial dimensions by the method specified in ISO 6935-2. Three measurements are taken at randomly picked spots and the average is calculated.

7.1.4 Concrete strength

The concrete strength test shall be conducted in accordance with the method specified in ISO 1920-4.

7.2 Test data recording

7.2.1 Test time

The recording starts after the 28 d curing period. The test duration and concrete destruction period is determined by the purpose of the experiment. The recommended experiment duration is 54 weeks. A triplicate set of specimens is examined destructively every 18 weeks.

7.2.2 Cracks record

The specimen is inspected every week during the experiment. The location of cracks and the inspection time are recorded. Figure 4 shows the location of cracks. The cross section is evenly divided by drawing vertical and horizontal lines to connect the middle of the parallel sides. The serial number of each area matches the serial number of bars.

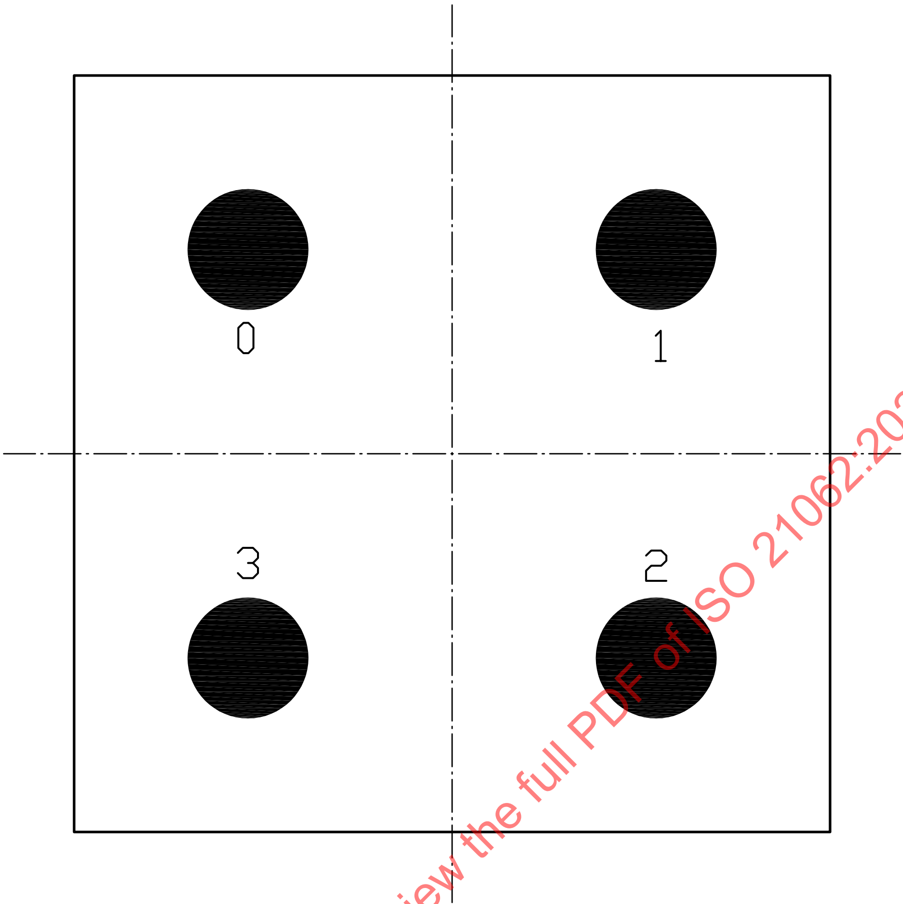


Figure 4 — Component cracks corresponding schematic diagram area

7.3 Breaking of specimens

7.3.1 General

Three specimens are broken each time. When necessary, photos are taken before and after the specimens are broken.

7.3.2 Mechanical properties

The mechanical properties of the bars should be tested after they are taken out of the broken concrete.

7.3.3 Mass

After the bars are taken out of the broken concrete, the rust shall be removed in accordance with ISO 8407:2009, Annex A, and the epoxy shall be removed with a light mechanical cleaning treatment by brushing. The mass, m_i, of the bars is then measured. The accuracy of the measurement is 0,01 g.

7.3.4 Dimensions

Three measurements of the bars are taken after they are taken out of the broken concrete with the rust and epoxy removed. The average of the measurements is calculated.

8 Test result

8.1 Mass loss rate of test bar

The mass loss rate of each test bar is calculated using Formula (1):

$$\eta_i = \frac{m_{io} - m_i}{m_{io}} \times 100 \tag{1}$$

where

η_i is the mass loss rate, in %;

m_{io} is the initial mass, in g;

m_i is the mass after being taken out of concrete, in g;

$m_{io} - m_i$ is the mass loss of each reinforcing bar, in g;

i is the serial number of each bar.

8.2 Average mass loss rate of test bar

The average mass loss rate of the test bar is calculated using Formula (2):

$$\eta = \overline{\eta_i} \tag{2}$$

where $\overline{\eta_i}$ is the average mass loss rate, in %.

8.3 Ratio of the mass loss rate of the benchmark bar and the test bar

The ratio of the mass loss rate of the benchmark bar and the test bar is calculated using Formula (3):

$$k_i = \eta_i / \eta_0 \tag{3}$$

where

k_i is the ratio of the mass loss rate;

η_i is the mass loss rate of the test bar, in %;

η_0 is the mass loss rate of the benchmark bar, in %.

8.4 Average ratio of the mass loss rate of the benchmark bar and the test bar

The average ratio of the mass loss rate of the benchmark bar and the test bar is calculated using Formula (4):

$$k = \overline{k_i} \tag{4}$$

where $\overline{k_i}$ is the average ratio of the mass loss rate, in %.

