# INTERNATIONAL STANDARD

# ISO 28721-3

First edition
2008-12-01

## Vitreous and porcelain enamels — Glass-lined apparatus for process plants —

## Part 3: Thermal shock resistance

*Émaux vitrifiés — Appareils émaillés pour les installations industrielles —*

*Partie 3: Résistance au choc thermique*



Reference number
ISO 28721-3:2008(E)

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Published in Switzerland

 

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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 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 28721-3 was prepared by the European Committee for Standardization (CEN) (as EN 15159-3) 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.

ISO 28721 consists of the following parts, under the general title *Vitreous and porcelain enamels — Glass-lined apparatus for process plants*:

— *Part 1: Quality requirements for apparatus, components, appliances and accessories*

— *Part 2: Designation and specification of resistance to chemical attack and thermal shock*

— *Part 3: Thermal shock resistance*



# Vitreous and porcelain enamels — Glass-lined apparatus for process plants —

# Part 3: Thermal shock resistance



## 1 Scope

This part of ISO 28721 specifies requirements for the thermal shock resistance of, and heating and cooling procedures for, glass-lined apparatus, components, accessories and pipes primarily used for process equipment in chemical plants.

It specifies the limits of thermal shock resistance using diagrams (see Figure 1 and Figure 2). For glass-lined steel, a distinction is made between a thermal shock on the glass-lined side (produced by charging an apparatus) and a thermal shock on the steel side (produced by heating or cooling an apparatus).

This part of ISO 28721 applies to operating temperatures from − 25 °C to + 230 °C.

It is only applicable to enamelled unalloyed and low-alloy carbon steels.

## 2 Terms and definitions

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

**2.1**
**glass-lined steel**
composite material produced by smelting a vitreous and porcelain enamel coat onto a steel substrate

**2.2**
**shock medium**
substance (e.g. steam, an aqueous liquid or a solid) having a higher or lower temperature than that of the enamel and thus causing a sudden temperature change when brought into contact with the glass-lined surface

**2.3**
**thermal shock**
sudden change of temperature, either on the glass-lined side or on the steel side of an enamelled steel item, resulting from contact with a shock medium

**2.4**
**wall temperature**
$T_W$
average steel temperature, in degrees Celsius, of the enamel

NOTE The wall temperature is often equivalent to the temperature of the heating or cooling medium entering the jacket of the apparatus.

**2.5**
**product temperature**
$T_P$
temperature, in degrees Celsius, of the product which is inside the apparatus and in contact with the glass-lined surface or is to be introduced into the apparatus

**2.6**
**temperature of heating or cooling medium**
$T_{HC}$
temperature, in degrees Celsius, of the medium (e.g. water, steam, heat-transfer oil) which is introduced into the jacket of an apparatus for heating or cooling purposes

NOTE Where steam is the heating medium, the temperature of the heating or cooling medium is the condensation temperature at the particular pressure in the jacket of the apparatus.

EXAMPLE For saturated steam at an overpressure of 0,6 MPa, $T_{HC}$ = 165 °C.

## 3 Thermal shock diagram

The thermal shock diagram (see Figure 1) defines the thermal shock limits for a shock medium brought into contact with the glass-lined surface of an apparatus [e.g. when a product is introduced into the apparatus and the heating or cooling medium is in a half-pipe coil (or other) jacket]. These thermal shock limits depend on the wall temperature, $T_W$, and the product temperature, $T_P$.

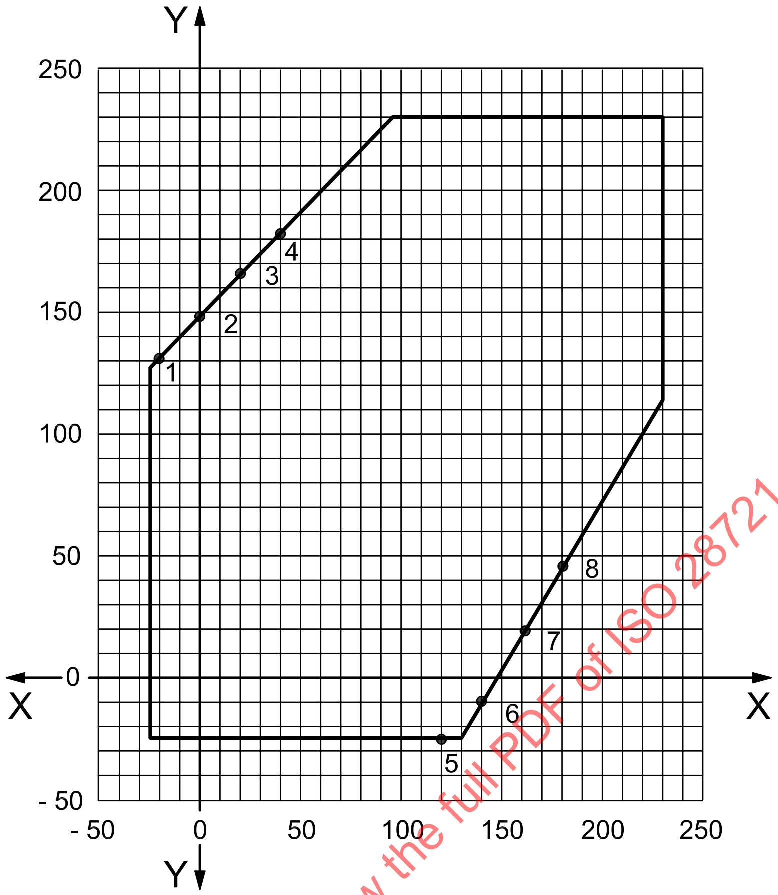
NOTE The values defined in the diagram were calculated assuming essentially infinitely high heat-transfer coefficients which are found to be approximately the case with aqueous shock media.

Tables 1 and 2 give examples showing the corresponding wall temperature and minimum and maximum product temperatures.

If the product (e.g. a gas, solid or highly viscous fluid) has a relatively low heat-transfer coefficient, higher thermal shock limits are permitted by agreement with the manufacturer (see Annex A).








**Key**

X wall temperature, $T_W$ (°C)
Y product temperature, $T_P$ (°C)

**Figure 1 — Thermal shock diagram for examples 1 to 8 (see Tables 1 and 2) (thermal shock on the glass-lined side of the steel)**

**Table 1 — Introducing a hot product into a cold apparatus**

| Example | Wall temperature $T_W$ | Maximum product temperature $T_P$ (rounded) |
|---|---|---|
| | °C | °C |
| 1 | – 20 | 130 |
| 2 | 0 | 150 |
| 3 | 20 | 165 |
| 4 | 40 | 180 |

**Table 2 — Introducing a cold product into a hot apparatus**

| Example | Wall temperature $T_W$ | Minimum product temperature $T_P$ (rounded) |
|---|---|---|
| | °C | °C |
| 5 | 120 | − 25 |
| 6 | 140 | − 5 |
| 7 | 160 | 20 |
| 8 | 180 | 50 |

## 4 Heating/cooling diagram

The heating/cooling diagram (see Figure 2) defines the thermal shock limits for a shock medium brought into contact with the steel side of the enamelled wall [e.g. when a heating or cooling medium is introduced into the half-pipe coil (or other) jacket of an apparatus filled with a product]. These thermal shock limits depend on the temperature of the heating or cooling medium, $T_{HC}$, and of the product, $T_P$.

NOTE The values defined in the diagram were calculated assuming essentially infinitely high temperature transfer coefficients for both the product and the heating or cooling medium. Such coefficients are found to be approximately the case with aqueous products, with steam used as a heating medium and with water used as a cooling medium.

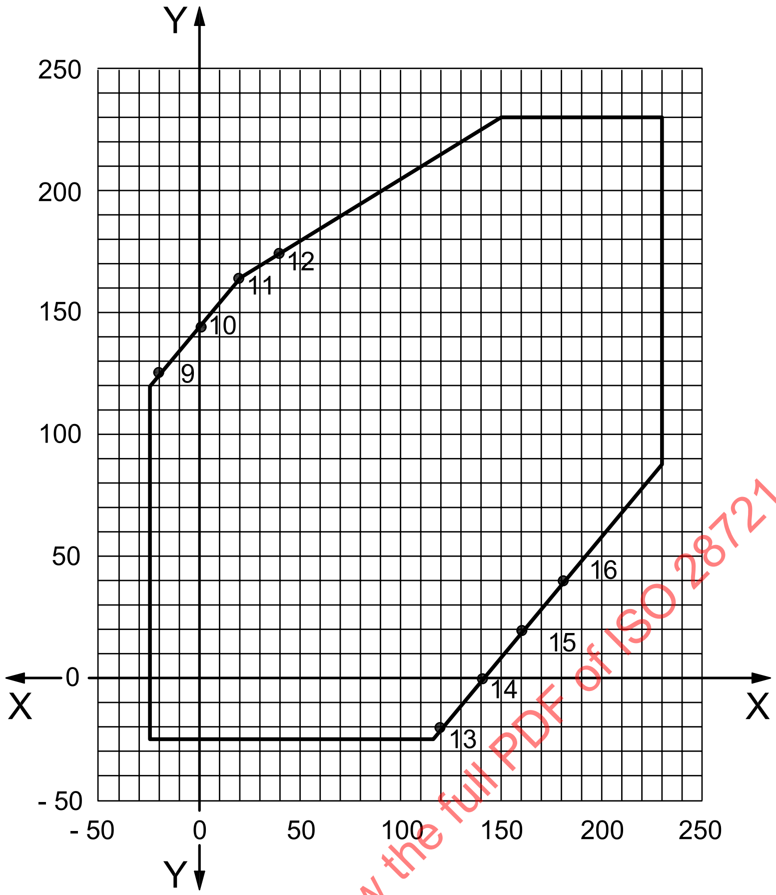
If the product (e.g. a gas, solid or highly viscous fluid) has a relatively low heat-transfer coefficient, higher thermal shock limits for heating are permitted by agreement with the manufacturer.

If relatively low heat-transfer coefficients prevail in the jacket (e.g. if heat-transfer oil is used as the shock medium instead of condensing steam or water), thermal shock limits wider than those shown in Figure 2 are permitted by agreement with the manufacturer (see Annex A).

Tables 3 and 4 give examples showing the corresponding product temperature and maximum heating or minimum cooling temperatures.






**Key**

X product temperature, $T_P$ (°C)

Y temperature of heating or cooling medium, $T_{HC}$ (°C)

**Figure 2 — Diagram for heating and cooling for examples 9 to 16 (see Tables 3 and 4) (thermal shock on the steel side of the enamel)**



**Table 3 — Introducing a heating medium into the half-pipe coil (or other) jacket of a cold apparatus**

| Example | Product temperature $T_P$ | Maximum temperature of heating medium $T_{HC}$ (rounded) |
|---|---|---|
| | °C | °C |
| 9 | – 20 | 125 |
| 10 | 0 | 145 |
| 11 | 20 | 165 |
| 12 | 40 | 175 |

**Table 4 — Introducing a cooling medium into the half-pipe coil (or other) jacket of a hot apparatus**

| Example | Product temperature $T_P$ °C | Minimum temperature of cooling medium $T_{HC}$ (rounded) °C |
|---|---|---|
| 13 | 120 | − 20 |
| 14 | 140 | 0 |
| 15 | 160 | 20 |
| 16 | 180 | 40 |

If the intended temperature change exceeds the limits in the diagram (see Figure 2), this operation shall be carried out in steps.

EXAMPLE Heating a cold apparatus containing a product at a temperature of 0 °C using saturated steam at a temperature of 165 °C:

— First step: Introduce steam at a pressure of 0,3 MPa into the jacket until the product temperature exceeds 25 °C.

— Second step: Switch to steam at a pressure of 0,6 MPa and heat until the product temperature reaches 165 °C.

## 5 Quality designation

Glass-lined steel apparatus, components and pipes conforming to this part of ISO 28721 shall be designated as follows:

Resistance to thermal shock in accordance with ISO 28721-3.



# Annex A
(informative)

## Explanatory notes

The thermal shock resistance of a glass-lined apparatus depends on several different factors, such as the physical properties of the enamel, the material characteristics of the steel, the design of the apparatus, the enamelling process used and the service conditions. The data on thermal shock resistance given in this part of ISO 28721 apply to most glass-lined apparatus in service, based on the following general conditions:

a) Apparatus design in accordance with ISO 28721-1; design of flanged pipes and flanged fittings in accordance with DIN 2873 (a permitted operating pressure from − 0,1 MPa to + 0,6 MPa and a permitted operating temperature from − 25 °C to 230 °C inside the apparatus or jacket).

b) Base material is unalloyed or low-alloy carbon steel which can be glass-lined with a minimum yield strength of 210 N/mm$^2$. In many cases, this value determines the thermal shock limits for heating and cooling as shown in Figure 2.

c) The apparatus and the pipe fittings comply with the quality requirements specified in ISO 28721-1.

d) At the moment of the thermal shock, the pressure in the apparatus and in the jacket is in the range − 0,1 MPa to + 0,6 MPa.

Deviations from these general conditions or from any other specifications given in this part of ISO 28721 can restrict or extend the limits in both the thermal shock diagram and the heating/cooling diagram. In such cases, a special agreement will be necessary between the manufacturer and the user before the apparatus concerned is put into service.