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Vitreous and porcelain enamels — Design of bolted steel tanks for the storage or treatment of water or municipal or industrial effluents and sludges

Émaux vitrifiés — Conception de réservoirs en acier boulonnés pour le stockage ou le traitement des eaux ou des effluents d'eaux usées urbains ou industriels

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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 28765 was prepared by the European Committee for Standardization (CEN) (as EN 15282) 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 — Design of bolted steel tanks for the storage or treatment of water or municipal or industrial effluents and sludges

1 Scope

This International Standard establishes the requirements for the design and use of vitreous-enamel-coated bolted cylindrical steel tanks for the storage or treatment of water or municipal or industrial effluents and sludges.

It applies to the design of the tank and any associated roof and gives guidance on the requirements for the design of the foundation.

It applies where

a) the tank is cylindrical and is mounted on a load-bearing base substantially at or above ground level;

b) the product of the tank diameter in metres and the wall height in metres lies within the range 5 to 500;

c) the tank diameter does not exceed 100 m and the total wall height does not exceed 50 m;

d) the stored material has the characteristics of a liquid, exerting a negligible frictional force on the tank wall; the stored material may be undergoing treatment as part of a municipal or industrial effluent treatment process;

e) the internal pressure in the headspace above the liquid does not exceed 50 kPa and the internal partial vacuum above the liquid does not exceed 10 kPa;

f) the walls of the tank are vertical;

g) the floor of the tank is substantially flat at its intersection with the wall; the floor of the tank may have a rise or fall built in to allow complete emptying of the tank contents, the slope of which does not exceed 1:100;

h) there is negligible inertial and impact load due to tank filling;

i) the minimum thickness of the tank shell is 1,5 mm;

j) the material used for the manufacture of the steel sheets is carbon steel (tanks constructed of sheets made from aluminium or stainless steel are outside the scope of this International Standard);

k) the temperature of the tank wall during operation is within the range −50 °C to +100 °C under all operating conditions.

This International Standard also gives details of procedures to be followed during installation on site and for inspection and maintenance of the installed tank.

It does not apply to chemical-reaction vessels.

It does not apply to tanks fitted with floating roofs.

It does not cover resistance to fire.

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

ISO 2747, *Vitreous and porcelain enamels — Enamelled cooking utensils — Determination of resistance to thermal shock*

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 4532, *Vitreous and porcelain enamels — Determination of the resistance of enamelled articles to impact — Pistol test*

ISO 6370-2, *Vitreous and porcelain enamels — Determination of the resistance to abrasion — Part 2: Loss in mass after sub-surface abrasion*

ISO 8289:2000, *Vitreous and porcelain enamels — Low voltage test for detecting and locating defects*

ISO 15686-1, *Buildings and constructed assets — Service life planning — Part 1: General principles*

ISO 28706-1:2008, *Vitreous and porcelain enamels — Determination of resistance to chemical corrosion — Part 1: Determination of resistance to chemical corrosion by acids at room temperature*

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 28706-3:2008, *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*

ISO 28706-4:2008, *Vitreous and porcelain enamels — Determination of resistance to chemical corrosion — Part 4: Determination of resistance to chemical corrosion by alkaline liquids using a cylindrical vessel*

EN 101, *Ceramic tiles — Determination of scratch hardness of surface according to Mohs*

EN 1993-1-6, *Eurocode 3 — Design of steel structures — Part 1-6: Strength and Stability of Shell Structures*

EN 1993-4-1, *Eurocode 3 — Design of steel structures — Part 4-1: Silos*

EN 1993-4-2, *Eurocode 3 — Design of steel structures — Part 4-2: Tanks*

EN 1998-4, *Eurocode 8 — Design of structures for earthquake resistance — Part 4: Silos, tanks and pipelines*

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

EN 14430:2004, *Vitreous and porcelain enamels — High voltage test*

ANSI/AWWA D 103-97, *Factory-Coated Bolted Steel Tanks for Water Storage*

3 Terms and definitions

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

3.1
brief
working document which specifies at any point in time the relevant needs and aims of the project, the resources to be provided by the client, the details of the project and any applicable design requirements within which all subsequent briefing (when needed) and designing can take place

3.2
client
person or organization that requires a tank to be provided, altered or extended and is responsible for initiating and approving the brief

3.3
defect
break in the surface of the vitreous enamel

3.4
designer
person or organization responsible for stating the shape and specification of the component to be designed

3.5
design life
service life intended by the designer

3.6
discontinuity
defect area or spot that allows an electric current to pass when tested with low-voltage or high-voltage test apparatus

3.7
enamel supplier
person or organization supplying materials for use by the vitreous enameller in the enamelling process

3.8
freeboard
distance between the top of the cylindrical-tank vertical shell wall and the surface of the contained liquid at the specified operating level

3.9
headspace pressure
pressure within a roofed tank above the stored liquid

3.10
inspection area
area inside a boundary 25 mm from any panel edge or hole and outside a boundary 25 mm from any opening or hole within the body of a panel

3.11
liquid
bulk substance that exerts substantially the same vertical and horizontal pressures and has no fixed shape

3.12
maintenance
combination of all technical and associated administrative actions during the service life to retain a tank or its parts in a state in which it can perform its required function

3.13
manufacturer
person or organization that manufactures the tank or parts of the tank

3.14
purchaser
person or organization purchasing the tank from the supplier

NOTE The purchaser can also be the client.

3.15
rectification
return of a tank or its parts to an acceptable condition by the renewal, replacement or repair of worn, damaged or degraded parts

3.16
supplier
person or organization that supplies the tank or parts of the tank

3.17
service life
period of time after installation during which the tank or its parts meets or exceeds the performance requirements

3.18
tank
cylindrical, vertical shell for containing liquid, with or without a roof, which is constructed from vitreous-enamelled curved steel panels bolted together on the construction site and mounted on a base which may also form the floor of the container

3.19
vitreous enameller
person undertaking and controlling the process of preparing the steel sheets and applying the vitreous-enamel coating to the surfaces of the steel sheets

NOTE The vitreous enameller will normally be the manufacturer.

3.20
vitreous enamel
substantially vitreous, or glassy, inorganic silica coating bonded to steel by fusion at a temperature above 750 °C

NOTE 1 This coating is applied for protective purposes to the internal liquid contact surface of the steel and for functional and decorative purposes to the external surface of the steel.

NOTE 2 The coating is produced by a proprietary formulation of silica glass, minerals and clays to produce a medium, dry or suspended in water, which can be sprayed on to the surface of curved steel sheets and subsequently fusion bonded.

4 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviations apply.

D	tank diameter
E	Young's modulus of elasticity
F_H	static hoop force
g	acceleration due to gravity
H	depth of liquid at point under consideration, measured from the liquid surface at the maximum possible filling level
H_0	total vertical wall height
l	length of shell between intermediate stiffeners
I_z	second moment of area of a stiffener
p_n	static liquid pressure at a specified depth
p_h	headspace pressure
r	tank radius
$q_{r,cr}$	critical external buckling pressure
$q_{w_{max}}$	maximum stagnation pressure due to wind
w	proportion of dissolved solids in sludge
t	shell plate thickness
ν	Poisson's ratio
γ	partial load factor
ρ	relative density of a liquid
σ	stress
$\sigma_{z,cr}$	critical axial buckling resistance
cr	(subscript) critical
ds	(subscript) dissolved solids
h	(subscript) headspace
max	(subscript) maximum value
n	(subscript) normal to the tank wall
s	(subscript) sludge
w	(subscript) wind
z	(subscript) coincident with the central axis of a shell of revolution
φ	(subscript) coincident with the radial axis of a shell of revolution

5 Units

The use of one of the following sets of consistent units is recommended:

— dimensions: m, mm

— unit weight: kN/m^3, N/mm^3

— forces and loads: kN, N

— line forces and line loads: kN/m, N/mm

— pressures and area-distributed actions: kPa, MPa

— unit mass: kg/m^3, kg/mm^3

— acceleration: km/s^2, m/s^2

— membrane-stress resultants: kN/m, N/mm

— bending-stress resultants: kNm/m, Nmm/mm

— stresses and elastic moduli: kPa, MPa (1 MPa = 1 N/mm^2)

6 Information and requirements to be agreed and documented

6.1 General

For the safe design and manufacture of the tank and associated parts, the specification shall be agreed between the contracting parties.

6.2 Information to be provided by the purchaser

The purchaser shall provide the supplier with a specification that shall include, but not be limited to, the following:

a) The specification of the stored liquid, that shall include, but not be limited to, the following:

   1) the name and/or a description of the liquid;

   2) the relative density;

   3) any relevant properties or characteristics particular to the liquid to be stored;

   4) the operating-temperature range.

b) The environmental conditions, that shall include, but not be limited to, the following:

   1) wind;

   2) seismic action;

   3) snow;

   4) ice;

   5) temperature ranges.

c) The use and planned dimensions of the tank, that shall include, but not be limited to, the following:

   1) the rates of fill and discharge;

   2) a summary describing the purpose of the tank and its method of operation;

   3) the net effects of the process on the tank or any of its components;

   4) the tank dimensions.

d) The planned location of all openings in the tank shell and roof.

e) Attached equipment:

   1) method of attachment;

   2) dead and live loads;

   3) connections.

f) The proximity of other tanks and buildings.

6.3 Information to be provided by the designer

The designer shall provide essential data concerning the design limitations of the tank, that shall include, but not be limited to, the following:

a) the name and a description of the stored liquid or liquids;

b) the range of the relative densities of the stored liquid or liquids;

c) the limits of the environmental criteria used in the design, including, where relevant, the design wind speed, the design operating-temperature range, the design snow load and the seismic zone and seismic coefficients;

d) the maximum access and superimposed loads used in the design;

e) a maintenance plan conforming to the requirements of ISO 15686-1;

f) guidance concerning change of use;

g) all relevant data assumed by the designer in the design process.

7 Applicable standards

All activities specified in this International Standard shall be carried out under an appropriate quality management system. A quality management system conforming to ISO 9001[1] will be deemed to satisfy this requirement.

The designer and client shall agree, through consultation, upon the applicable standards to be used for design purposes. Where provision is not made within this International Standard, other international or national standards may be specified.

The applicable standards agreed upon shall include, but not be limited to, standards providing details of parameters for the following design procedures:

a) hydrostatic loads;

b) wind loads;

c) seismic loads;

d) access loads;

e) snow loads;

f) rain loads;

g) load factors;

h) sheet strength calculations;

i) bolt strength calculations;

j) stability calculations;

k) foundation design.

8 Loads

8.1 General

All tanks and supporting structures shall be designed on a “limit state design” basis.

8.2 Contents

8.2.1 General

Loads due to the liquid shall be calculated considering:

a) the relative density of the specified range of liquids to be stored in the tank;

b) the geometry of the tank;

c) the maximum possible depth of the liquid in the tank.

If the liquid to be stored is sludge, and unless reliable or measured data are provided, the value of the relative density of the sludge, ρ_s, may be estimated by simple proportion using the following equation:

$$\rho_s = 1 + w(\rho_{ds} - 1) \quad (1)$$

where ρ_{ds} is taken as 1,9 in the case of municipal sewage sludge.

8.2.2 Freeboard

The freeboard used for design purposes shall be as agreed between the client and the designer.

Where the tank is designed for seismic conditions, sufficient freeboard shall be provided to contain the sloshing wave determined in accordance with EN 1998-4. This shall take account of any equipment and structural members in the top of the tank.