
**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**

iTeh STANDARD PREVIEW
(standards.iteh.ai)

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

ISO 28706-3:2008

*Partie 3: Détermination de la résistance à la corrosion chimique par des
liquides alcalins dans un récipient hexagonal*



PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 28706-3:2008

<https://standards.iteh.ai/catalog/standards/sist/ee9d3c55-1518-48a2-8af2-721dcf686bfd/iso-28706-3-2008>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2008

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword.....	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Principle	1
4 Reagents	2
5 Apparatus and materials	2
6 Test specimens	7
7 Procedure	7
8 Expression of results	7
9 Standard detergent solution test	8
9.1 General	8
9.2 Test solution	8
9.3 Test temperature	8
9.4 Duration of the test	8
9.5 Test report	9
10 Other test solutions and/or conditions	9
10.1 General	9
10.2 Test solution	9
10.3 Test temperature	9
10.4 Duration of the test	9
10.5 Test report	10

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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 28706-3 was prepared by the European Committee for Standardization (CEN) (as EN 14483-3) and was adopted, under a special “fast-track procedure”, by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, in parallel with its approval by the ISO member bodies.

It cancels and replaces ISO 4533:1983 and ISO 4535:1983, which have been technically revised.

ISO 28706 consists of the following parts, under the general title *Vitreous and porcelain enamels — Determination of resistance to chemical corrosion*: [ISO 28706-3:2008](https://standards.iteh.ai/catalog/standards/sist/ee9d3c55-1518-48a2-8af2-721dcf86bfd/iso-28706-3-2008)

- *Part 1: Determination of resistance to chemical corrosion by acids at room temperature*
- *Part 2: Determination of resistance to chemical corrosion by boiling acids, boiling neutral liquids and/or their vapours*
- *Part 3: Determination of resistance to chemical corrosion by alkaline liquids using a hexagonal vessel*
- *Part 4: Determination of resistance to chemical corrosion by alkaline liquids using a cylindrical vessel*
- *Part 5: Determination of resistance to chemical corrosion in closed systems*

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 hydrolysed 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 Clause 9 of ISO 28706-4:2008), the silica network of the enamel is considerably attacked at 80 °C. Silicates and most of the other hydrolysed 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 Clause 9 of ISO 28706-1:2008) or also in stronger acids like sulfuric acid (see Clause 10 of ISO 28706-1:2008), 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 Clause 10 of ISO 28706-2:2008) and boiling 30 % sulfuric acid (see Clause 11 of ISO 28706-2:2008)**

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 Clause 12 of ISO 28706-2:2008)**

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).

- 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 Clause 8 of ISO 28706-5:2008), artificial test solutions (see Clause 10 of ISO 28706-5:2008) or process fluids (see Clause 11 of ISO 28706-5:2008) 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 Clause 13 of ISO 28706-2:2008), 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 9 of ISO 28706-3:2008), 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 Clause 14 of ISO 28706-2:2008) and other alkaline solutions (see Clause 10 of ISO 28706-3:2008 and Clause 10 of ISO 28706-4:2008), 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 this International Standard.

For vitreous enamels fired at temperatures below 700 °C, the test parameters (media, temperatures and times) of this International Standard 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 Parts 1, 2, 3 and 4 of this International Standard.

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

1 Scope

This part of ISO 28706 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 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 at 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 referenced documents are indispensable for the application 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 3696, *Water for analytical laboratory use — Specification and test methods*

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

3 Principle

Six similarly enamelled specimens are simultaneously exposed to attack by an alkaline liquid under specified conditions of temperature and time, the solution being continuously stirred during the test.

The loss in mass is determined and used to calculate the rate of loss in mass per unit area.

NOTE In order to correspond to the conditions of a washing machine used in practice, the alkaline liquid is stirred during the test. The solution is cold when put into the vessel and is heated to the desired temperature in the vessel.

4 Reagents

During the determination, use only reagents of recognized analytical grade, unless otherwise specified.

- 4.1 **Water**, conforming to the requirements of grade 3 of ISO 3696, i.e. distilled water or water of equivalent purity.
- 4.2 **Degreasing solvent**, such as ethanol, or water (4.1) containing a few drops of liquid detergent, suitable for cleaning the test apparatus and test specimens.
- 4.3 **Sodium tripolyphosphate** ($\text{Na}_5\text{P}_3\text{O}_{10}$).
- 4.4 **Sodium carbonate** (Na_2CO_3), anhydrous.
- 4.5 **Sodium perborate**, hydrated ($\text{NaBO}_2 \cdot \text{H}_2\text{O}_2 \cdot 3\text{H}_2\text{O}$).
- 4.6 **Sodium silicate**, containing about 81 % (by mass) of Na_2SiO_3 .
- 4.7 **Alkylsulfonate** [$\text{CH}_3(\text{CH}_2)_x - \text{C}(\text{SO}_2\text{Na})\text{H} - (\text{CH}_2)_3 - \text{CH}_3$].

iTeh STANDARD PREVIEW

5 Apparatus and materials (standards.iteh.ai)

5.1 Test apparatus

[ISO 28706-3:2008](#)

5.1.1 General description

<https://standards.iteh.ai/catalog/standards/sist/ee9d3c55-1518-48a2-8af2-721dcf686bfd/iso-28706-3-2008>

The apparatus (see Figures 1 to 4) consists of a hexagonal vessel having a circular opening in each side. A specimen is pressed against each of these openings by means of gripping plates which are held in place by wing nuts, sealing rings being placed between the vessel and the specimens. A lid having four holes, for a paddle stirrer, two immersion heaters and a temperature-controlling device, is screwed on to the vessel, a sealing ring being placed between the vessel and the lid. The paddle stirrer, immersion heaters and temperature-controlling device are fixed such that their distance from the bottom of the vessel is 30 mm.

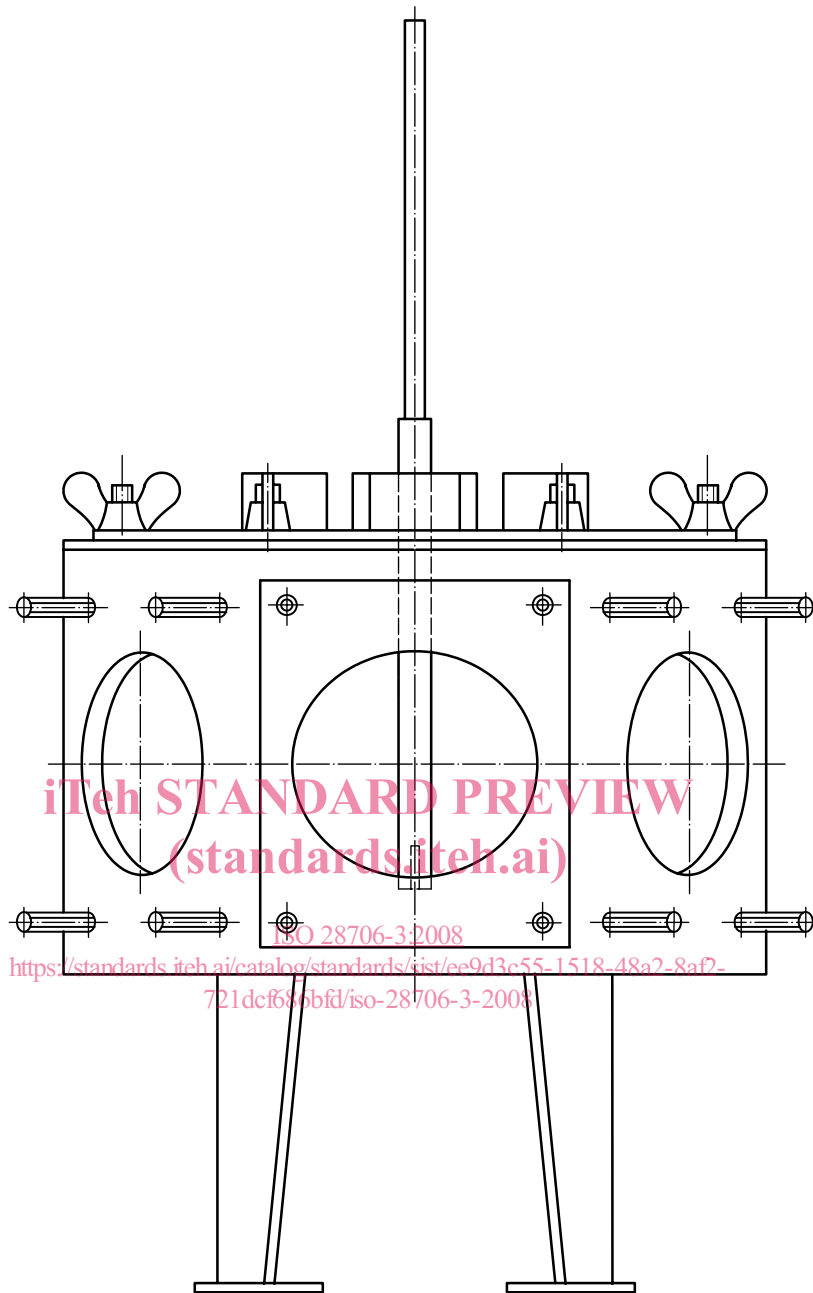


Figure 1 — Hexagonal vessel with lid, stirrer and gripping plate