INTERNATIONAL STANDARD

ISO 10271

First edition
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Dental metallic materials — Corrosion test methods

Produits dentaires métalliques — Méthodes pour les essais de corrosion

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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.

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.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10271 was prepared by Technical Committee ISO/TC 106, *Dentistry*, Subcommittee SC 2, *Prosthodontic materials*.

This first edition cancels and replaces ISO/TR 10271:1993 which has been technically revised, in particular by the inclusion of a wider range of test methods.

Annex A of this International Standard is for information only.

Introduction

ISO 10271 was developed from the original Technical Report (ISO/TR 10271) as a result of worldwide demand for standard test methods to determine acceptability of metallic materials for oral restorations in relation to corrosion.

The testing of the corrosion behaviour of metallic materials in dentistry is complicated by the diversity of the materials themselves, their applications and the environment to which they are exposed. Variation occurs between devices and within the same device during the exposure time. The type of corrosion behaviour or effect may also vary with exposure time. Accordingly, it is not possible to specify a single test capable of covering all situations, nor is it a practical proposition to define a test for each situation. This International Standard therefore gives detailed protocols for test methods which have been found to be of merit as evidenced by considerable use.

In addition, an informative annex (annex A) is provided that sets out a protocol for each element of the test system such that a consistent approach may be taken for the development of further test methods. Equally, it is recognized that any element can only represent the current recommendation, but changes in the future are unlikely to change the framework

It is not the purpose of this International Standard to propose corrosion test methods for specific applications or to set limits as precise as those in the standard relating to the type of product and its application.

Dental metallic materials — Corrosion test methods

1 Scope

This International Standard provides test methods and protocols to determine the corrosion behaviour of all metallic materials used in restorative, prosthetic and orthodontic dentistry in the oral cavity, including cast, machined and prefabricated devices.

This International Standard is not applicable to instruments and appliances.

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 editions of the normative documents referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1562, *Dental casting gold alloys.*

ISO 3585, *Borosilicate glass 3.3 — Properties*.

ISO 3696:1987, *Water for analytical laboratory use — Specification and test methods*.

ISO 7183-2:1996, *Compressed air dryers — Part 2: Performance ratings.*

ISO 8891, *Dental casting alloys with noble metal content of at least 25 % but less than 75 %.*

ISO 9333, *Dental brazing materials.*

ISO 9693, *Metal-ceramic dental restorative systems.*

3 Terms and definitions

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

3.1
breakdown potential
E_p
least noble potential at which pitting or crevice corrosion, or both, will initiate and propagate

3.2
corrosion
physicochemical interaction between a metal or an alloy and its environment that results in a partial or total destruction of the material or in a change of its properties

3.3
corrosion potential
E_{corr}
open-circuit potential measured under either service conditions or laboratory conditions that closely approximate to service conditions

3.4
corrosion product
substance formed as a result of corrosion

3.5
crevice corrosion
corrosion associated with and taking place in or near a narrow aperture or crevice

3.6
current density
value of electric current per unit surface area flowing through a conductor

3.7
electrochemical corrosion
degradation occurring in an electrolyte as a result of electrochemical reactions

3.8
electrolyte
solution or liquid which will conduct an electrical current by means of ions

3.9
electrode potential
potential difference between the sample and a reference electrode

3.10
dynamic immersion test
test in which the sample is exposed to a corrosive solution under conditions of relative motion between sample and solution

3.11
static immersion test
test in which the sample is exposed to a corrosive solution under conditions of minimum relative motion between sample and solution

3.12
open-circuit potential
E_{ocp}
potential of an electrode measured with respect to a reference electrode or another electrode when no current flows

3.13
pitting corrosion
localized corrosion which results in pits

3.14
potentiodynamic test
test in which the electrode potential is varied at a pre-programmed rate and the relationship between current density and electrode potential is recorded

3.15
potentiostatic test
test in which the electrode potential is maintained constant

3.16
stress corrosion
corrosion resulting from the combined action of static tensile stress and an electrolyte

3.17
synthetic saliva
test medium that simulates natural saliva

3.18
tarnish
surface discolouration due to the interaction between metal and its environment

3.19
zero-current potential
potential at which cathodic and anodic currents are equal

4 Test methods

4.1 Static immersion test

4.1.1 Information required

Composition, including hazardous elements, in accordance with the appropriate ISO material standard.

4.1.2 Application

Dental metallic materials and devices covered by the scope of ISO 1562, ISO 8891, ISO 9333 or ISO 9693.

4.1.3 Reagents

4.1.3.1 **Lactic acid** ($C_3H_6O_3$), 90 % analytical grade.

4.1.3.2 **Sodium chloride** (NaCl), analytical grade.

4.1.3.3 **Water**, complying with grade 2 of ISO 3696:1987.

4.1.3.4 **Ethanol or methanol** (C_2H_5OH or CH_3OH), analytical grade.

4.1.4 Apparatus

4.1.4.1 **Borosilicate glass container**, complying with ISO 3585.

4.1.4.2 **pH meter.**

4.1.4.3 **Analytical instrumentation.**

4.1.4.4 **Micrometer.**

4.1.5 Solution preparation

Prepare a fresh immersion solution for each test. Dissolve 10,0 ± 0,1 g 90 % $C_3H_6O_3$ (4.1.3.1) and 5,85 ± 0,005 g NaCl (4.1.3.2) in approximately 300 ml of water (4.1.3.3). Dilute to 1 000 ± 10 ml with water. The pH shall be 2,3 ± 0,1. If not, the solution shall be discarded and reagents checked.

4.1.6 Samples

4.1.6.1 Fabrication

4.1.6.1.1 Casting alloys

Samples shall be cast in accordance with the manufacturer's recommendations.

4.1.6.1.2 Prefabricated

Prefabricated parts/devices shall be used in the as-received condition.

4.1.6.1.3 Other

Samples prepared by other methods, e.g. machined, sintered, eroded, etc., shall be tested in the as-manufactured condition after suitable cleaning.

4.1.6.2 Number of samples

The number of samples shall be sufficient to provide at least two parallel sets. (The number of specimens in a set can vary.)

4.1.6.3 Size

The total surface area of samples shall be at least 10 cm^2.

4.1.6.4 Preparation

4.1.6.4.1 Cast samples

Remove any sprues, runners or other projections from sample surface. Blast surfaces with 125 µm pure alumina.

If recommended, heat-treat casting alloys following the manufacturer's instructions. Heat-treat all metal-ceramic alloys for 10 min in air at the highest firing temperature recommended by the ceramic manufacturer (i.e. within the range of 800 °C to 950 °C) and bench cool.

Remove at least 0,1 mm from each surface using standard metallurgical procedures unless samples are to be tested in the as-received condition. Use fresh abrasive paper for each alloy. Finish with ASTM 600 or FEPA 1200 wet silicon carbide paper. Determine each sample area to the nearest 1 %. Clean surfaces ultrasonically for 2 min in ethanol or methanol (4.1.3.4).

Rinse with water (4.1.3.3). Dry with oil- and water-free compressed air in accordance with ISO 7183.

4.1.6.4.2 Machined, sintered, eroded or electroformed samples

Heat-treat the samples if recommended.

Remove at least 0,1 mm, measured using a measuring instrument accurate to 0,01 mm [e.g. micrometer (4.1.4.4)] from each surface using standard metallurgical procedures. If the samples are prefabricated parts these shall be tested in the as-received condition. Use fresh abrasive paper for each alloy. Finish with ASTM 600 or FEPA 1200 wet silicon carbide paper. Determine each sample area to ± 0,1 cm^2.

Clean surfaces ultrasonically for 2 min in ethanol or methanol. Rinse with water (4.1.3.3). Dry with oil- and water-free compressed air.

4.1.6.4.3 Prefabricated parts/devices

Determine each sample area to the nearest $\pm 0{,}1\ cm^2$. Clean the surfaces ultrasonically for 2 min in ethanol or methanol. Rinse with water (4.1.3.3). Dry with oil- and water-free compressed air.

4.1.7 Test procedure

Place each sample in a separate glass container (4.1.4.1) approximately 16 mm diameter × approximately 160 mm such that the samples do not touch the glass surface except in a minimum support line or point. If a sample is made up of two or more pieces, the pieces shall not touch each other.

Record the pH of the solution. Add the solution to each container sufficient to produce a ratio of 1 ml of solution per 1 cm^2 of sample surface area. Record the volume of solution to an accuracy of 0,1 ml. Close the container to prevent evaporation of the solution. Maintain at 37 °C ± 1 °C for 7 d ± 1 h. Remove the samples and record the pH of the residual solution.

4.1.8 Elemental analysis

Use analytical instrumentation (4.1.4.3) of adequate sensitivity. Analyse the solution qualitatively and quantitatively. Emphasis shall be on those elements listed in 4.1.1 but if impurities are found in a concentration greater than 0,1 %, they shall also be reported.

4.1.9 Test report

Report the method of analysis and detection limits of all observed elements. Report and justify any deviations from sample preparation, 4.1.6.4, or test procedure, 4.1.7. Report the number of specimens making up a sample. Report each element of each test separately in µg/cm^2·7 days. Each element listed in accordance with 4.1.1 shall be reported as well as any others found.

4.2 Electrochemical test

4.2.1 Information required

Composition, including hazardous elements, in accordance with the appropriate material standard.

4.2.2 Application

Dental metallic materials and devices covered by the scope of ISO 1562, ISO 8891, ISO 9333 or ISO 9693.

4.2.3 Reagents

4.2.3.1 **Lactic acid** ($C_3H_6O_3$), 90 % analytical grade.

4.2.3.2 **Sodium chloride** (NaCl), analytical grade.

4.2.3.3 **Sodium hydroxide** (NaOH), analytical grade.

4.2.3.4 **Water**, complying with grade 2 of ISO 3696:1987.

4.2.3.5 **Argon or nitrogen gas**, with oxygen content $\leqslant 5 \times 10^{-6}$.