INTERNATIONAL STANDARD

ISO 28763

First edition
2008-10-15

Vitreous and porcelain enamels — Regenerative, enamelled and packed panels for air-gas and gas-gas heat exchangers — Specifications

Émaux vitrifiés — Échangeurs thermiques pour réchauffeurs air-gaz et gaz-gaz à empilement de panneaux émaillés remplaçables et démontables — Spécifications

Reference number
ISO 28763:2008(E)

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

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 28763 was prepared by the European Committee for Standardization (CEN) (as EN 14866) 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.

Vitreous and porcelain enamels — Regenerative, enamelled and packed panels for air-gas and gas-gas heat exchangers — Specifications

1 Scope

This International Standard specifies the minimum requirements and the functional characteristics of enamel coatings applied by any process, such as wet dipping, wet flow-coating, wet spraying, wet electrostatic spraying, wet electrodeposition or dry-powder electrostatic spraying, to profiled steel heat exchanger panels in regenerative heat exchangers, before and after packing in baskets.

For very severe service conditions, or to obtain extended operational life, more stringent limits may be agreed between customer and supplier.

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 105-J03, *Textiles — Tests for colour fastness — Part J03: Calculation of colour differences* (including Technical Corrigendum 1:1996 and Technical Corrigendum 2:2006)

ISO 2178, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method*

ISO 4534, *Vitreous and porcelain enamels — Determination of fluidity behaviour — Fusion flow test*

ISO 7991, *Glass — Determination of coefficient of mean linear thermal expansion*

ISO 8289:2001, *Vitreous and porcelain enamels — Low voltage test for detecting and locating defects*

ISO 28706-2:2008, *Vitreous and porcelain enamels — Determination of resistance to chemical corrosion — Part 2: Determination of resistance to chemical corrosion by boiling acids, boiling neutral liquids and/or their vapours*

ISO 28723, *Vitreous and porcelain enamels — Determination of the edge covering on enamelled steel plate to be used in heat exchangers*

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

EN 10204:2004, *Metallic products — Types of inspection documents*

EN 10209:1996, *Cold rolled low carbon steel flat products for vitreous enamelling — Technical delivery conditions*

3 Terms and definitions

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

3.1
blisters
localized bubbles under the surface of the fired enamel

3.2
burn-off
localized areas of rough black oxide erupting through the enamel coating

3.3
chipping
fracturing and detachment of particles from a vitreous enamelled surface

3.4
copperheads
small freckle-like or pimple-like reddish-brown spots occurring in ground-coats or in direct-on enamels applied to sheet metals

3.5
cracking
laminar interruptions in the fused coating usually running vertical to the surface

NOTE 1 The laminar interruptions can also occur at different angles.

NOTE 2 Their causes are mainly the result of tensile stresses within the enamel coating.

3.6
crazing
fine cracks in the enamel coating

3.7
fire tool marks
fire marks
small indentations similar in appearance to shallow pinholes

3.8
fish-scaling
small half-moon-shaped defects occurring in the vitreous enamelled surface

NOTE Fish-scaling can occur immediately on cooling or after some time has elapsed following firing. These defects originate from supersaturation of the substrate with hydrogen (acquired during firing) that suddenly fractures the enamel coating in order to relieve the pressure that has accumulated with time at the enamel-steel interface.

3.9
spalling
spontaneous fracturing and detachment of particles of enamel from within the coating layer

NOTE Spalling often occurs on corners, sharp radii or panel edges and is the result of too low an enamel coefficient of expansion for the substrate, the external radii and the enamel thickness concerned. Thermal stresses can aggravate the spalling.

3.10
tearing
short breaks or cracks in the enamel bisque that have healed during firing

3.11
air-gas heater
heat exchanger used to heat up the air needed for combustion in the boiler, using the combustion gases from the boiler as the hot fluid

NOTE 1 The maximum temperature of the hot gases entering the heat exchanger is 450 °C with a normal operating temperature from 380 °C to 320 °C.

NOTE 2 Air-gas heat exchangers through which gases from DeNOx installations pass are considered as gas-gas heaters for the purposes of this International Standard.

3.12
gas-gas heater
heat exchanger used in desulfuration plants to reheat the gases treated in the scrubber to obtain the proper draft in the stack

NOTE 1 The hot gases are the untreated gases going to the scrubber.

NOTE 2 The maximum temperature of the hot gases entering the heat exchanger is 200 °C with a normal operating temperature from 160 °C to 120 °C.

4 Steel substrates

4.1 Delivery

The steel for enamelling shall conform to the requirements of EN 10209 and shall be delivered with a certificate in accordance with 3.1 of EN 10204:2004.

4.2 Analysis

The chemical composition shall be determined by a ladle analysis and shall conform to the requirements of EN 10209:1996, Table 2. At the request of the enameller, other elements as mentioned in Table 2 of EN 10209:1996 shall be agreed with the steel manufacturer. For grades DCO3ED and DCO4ED, the carbon content of the product shall be determined and shall conform to EN 10209:1996, Table 2.

4.3 Hydrogen permeability

The hydrogen permeability shall have a minimum TH value of 100, calculated in accordance with EN 10209:1996, B.1.8, Equation (1), or shall give the result of a minimum of 8 min in accordance with EN 10209:1996, B.1, calculated in accordance with B.1.8, Equation (2).

In the absence of a certificate from the steel supplier confirming the above minimum hydrogen permeability, and with prior agreement between the customer and the supplier, the fish-scale resistance shall then be determined as described in 4.4.

The hydrogen permeability method is not acceptable for the steel grades DCO6EK and DCO6ED (see EN 10209:1996, Table 2). For these grades, the fish-scale test described in 4.4 shall be used.

4.4 Fish-scale test

The fish-scale test shall be carried out in accordance with EN 10209:1996, B.2, method B.2. The test sheet (150 mm × coil width) shall be pre-treated without a nickel dip. The front and back shall be coated with enamel prepared in accordance with the supplier's milling formula and applied to produce a fired thickness of 100 µm to 130 µm. After drying, the coated test sheet shall be fired for 5 min at 820 °C. The test sheet shall then be subjected to thermal treatment at 60 °C to 80 °C for 24 h and subsequently inspected for fish scales. No fish scales are allowed.

4.5 Pickling speed

If required by the enameller, the pickling speed shall be determined in accordance with EN 10209:1996, Annex C, and an acceptable level shall be agreed with the steel manufacturer.

5 Enamel frit

5.1 Delivery

Enamel frit shall be ordered by the enameller with a certificate conforming to the requirements of 3.1 of EN 10204:2004, including the results for the items given under 5.5 and 5.7.

The tests in 5.4 and 5.6 shall be carried out whenever there is a change in the frit or a change in the milling formula.

When taking delivery of “ready to use” enamel, enamel slip or enamel powder, the enameller can ask for additional requirements for the application properties in the certificate.

Any other requirements and the test recipes shall be determined by consultation between the enameller (and/or customer) and the frit manufacturer.

5.2 Coefficient of expansion

If required by the enameller, the coefficient of expansion shall be determined in accordance with the house test of the manufacturer of the enamel frit (base material for “ready to use” enamel, enamel slip or powder enamel) or in accordance with ISO 7991.

5.3 Fusion flow

If required by the enameller, the fusion flow shall be determined in accordance with the house test of the manufacturer of the enamel frit (base material for “ready to use” enamel, enamel slip or powder enamel) or in accordance with ISO 4534.

5.4 Boiling-water vapour resistance

If required by the enameller, the boiling-water vapour resistance shall be determined in accordance with ISO 28706-2:2008, Clause 13.

When determined in this way, the maximum loss in mass of the enamel coating shall be as given in Table 1.

Table 1 — Maximum loss in mass

Heater type	Mass loss, max.
Air-gas	20 g/m^2/48 h
Gas-gas	6 g/m^2/48 h

5.5 Acid resistance

The boiling sulfuric acid resistance shall be determined in accordance with ISO 28706-2:2008, Clause 11.

5.6 Thermal-shock resistance

If required by the enameller, the thermal-shock resistance shall be determined in accordance with Annex A at a test temperature of 350 °C on at least three test specimens prepared in accordance with ISO 28764.

After testing five times at the test temperature, the test specimens shall show no damage.

5.7 Adherence

The adherence shall be determined in accordance with EN 10209:1996, Annex D, using test specimens with a known pickling speed (see 4.5) prepared in accordance with ISO 28764.

The method of pre-treatment, application and firing of the enamel shall be described.

6 Characteristics of the enamel coating

6.1 Adherence

Test specimens for the determination of adherence shall be prepared in accordance with ISO 28764 and shall be pre-treated and enamelled under the same conditions as for the production of the heat exchanger panels.

When determined in accordance with EN 10209:1996, Annex D, the adherence of the enamel shall be at least level 2.

Tests shall be carried out on every pre-treated batch of panels.

6.2 Thickness

The thickness shall be determined in accordance with ISO 2178. Adjustment of the measurement equipment shall be carried out on the profile concerned. Select a pair of panels, one corrugated and one undulated, and carry out measurements from point A to point I (see Figure 1) on the front and reverse faces of each panel. The measurement points shall be situated at least 50 mm from the edge. The measurement points on the corrugated panel shall be as indicated by numbers 1 and 2, and on the undulated panel as indicated by 3. This will result in 54 measurements from each pair of panels tested, 36 from the corrugated panel and 18 from the undulated panel.

The mean of the 54 measurements (36 measurements at point number 1 and point number 2 of the corrugated panel plus the 18 measurements at point number 3 of the undulated panel) shall be 150 µm ± 30 µm, unless a different mean is agreed between customer and supplier at the time of ordering.

Along the area bordering the edges of the panels, the total thickness may measure up to 600 µm (i.e. two faces of 300 µm) plus the thickness of the substrate. If a different mean has been agreed between customer and supplier, the total enamel thickness along the area bordering the edge of the panel may vary, but should preferably be kept to a minimum to avoid chipping and spalling, etc.

With the exception of edges and suspension holes, the application thickness beside the measurement point (such as on both sides of the notches of the corrugation) shall nowhere fall below 80 µm.

Measurements other than those at the points indicated shall be carried out using a microscope.

The test shall be carried out on a 2 h cycle.