
**Vitreous and porcelain enamel
finishes — Guide to selection of test
methods for vitreous and porcelain
enamelled areas of articles**

*Finitions en émail vitrifié — Guide pour le choix des méthodes d'essai
applicables aux surfaces émaillées de pièces*

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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 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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

ISO 4528 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 4528:2000), which has been technically revised.

Introduction

Standard test methods are required for measuring and controlling the properties and hence also the quality of vitreous and porcelain enamelled finishes.

To ensure that these finishes meet the requirements of various applications, test methods have to be chosen to measure the properties that are important to the function of a specific enamelled article.

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Vitreous and porcelain enamel finishes — Guide to selection of test methods for vitreous and porcelain enamelled areas of articles

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1 Scope

This International Standard is a guide to the selection of test methods for evaluating the performance of vitreous and porcelain enamelled finishes in different applications. It references the test methods available for measuring the properties of these finishes and correlates these properties to the requirements of specific enamelled articles.

It is limited for the most part to test methods that are described in ISO International/European Standards and does not provide acceptance criteria or performance limits for the properties.

This International Standard applies to all enamelled articles irrespective of their basis metals.

2 Selection of test methods

The properties of enamelled surfaces are listed in [Table 1](#), along with the numbers of the ISO test methods by which they may be measured. The table identifies the tests that should be performed to assess the performance of 30 specific enamelled articles. Suitable standard test methods are selected by noting the specific tests recommended in the column for each of the enamelled articles.

The following symbols are used in [Table 1](#).

- + testing in accordance with the method given is suitable;
- (+) the test method that is cited may need to be modified to take into account special requirements of a specific application;
- - the test is not applicable and/or the test method is not suitable.

Table 1 — Test methods for assessing the properties of enamelled articles

No.	Property	ISO or EN test method	Number and description of enamelled article			
			1 Cookers (top plate)	2 Cookers (baking compartment ^a , grills, burner caps, pan supports, accessories)	3 Cookers [other components (excluding cookware)]	4 Room heating equipment
Methods of assessing resistance to chemical attack in various solutions						
1	Cold citric acid	ISO 28706-1:2008, Clause 9	+	+	+	+
2	Cold sulfuric acid	ISO 28706-1:2008, Clause 10	-	-	+ ^b	+ ^b
3	Boiling citric acid	ISO 28706-2:2008, Clause 10	-	-	-	-
4	Boiling sulfuric acid	ISO 28706-2:2008, Clause 11	-	-	-	-
5	Condensing hydrochloric acid vapour	ISO 28706-2:2008, Clause 12	-	-	-	-
6	Condensing products of combustion vapour	EN 1856-1, Annex A	-	-	-	-
7	Hot sodium hydroxide	ISO 28706-4, Clause 9	-	-	-	-
8	Boiling water	ISO 28706-2:2008, Clause 13	-	-	-	-
9	Water vapour	ISO 28706-2:2008, Clause 13	-	-	-	-
10	Hot standard detergent	ISO 28706-3:2008, Clause 9	-	-	-	-
11	Liquid cleaners	^c	-	+	+	+
12	Weathering resistance	^d	-	-	-	-
13	Special corrosive substances	ISO 28706-4	-	-	-	-
14	Special corrosive substances	ISO 28706-5	-	-	-	-
15	Release of lead and cadmium ^e	ISO 4531-1/EN 1388-2	-	+	-	-
Methods of assessing thickness and other properties						
16	Thickness	ISO 2178, ISO 2360	+	+	+	+
17	Reflectivity and gloss	ISO 2813	-	-	-	-
18	Waviness	^c	-	-	-	-
19	Colour	ISO 105-J03/ISO 7724 (all parts)	+	+	+	+
20	Defects (visual inspection)	^c	+	+	+	+
21	Continuity and porosity (low voltage test)	ISO 8289	-	-	-	-
22	Continuity and porosity (high voltage test)	EN 14430	-	-	-	-
23	Resistance to thermal shock	ISO 2747	-	-	-	-
24	Resistance to thermal shock	ISO 28763:2008, Annex A	+	+	-	+
25	Resistance to thermal shock	ISO 13807	-	-	-	-
26	Resistance to heat	ISO 4530	+	+	+	+
27	Temperature class	EN 1859, 4.6	-	-	-	-
28	Resistance to impact	ISO 4532	+	+	+	+
29	Adhesion	EN 10209:2013, Annex C	+	+	+	+
30	Abrasion resistance	^c	+	+	+	-
31	Subsurface abrasion resistance	ISO 6370-2	-	-	-	-
32	Scratch resistance	ISO 15695	-	-	-	-
33	Scratch hardness	EN 15771	-	-	-	-

Table 1 — (continued)

No.	Property	ISO or EN test method	Number and description of enamelled article			
			5 Cookware (inside surfaces and utensils)	6 Cookware (outside sur- faces)	7 Chimneys and flue pipes	8 Tableware
Methods of assessing resistance to chemical attack in various solutions						
1	Cold citric acid	ISO 28706-1:2008, Clause 9	+	+	-	+
2	Cold sulfuric acid	ISO 28706-1:2008, Clause 10	-	-	-	-
3	Boiling citric acid	ISO 28706-2:2008, Clause 10	+	-	-	-
4	Boiling sulfuric acid	ISO 28706-2:2008, Clause 11	-	-	-	-
5	Condensing hydrochloric acid vapour	ISO 28706-2:2008, Clause 12	-	-	-	-
6	Condensing products of combustion vapour	EN 1856-1, Annex A	-	-	(+)	-
7	Hot sodium hydroxide	ISO 28706-4:2008, Clause 9	-	-	-	-
8	Boiling water	ISO 28706-2:2008, Clause 13	+	-	-	-
9	Water vapour	ISO 28706-2:2008, Clause 13	+	-	-	-
10	Hot standard detergent	ISO 28706-3:2008, Clause 9	-	-	-	-
11	Liquid cleaners	c	+	+	-	+
12	Weathering resistance	d	-	-	-	-
13	Special corrosive substances	ISO 28706-4	+	+	-	+
14	Special corrosive substances	ISO 28706-5	-	-	-	-
15	Release of lead and cadmium ^e	ISO 4531-1/EN 1388-2	+	-	-	+
Methods of assessing thickness and other properties						
16	Thickness	ISO 2178, ISO 2360	+	+	+	+
17	Reflectivity and gloss	ISO 2813	-	-	-	-
18	Waviness	c	-	-	-	-
19	Colour	ISO 105-J03/ISO 7724 (all parts)	+	+	-	+
20	Defects (visual inspection)	c	+	+	(+)	+
21	Continuity and porosity (low voltage test)	ISO 8289	-	-	-	-
22	Continuity and porosity (high voltage test)	EN 14430	-	-	-	-
23	Resistance to thermal shock	ISO 2747	+	+	-	-
24	Resistance to thermal shock	ISO 28763:2008, Annex A	-	-	-	-
25	Resistance to thermal shock	ISO 13807	-	-	-	-
26	Resistance to heat	ISO 4530	-	-	-	-
27	Temperature class	EN 1859, 4.6	-	-	+	-
28	Resistance to impact	ISO 4532	+	+	-	+
29	Adhesion	EN 10209:2013, Annex C	+	+	(+)	+
30	Abrasion resistance	c	+	+	-	+
31	Subsurface abrasion resistance	ISO 6370-2	-	-	-	-
32	Scratch resistance	ISO 15695	-	-	-	-
33	Scratch hardness	EN 15771	-	-	-	-

Table 1 — (continued)

No.	Property	ISO or EN test method	Number and description of enamelled article			
			9 Sinks	10 Refrigerators (inside surfaces)	11 Refrigerators (outside sur- faces)	12 Washing machines (drum)
Methods of assessing resistance to chemical attack in various solutions						
1	Cold citric acid	ISO 28706-1:2008, Clause 9	+	+	+	+
2	Cold sulfuric acid	ISO 28706-1:2008, Clause 10	+	-	-	-
3	Boiling citric acid	ISO 28706-2:2008, Clause 10	+	-	-	-
4	Boiling sulfuric acid	ISO 28706-2:2008, Clause 11	-	-	-	-
5	Condensing hydrochloric acid vapour	ISO 28706-2:2008, Clause 12	-	-	-	-
6	Condensing products of combustion vapour	EN 1856-1, Annex A	-	-	-	-
7	Hot sodium hydroxide	ISO 28706-4:2008, Clause 9	-	-	-	-
8	Boiling water	ISO 28706-2:2008, Clause 13	+	-	-	+
9	Water vapour	ISO 28706-2:2008, Clause 13	-	-	-	+
10	Hot detergent	ISO 28706-3:2008, Clause 9	+	-	-	+
11	Liquid cleaners	c	+	+	+	-
12	Weathering resistance	d	-	-	-	-
13	Special corrosive substances	ISO 28706-4	-	-	-	-
14	Special corrosive substances	ISO 28706-5	-	-	-	-
15	Release of lead and cadmium ^e	ISO 4531-1/EN 1388-2	-	-	-	-
Methods of assessing thickness and other properties						
16	Thickness	ISO 2178, ISO 2360	+	+	+	+
17	Reflectivity and gloss	ISO 2813	+	-	-	-
18	Waviness	c	-	-	-	-
19	Colour	ISO 105-J03/ISO 7724 (all parts)	+	+	+	-
20	Defects (visual inspection)	c	+	+	+	+
21	Continuity and porosity (low voltage test)	ISO 8289	-	-	-	+
22	Continuity and porosity (high voltage test)	EN 14430	+	-	-	-
23	Resistance to thermal shock	ISO 2747	-	-	-	-
24	Resistance to thermal shock	ISO 28763:2008, Annex A	-	-	-	-
25	Resistance to thermal shock	ISO 13807	-	-	-	-
26	Resistance to heat	ISO 4530	-	-	-	-
27	Temperature class	EN 1859, 4.6	-	-	-	-
28	Resistance to impact	ISO 4532	+	+	+	+
29	Adhesion	EN 10209:2013, Annex C	+	+	+	+
30	Abrasion resistance	c	+	-	-	+
31	Subsurface abrasion resistance	ISO 6370-2	-	-	-	-
32	Scratch resistance	ISO 15695	+	-	-	-
33	Scratch hardness	EN 15771	+	-	-	-

Table 1 — (continued)

No.	Property	ISO or EN test method	Number and description of enamelled article			
			13 Washing machines [box (out-side)]	14 Dishwasher [rinsing container (inside)]	15 Dishwasher [box (out-side)]	16 Bathtubs and articles for sanitary use (households)
Methods of assessing resistance to chemical attack in various solutions						
1	Cold citric acid	ISO 28706-1:2008, Clause 9	+	+	+	+
2	Cold sulfuric acid	ISO 28706-1:2008, Clause 10	-	-	-	+
3	Boiling citric acid	ISO 28706-2:2008, Clause 10	-	-	-	+
4	Boiling sulfuric acid	ISO 28706-2:2008, Clause 11	-	-	-	-
5	Condensing hydrochloric acid vapour	ISO 28706-2:2008, Clause 12	-	-	-	-
6	Condensing products of combustion vapour	EN 1856-1, Annex A	-	-	-	-
7	Hot sodium hydroxide	ISO 28706-4:2008, Clause 9	-	+	-	-
8	Boiling water	ISO 28706-2:2008, Clause 13	-	+	-	(+)
9	Water vapour	ISO 28706-2:2008, Clause 13	-	+	-	-
10	Hot standard detergent	ISO 28706-3:2008, Clause 9	+	+	-	(+)
11	Liquid cleaners	c	+	-	+	+
12	Weathering resistance	d	-	-	-	-
13	Special corrosive substances	ISO 28706-4	-	+	-	+
14	Special corrosive substances	ISO 28706-5	-	-	-	-
15	Release of lead and cadmium ^e	ISO 4531-1/EN 1388-2	-	-	-	-
Methods of assessing thickness and other properties						
16	Thickness	ISO 2178, ISO 2360	+	+	+	+
17	Reflectivity and gloss	ISO 2813	-	-	-	-
18	Waviness	c	-	-	-	-
19	Colour	ISO 105-J03/ISO 7724 (all parts)	+	-	+	+
20	Defects (visual inspection)	c	+	+	+	+
21	Continuity and porosity (low voltage test)	ISO 8289	-	+	-	+
22	Continuity and porosity (high voltage test)	EN 14430	-	-	-	+
23	Resistance to thermal shock	ISO 2747	-	-	-	-
24	Resistance to thermal shock	ISO 28763:2008, Annex A	-	-	-	-
25	Resistance to thermal shock	ISO 13807	-	-	-	-
26	Resistance to heat	ISO 4530	-	-	-	-
27	Temperature class	EN 1859, 4.6	-	-	-	-
28	Resistance to impact	ISO 4532	+	+	+	(+)
29	Adhesion	EN 10209:2013, Annex C	+	+	+	+
30	Abrasion resistance	c	-	-	-	+
31	Subsurface abrasion resistance	ISO 6370-2	-	-	-	-
32	Scratch resistance	ISO 15695	-	-	-	-
33	Scratch hardness	EN 15771	-	-	-	+

Table 1 — (continued)

No.	Property	ISO or EN test method	Number and description of enamelled article			
			17 Bathtubs; articles for sanitary use/ medical uses	18 Hot water tanks	19 Traffic and other signs, posters	20 Building panels, light reflectors, furniture for indoor use
Methods of assessing resistance to chemical attack in various solutions						
1	Cold citric acid	ISO 28706-1:2008, Clause 9	+	(+)	+	+
2	Cold sulfuric acid	ISO 28706-1:2008, Clause 10	+	+	-	-
3	Boiling citric acid	ISO 28706-2:2008, Clause 10	+	-	-	-
4	Boiling sulfuric acid	ISO 28706-2:2008, Clause 11	-	-	-	-
5	Condensing hydrochloric acid vapour	ISO 28706-2:2008, Clause 12	-	-	-	-
6	Condensing products of combustion vapour	EN 1856-1, Annex A	-	-	-	-
7	Hot sodium hydroxide	ISO 28706-4:2008, Clause 9	-	-	-	-
8	Boiling water	ISO 28706-2:2008, Clause 13	(+)	(+)	-	-
9	Water vapour	ISO 28706-2:2008, Clause 13	-	-	-	-
10	Hot standard detergent	ISO 28706-3:2008, Clause 9	(+)	-	-	-
11	Liquid cleaners	c	+	-	+	+
12	Weathering resistance	d	-	-	+	-
13	Special corrosive substances	ISO 28706-4	+	-	-	-
14	Special corrosive substances	ISO 28706-5	-	-	-	-
15	Release of lead and cadmium ^e	ISO 4531-1/EN 1388-2	-	+	-	-
Methods of assessing thickness and other properties						
16	Thickness	ISO 2178, ISO 2360	+	+	+	+
17	Reflectivity and gloss	ISO 2813	-	-	+	+
18	Waviness	c	-	-	+	+
19	Colour	ISO 105-J03/ISO 7724 (all parts)	+	-	+	+
20	Defects (visual inspection)	c	+	+	+	+
21	Continuity and porosity (low voltage test)	ISO 8289	+	-	+	-
22	Continuity and porosity (high voltage test)	EN 14430	+	-	+	-
23	Resistance to thermal shock	ISO 2747	-	-	-	-
24	Resistance to thermal shock	ISO 28763:2008, Annex A	-	-	-	-
25	Resistance to thermal shock	ISO 13807	-	-	-	-
26	Resistance to heat	ISO 4530	-	-	-	-
27	Temperature class	EN 1859, 4.6	-	-	-	-
28	Resistance to impact	ISO 4532	(+)	+	+	+
29	Adhesion	EN 10209:2013, Annex C	+	+	+	+
30	Abrasion resistance	c	+	-	+	+
31	Subsurface abrasion resistance	ISO 6370-2	-	-	-	-
32	Scratch resistance	ISO 15695	-	-	-	-
33	Scratch hardness	EN 15771	+	-	-	-

Table 1 — (continued)

No.	Property	ISO or EN test method	Number and description of enamelled article			
			21 Building panels, light reflectors, furniture for exterior use (outside)	22 Petrol pump panels	23 Exhaust pipe silencers and heat exchangers	24 Apparatus and containers for chemicals, pharmaceutical, and food industry
Methods of assessing resistance to chemical attack in various solutions						
1	Cold citric acid	ISO 28706-1:2008, Clause 9	+	+	-	-
2	Cold sulfuric acid	ISO 28706-1:2008, Clause 10	-	-	-	-
3	Boiling citric acid	ISO 28706-2:2008, Clause 10	+	-	-	-
4	Boiling sulfuric acid	ISO 28706-2:2008, Clause 11	-	-	+	-
5	Condensing hydrochloric acid vapour	ISO 28706-2:2008, Clause 12	-	-	-	+
6	Condensing products of combustion vapour	EN 1856-1, Annex A	-	-	-	-
7	Hot sodium hydroxide	ISO 28706-4:2008, Clause 9	-	-	-	+
8	Boiling water	ISO 28706-2:2008, Clause 13	-	-	-	(+)
9	Water vapour	ISO 28706-2:2008, Clause 13	-	-	+	+
10	Hot standard detergent	ISO 28706-3:2008, Clause 9	-	-	-	-
11	Liquid cleaners	c	+	+	-	-
12	Weathering resistance	d	+	+	-	-
13	Special corrosive substances	ISO 28706-4	-	-	(+)	+
14	Special corrosive substances	ISO 28706-5	-	-	+	+
15	Release of lead and cadmium ^e	ISO 4531-1/EN 1388-2	-	-	-	-
Methods of assessing thickness and other properties						
16	Thickness	ISO 2178, ISO 2360	+	+	+	+
17	Reflectivity and gloss	ISO 2813	+	+	-	-
18	Waviness	c	+	+	-	-
19	Colour	ISO 105-J03/ISO 7724 (all parts)	+	+	-	-
20	Defects (visual inspection)	c	+	+	+	+
21	Continuity and porosity (low voltage test)	ISO 8289	+	+	(+)	-
22	Continuity and porosity (high voltage test)	EN 14430	+	-	+	+
23	Resistance to thermal shock	ISO 2747	-	-	(+)	-
24	Resistance to thermal shock	ISO 28763:2008, Annex A	+	+	+	-
25	Resistance to thermal shock	ISO 13807	-	-	-	+
26	Resistance to heat	ISO 4530	-	-	(+)	-
27	Temperature class	EN 1859, 4.6	-	-	-	-
28	Resistance to impact	ISO 4532	+	+	(+)	(+)
29	Adhesion	EN 10209:2013, Annex C	+	+	(+)	(+)
30	Abrasion resistance	c	+	+	(+)	-
31	Subsurface abrasion resistance	ISO 6370-2	-	-	-	(+)
32	Scratch resistance	ISO 15695	+	-	-	-
33	Scratch hardness	EN 15771	+	-	-	-

Table 1 — (continued)

No.	Property	ISO or EN test method	Number and description of enamelled article			
			25 Tanks for less demanding industrial/ municipal treatment liquid appli- cation	26 Tanks for more demanding industrial/ municipal treatment liq- uid application	27 Tanks for general industrial dry bulk storage application	28 Agricultural slurry tanks
			(For more information, see ISO 28765.)			
Methods of assessing resistance to chemical attack in various solutions						
1	Cold citric acid	ISO 28706-1:2008, Clause 9	+	+	+	+
2	Cold sulfuric acid	ISO 28706-1:2008, Clause 10	-	+	-	-
3	Boiling citric acid	ISO 28706-2:2008, Clause 10	+	+	+	+
4	Boiling sulfuric acid	ISO 28706-2:2008, Clause 11	-	-	-	-
5	Condensing hydrochloric acid vapour	ISO 28706-2:2008, Clause 12	-	+	-	-
6	Condensing products of combustion vapour	EN 1856-1, Annex A	-	-	-	-
7	Hot sodium hydroxide	ISO 28706-4:2008, Clause 9	+	+	+	+
8	Boiling water	ISO 28706-2:2008, Clause 13	+	+	+	+
9	Water vapour	ISO 28706-2:2008, Clause 13	-	+	-	-
10	Hot standard detergent	ISO 28706-3:2008, Clause 9	-	+	-	-
11	Liquid cleaners	c	-	-	-	-
12	Weathering resistance	d	-	-	-	-
13	Special corrosive substances	ISO 28706-4	-	+	-	-
14	Special corrosive substances	ISO 28706-5	-	-	-	-
15	Release of lead and cadmium ^e	ISO 4531-1/EN 1388-2	+	+	+	+
Methods of assessing thickness and other properties						
16	Thickness	ISO 2178, ISO 2360	+	+	+	+
17	Reflectivity and gloss	ISO 2813	-	-	-	-
18	Waviness	c	-	-	-	-
19	Colour	ISO 105-J03/ISO 7724 (all parts)	-	-	-	-
20	Defects (visual inspection)	c	+	+	+	+
21	Continuity and porosity (low voltage test)	ISO 8289	-	-	-	+
22	Continuity and porosity (high voltage test)	EN 14430	+	+	+	-
23	Resistance to thermal shock	ISO 2747	-	-	-	-
24	Resistance to thermal shock	ISO 28763:2008, Annex A	-	+	-	-
25	Resistance to thermal shock	ISO 13807	-	-	-	-
26	Resistance to heat	ISO 4530	-	-	-	-
27	Temperature class	EN 1859, 4.6	-	-	-	-
28	Resistance to impact	ISO 4532	+	+	+	+
29	Adhesion	EN 10209:2013, Annex C	+	+	+	+
30	Abrasion resistance	c	+	+	+	+
31	Subsurface abrasion resistance	ISO 6370-2	-	+	-	-
32	Scratch resistance	ISO 15695	-	-	-	-
33	Scratch hardness	EN 15771	+	+	+	+