



NSAI
Standards

Irish Standard
I.S. EN ISO 28706-3:2018

Vitreous and porcelain enamels -
Determination of resistance to chemical
corrosion - Part 3: Determination of
resistance to chemical corrosion by alkaline
liquids using a hexagonal vessel or a
tetragonal glass bottle (ISO 28706-3:2017)

I.S. EN ISO 28706-3:2018

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National Foreword

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EUROPEAN STANDARD

EN ISO 28706-3

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Supersedes EN ISO 28706-3:2011

English Version

**Vitreous and porcelain enamels - Determination of
resistance to chemical corrosion - Part 3: Determination of
resistance to chemical corrosion by alkaline liquids using a
hexagonal vessel or a tetragonal glass bottle (ISO 28706-
3:2017)**

Émaux vitrifiés - Détermination de la résistance à la
corrosion chimique - Partie 3: Détermination de la
résistance à la corrosion chimique par des liquides
alcalins dans un récipient hexagonal ou une bouteille
en verre tétragonale (ISO 28706-3:2017)

Emails und Emailierungen - Bestimmung der
Beständigkeit gegen chemische Korrosion - Teil 3:
Bestimmung der Beständigkeit gegen chemische
Korrosion durch alkalische Flüssigkeiten unter
Verwendung eines Gerätes mit hexagonalem Gefäß
oder einer tetragonalen Glasflasche (ISO 28706-
3:2017)

This European Standard was approved by CEN on 1 December 2017.

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EN ISO 28706-3:2018 (E)

Contents	Page
European foreword.....	3

European foreword

This document (EN ISO 28706-3:2018) has been prepared by Technical Committee ISO/TC 107 “Metallic and other inorganic coatings” in collaboration with Technical Committee CEN/TC 262 “Metallic and other inorganic coatings, including for corrosion protection and corrosion testing of metals and alloys” the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2018, and conflicting national standards shall be withdrawn at the latest by August 2018.

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

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According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

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INTERNATIONAL
STANDARD

ISO
28706-3

Second edition
2017-11

**Vitreous and porcelain enamels —
Determination of resistance to
chemical corrosion —**

**Part 3:
Determination of resistance to
chemical corrosion by alkaline
liquids using a hexagonal vessel or a
tetragonal glass bottle**

*Émaux vitrifiés — Détermination de la résistance à la corrosion
chimique —*

*Partie 3: Détermination de la résistance à la corrosion chimique par
des liquides alcalins dans un récipient hexagonal ou une bouteille en
verre tétraogonale*



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Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Principle	2
5 Reagents	2
6 Apparatus and materials	2
7 Test specimens	9
8 Procedure	9
8.1 General.....	9
8.2 Hexagonal vessel.....	9
8.3 Tetragonal glass bottle.....	10
9 Expression of results	10
10 Standard detergent solution test	10
10.1 General.....	10
10.2 Test solution.....	11
10.3 Test temperature.....	11
10.4 Duration of the test.....	11
10.5 Test report.....	11
11 Other test solutions and/or conditions	12
11.1 General.....	12
11.2 Test solution.....	12
11.3 Test temperature.....	12
11.4 Duration of the test.....	12
11.5 Test report.....	12
Bibliography	13

ISO 28706-3:2017(E)

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).

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

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*.

This second edition cancels and replaces the first edition (ISO 28706-3:2008), which has been technically revised.

A list of all parts in the ISO 28706 series can be found on the ISO website.

Introduction

Corrosion of vitreous and porcelain enamels by aqueous solutions is a dissolution process. The main component of the enamel, SiO_2 , forms a three-dimensional silica network. After hydrolysis, it decomposes and forms silicic acid or silicates. These are released into the attacking medium. Other components, mainly metal oxides, are hydrolyzed as well and form the corresponding hydrated metal ions or hydroxides. All corrosion products are more or less soluble in the attacking medium. The whole process results in a loss in mass per unit area.

For some aqueous solutions, the attack on the enamel proceeds linearly during the corrosion time; for other aqueous solutions, the attack on the enamel proceeds in a logarithmic manner during the corrosion time. Only for the first series of solutions can a scientifically exact rate of loss in mass per unit area ($\text{g/m}^2\cdot\text{h}$) be calculated as well as a corrosion rate (mm/year).

The most important parameters influencing aqueous corrosion of the enamel are the enamel quality, the temperature and the pH-value. Inhibition effects resulting from the limited solubility of silica can also contribute. The following list describes different types of enamel attack for different corrosion conditions.

- a) In aqueous alkali solutions like 0,1 mol/l NaOH (see ISO 28706-4:2016, Clause 9), the silica network of the enamel is considerably attacked at 80 °C. Silicates and most of the other hydrolyzed components are soluble in the alkali. Attack proceeds linearly during regular test times. Therefore, test results are expressed in terms of a rate of loss in mass per unit area (mass loss per unit area and time) and a corrosion rate (millimetres per year).
- b) At room temperature, in weak aqueous acids like citric acid (see ISO 28706-1:2008, Clause 9) or also in stronger acids like sulfuric acid (see ISO 28706-1:2008, Clause 10), there is only minor attack on the silica network of the enamel. Other constituents are leached to some extent from the surface. Highly resistant enamels will show no visual change after exposure. On less resistant enamels, some staining or surface roughening will occur.
- c) In boiling aqueous acids (see ISO 28706-2), the silica network of the enamel is being attacked, and silica as well as the other enamel components are released into solution. However, the solubility of silica in acids is low. Soon, the attacking solutions will become saturated with dissolved silica and will then only leach the surface. The acid attack is inhibited and the rate of corrosion drops markedly.

NOTE The glass test equipment also releases silica by acid attack and contributes to the inhibition of the corrosion.

Inhibition is effectively prevented in vapour phase tests. The condensate formed on the test specimen is free of any dissolved enamel constituents.

Examples of enamel corrosion proceeding in a logarithmic manner [see 1)] and linearly [see 2)] are:

- 1) Boiling citric acid (see ISO 28706-2:2017, Clause 11) and boiling 30 % sulfuric acid (see ISO 28706-2:2017, Clause 12)

Since only minute amounts of these acids are found in their vapours, the test is restricted to the liquid phase. The attack is influenced by inhibition effects, and corrosion depends on the time of exposure. Therefore, test results are expressed in terms of loss in mass per unit area; no rate of loss in mass per unit area is calculated.

- 2) Boiling 20 % hydrochloric acid (see ISO 28706-2:2017, Clause 13)

Since this is an azeotropic boiling acid, its concentration in the liquid and the vapour phase are identical, and liquid phase testing need not be performed. Vigorous boiling supplies an uninhibited condensate, and the attack proceeds linearly with time of exposure. Therefore, test results are only expressed in terms of rate of loss in mass per unit area (mass loss per unit area and time) and the corrosion rate (millimetres per year).

ISO 28706-3:2017(E)

- d) At high temperatures, with tests in the liquid phase under autoclave conditions (see ISO 28706-5), aqueous acid attack is severe. To avoid inhibition, the test time is restricted to 24 h and the ratio of attacking acid to attacked enamel surface is chosen so that it is comparatively high (similar to that in a chemical reaction vessel). In addition, only low-silica water is used for the preparation of test solutions. Under these conditions, attack will proceed linearly with time of exposure. Therefore, test results with 20 % hydrochloric acid (see ISO 28706-5:2010, Clause 8), artificial test solutions (see ISO 28706-5:2010, Clause 10) or process fluids (see ISO 28706-5:2010, Clause 11) are also expressed in terms of a rate of loss in mass per unit area (loss in mass per unit area and time).
- e) In boiling water (see ISO 28706-2:2017, Clause 14), the silica network is fairly stable. The enamel surface is leached and silica is dissolved only to a small extent. This type of attack is clearly represented by the vapour phase attack. In the liquid phase, some inhibition can be observed with highly resistant enamels. However, if the enamel being tested is weak, leached alkali from the enamel can raise pH-values to alkaline levels, thus increasing the attack by the liquid phase. Both liquid and vapour phase testing can give valuable information.
- f) Since the attack may or may not be linear, the results are expressed only in terms of loss in mass per unit area, and the test time should be indicated.
- g) For standard detergent solution (see [Clause 10](#)), it will not be certain whether the linear part of the corrosion curve will be reached during testing for 24 h or 168 h. Calculation of the corrosion rate is therefore not included in the test report.
- h) For other acids (see ISO 28706-2:2017, Clause 16) and other alkaline solutions (see [Clause 11](#) and ISO 28706-4:2016, Clause 11), it will also not be known if a linear corrosion rate will be reached during the test period. Calculation of the corrosion rate is therefore not included in the test reports of those parts of the ISO 28706 series.

For vitreous enamels fired at temperatures below 700 °C, the test parameters (media, temperatures and times) of this document are not appropriate. For such enamels, for example, aluminium enamels, other media, temperatures and/or times should be used. This can be done following the procedures described in the clauses for “other test solutions” in ISO 28706-1, ISO 28706-2, this document (ISO 28706-3) and ISO 28706-4.

Vitreous and porcelain enamels — Determination of resistance to chemical corrosion —

Part 3:

Determination of resistance to chemical corrosion by alkaline liquids using a hexagonal vessel or a tetragonal glass bottle

1 Scope

This document describes a test method for the determination of the resistance of vitreous and porcelain enamelled articles to attack by alkaline liquids at temperatures between 25 °C and 95 °C. The apparatus used is a hexagonal vessel in which six enamelled specimens or a tetragonal glass bottle in which four enamelled specimens are simultaneously tested.

NOTE 1 The resistance to any alkaline liquid can be determined. However, the test method was originally used for the determination of the resistance to hot detergent solutions, within the neutral and alkaline range, used for washing textiles.

NOTE 2 Since detergents are continually subject to alterations in their composition, a standard test solution is specified which, in respect to its alkalinity, wetting properties and complexing behaviour, can be considered as a typical composition for the detergents present on the market. The pH value and alkalinity of the standard test solution depend on the proportions of sodium tripolyphosphate, sodium carbonate and sodium perborate present; sodium tripolyphosphate acts simultaneously as a complexing agent. The wetting properties of the standard test solution are obtained by the addition of alkylsulfonate. A higher sodium perborate content is not considered necessary since the effect of oxygen on enamel is unimportant and an increase in the perborate content does not cause any significant alteration in the alkalinity of the standard test solution. The testing of different enamels using this standard test solution and other test solutions (including 5 % sodium pyrophosphate solution) has justified the use of this standard test solution for determining the resistance of enamels to hot detergent solutions.

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 48, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 3585, *Borosilicate glass 3.3 — Properties*

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

ISO 4799, *Laboratory glassware — Condensers*

ISO 28764, *Vitreous and porcelain enamels — Production of specimens for testing enamels on sheet steel, sheet aluminium and cast iron*

3 Terms and definitions

No terms and definitions are listed in this document.

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