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Neogrevane (nekurjene) tlačne posode - 102. del: Primer uporabe pokončne posode s konzolnimi podporami

Unfired pressure vessels - Part 102: Example of application of vertical vessel with bracket supports

Unbefeuerte Druckbehälter - Teil 102: Beispiel 2: Stehende Behälter mit Tragpratzen

Récipients sous pression non soumis à la flamme - Partie 102: Exemple d'application d'un récipient vertical avec supports de berceaux

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Unfired pressure vessels - Part 102: Example of application of vertical vessel with bracket supports

Unbefeuerte Druckbehälter - Beispiel 2: Stehende Behälter mit Tragpratzen

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (CEN/TR 13445-102:2015) has been prepared by Technical Committee CEN/TC 54 “Unfired pressure vessels”, the secretariat of which is held by BSI.

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Introduction

Harmonized standards under Pressure Equipment Directive (97/23/EC) have been adopted over the past few years on the basis of mandate M 071. These standards give appropriate solutions for designing and building safe pressure equipment complying with the pressure equipment directives.

Although the main standards for the major product groups are now available, further action is needed to ensure a take-up by industry of these standards.

A recent public consultation on the use of EN Standards in the field of pressure equipment has shown that better knowledge of content and better usability are the more substantial aspects to encourage the use of the harmonized European standards (document CEN/PE/AN N 220).

The Pressure equipment Migration Help Desk, EN 13445/MHD, was created in August 2002 to give to the standard users a central point where raising questions and obtaining authorized answers. From the questions it received, the help desk has identified the publication of examples of application as a key issue and has developed rules of procedure for their publication as CEN deliverables (document CEN/PE/AN N 128).

Examples of application is an efficient way to help the standard user to correctly understand and apply the requirements of the standard and to be aware of the permissible deviations, possible alternatives, use of normative reference documents, etc. It can also assist training organization and software developers.

The project, in its efforts to broaden the application of the European Standards harmonized for PED, will support the actions of the European Commission in the field of safety of pressure equipment.

It will also promote the use of these European Standards on the global market.

1 Scope

This Technical Report details the design, manufacturing, inspection and testing of a steel vessel submitted to pressure cycles, using the EN 13445 series for "Unfired pressure vessels", to guide the user of these standards in sequential decision making, together with some alternative choices.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13445-1:2009_Issue 5, *Unfired pressure vessels – Part 1: General* [1]

EN 13445-2:2009_Issue 5, *Unfired pressure vessels – Part 2: Materials* [2]

EN 13445-3:2009_Issue 5, *Unfired pressure vessels – Part 3: Design* [3]

EN 13445-4:2009_Issue 5, *Unfired pressure vessels – Part 4: Fabrication* [4]

EN 13445-5:2009_Issue 5, *Unfired pressure vessels – Part 5: Inspection and testing* [5]

EN 10028-2:2003, *Flat products made of steels for pressure purposes – Part 2: Non-alloy and alloy steels with specified elevated temperature properties* [6]

3 The vessel and its operating conditions

3.1 Drawing of the vessel

The technical drawing of the vessel and vessel details is represented in Annex A:

A note in the introduction of EN 13445-1, clearly says that "In EN 13445 the term pressure vessel includes the welded attachments up to and including the nozzle flanges, screwed or welded connections".

The briefed lay-out is given as in Figure 1.

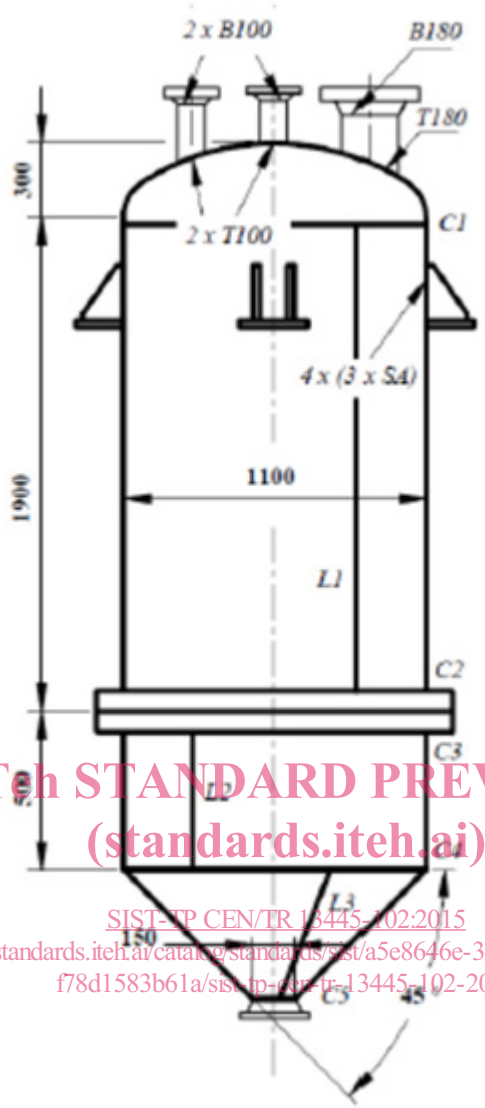

Figure 1 — Briefed lay-out

3.2 Calculation model

The calculation model is presented in 3D in Figure 2.

Figure 2 — Calculation model

3.3 Operating conditions

The general characteristics given by the user are reproduced below:

a) content: gas group 1, density of 0,48;

b) internal pressure: 18 bar / 0,5 bar;

c) temperature: 20 °C/260 °C;

d) number of expected full pressure cycles: 1200.

3.4 Comments on the operating conditions provided by the User

The gas group 1 is a dangerous fluid according to Council Directive 67/548/EEC of 27 June 1967 on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances.

See also:

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31967L0548:en:NOT

and further information on

https://osha.europa.eu/nl/legislation/directives/exposure-to-chemical-agents-and-chemical-safety/osh-related-aspects/58

In the contract 1 200 pressure cycles from 18 bar (1,8 MPa) to 0,5 bar (0,05 MPa) are expected. A design pressure of 1,8 MPa will not be used to avoid a short duration pressure surge at each cycle (See Pressure

Equipment Directive, *Annex I*, clause 2.11.2 *Pressure limiting devices*). Therefore the safety valve will be set at 2 MPa (pressure higher than 1,8 MPa + 10 %) and the design pressure of 2 MPa will be used in design calculations for static loadings.

4 Application of EN 13445-1 [1]

4.1 General

This part contains general information on the scope of the standard as well as terms, definitions, quantities, symbols and units which are applied throughout the standard.

Before designing and manufacturing the vessel according to the standard, the manufacturer shall verify the applicability of the standard EN 13445 and perform a number of prerequisites.

4.2 Is EN13445 applicable to the vessel?

The answer is yes, since the vessel does not belong to the vessels mentioned in Clause 1 of reference [1] which are:

— Vessels of riveted construction;

— Vessels of lamellar cast iron or any material not included in part 2, 6 or 8 of the standard;

— Multilayered, autofrettaged or pre-stressed vessels.

4.3 Warning of Annex A of reference [1]

The standard EN 13445 is harmonized under the Pressure Equipment Directive (97/23/EC). This means that if the vessel meets the requirements of this standard, it can be presumed to conform to those essential safety requirements which are listed in the Annexes ZA of each individual part.

In this connection, it should be understood that the standard is indivisible. The design and manufacturing of the vessel requires application of all relevant parts of the standard, in this case of Part 1 General [1], Part 2 Materials [2], Part 3 Design [3], Part 4 Fabrication [4] and Part 5 Inspection and testing [5], since the vessel is a steel vessel.

Part 7 and Part 9 are not mandatory parts in this sense.

4.4 Prerequisites of Annex A of reference [1]

4.4.1 Operating conditions

Operating conditions provided by the User will be used in the design calculations, but a design pressure of 2 MPa will be used in calculations for static loadings, as it is mentioned in 4.3.

4.4.2 Actions to be considered according to the list in 5.3.1 of EN 13445-3 reference [3]

a) internal pressure;

b) maximum static head of contained fluid;

c) weight of the vessel;

d) maximum weight of contents under operating conditions;

e) weight of water under hydraulic pressure test conditions;

f) wind, snow, and ice loading (not present);

g) earthquake loading (negligible);

h) other loads supported by or reacting on the vessel, including loads during transport and installation (negligible);

i) stresses caused by supporting lugs, ring, girders, saddles, internal structures or connecting piping or intentional offsets of median lines on adjacent components. (Only stresses caused by bracket supports will be considered);

j) shock loads caused by water hammer or surging of the vessel contents (not present);

k) bending moments caused by eccentricity of the centre of the working pressure relative to the neutral axis of the vessel (not present);

l) stresses caused by temperature differences including transient conditions and by differences in coefficients of thermal expansion (Not requested by the User);

m) stresses caused by fluctuations of pressure, temperature and external loads (Stresses caused by fluctuations of pressure and temperature will be considered);

n) stresses caused by the decomposition of unstable fluids (not present).

4.4.3 Classification of load cases

4.4.3.1 Normal load cases

Normal load cases are those acting on the pressure vessel during normal operation, including start-up and shutdown. They result of combination of actions mentioned in 5.3.2.

4.4.3.2 Exceptional load cases

Exceptional load cases are those corresponding to events of very low probability requiring the safe shutdown and inspection of the vessel or plant. No such exceptional load case is expected.

4.4.3.3 Testing load cases

Testing load cases include testing load cases for final assessment and testing load cases in service. Only the hydraulic test for final assessment will be considered.

4.4.4 The Category of the vessel as defined in the Pressure Equipment Directive (PED)

Taking into consideration:

— The maximum allowable pressure PS: 20 bar

— The fluid group: 1

— The volume of the vessel: 2.656 L

— The potential energy content product PS.V = 53.120 bar.L

The vessel category is IV (See Figure 3, Excerpt from Table 1 of *Annex II* of the PED where the case is represented by a red dark dot or see Figure A-1 of CR 13445-7).

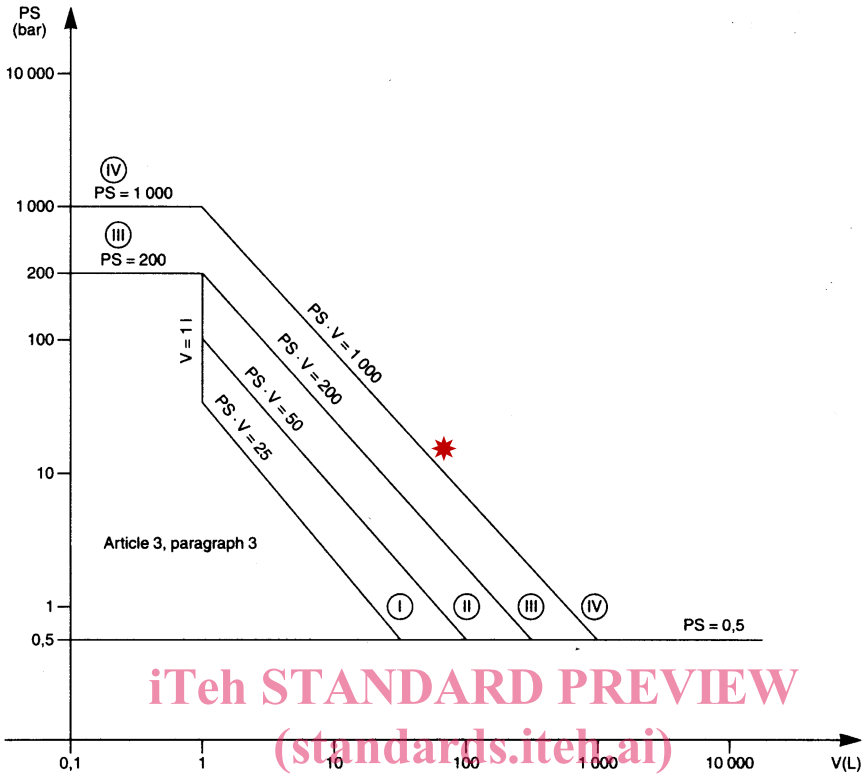

Figure 3 — Vessel category

4.4.5 The Conformity Assessment Module to be used

Applicable modules of Category IV are B+D, B+F, G, H1. Module G is used throughout this example (this is according to the drawing Example 2).

5 Application of EN 13445-2 [2]

5.1 Permitted materials

5.1.1 General

Clause **A.4 Materials** of reference [1] recalls the principles.

Specific requirements apply to materials for pressure-bearing parts. They are given in 4.1, 4.2, 4.3 and 4.4 of reference [2].

5.1.2 Requirements given in 4.1 of reference [2]

— Materials shall be selected to be compatible with anticipated fabrication steps and to be suitable for internal fluid and external environment

— Materials shall be accompanied by inspection documents in accordance with EN 10204:2004

NOTE 1 This is not properly speaking a design requirement, but a means to inspect material properties.

— Materials shall be free from surface and internal defects which can impair their intended usability

— Steels shall have a specified minimum elongation after fracture: 14 %

— Steels shall have a specified minimum impact energy measured on a Charpy V-notch impact test specimen greater or equal to 27 J for ferritic steels, etc.

— The chemical composition of ferritic steels intended for welding and forming shall not exceed 0,25 % C, 0,035 % P, 0,025 % S.

Only materials which are qualified for pressure equipment may be used. Qualification of materials can be made in three different ways:

— Materials from European harmonized Standards, see 4.3.1 of reference [2]. Certain materials supplied in accordance with European material Standards are accepted as qualified for use in pressure-bearing parts. These materials are enumerated in Table E.2-1 of reference [2].

— Materials with a European Approval for materials (EAM), see 4.3.2 of reference [2]. Materials with an EAM, which states that they can be used for products under the PED, are qualified for use in relevant products according to this standard. EAMs are published in the Official Journal, and the European Commission maintains a list of EAMs on their web site.

NOTE 2 This web site is presently accessible under the address

http://ec.europa.eu/enterprise/pressure_equipment/ped/materials/published_en.html.

— Materials with a Particular Material Appraisal (PMA), see 4.3.3 of reference [2]. Materials, which have been subject to a PMA are qualified. This appraisal is carried out by the manufacturer (and in certain cases checked by a Notified Body).

NOTE 3 The European Commission and Member States have in November 2006 agreed on "Guiding Principles for the contents of Particular Materials Appraisals". The document is published on:

http://ec.europa.eu/enterprise/pressure_equipment/ped/materials/index_en.html.

5.2 Requirements given in 4.2 of reference [2]

Materials for example 2 are high temperatures steels for which the requirements of **4.2.2 Design temperature above 20 °C** apply.

In **4.2.5** specific requirements are given for steels for **fasteners** (bolts, nuts, etc.).

5.3 Requirements given in 4.3 of reference [2]

4.3 addresses **Technical delivery conditions** for steels and welding consumables. For example 2, the **European standards** for plates, tubes, and forgings will be used. European standards will also be used for welding consumables.

Table E.2-1 of reference [2] provides an overview on materials for pressure purposes. This Table will be used for example 2.

5.4 Requirements given in 4.4 of reference [2]

4.4 addresses **Marking**. This marking ensures traceability between the product and the inspection documents.

NOTE Marking has no incidence on design calculations.

5.5 Materials selected for the vessel example 2

Characteristics of the steels, fasteners and gaskets selected for the vessel are given in Table 1 and reproduced in Annex C to this report.

P355 GH of the European harmonized standard EN 10028-2 [6] was selected for the shell (upper, lower), dished end and cone elements of the vessel (also support brackets). This steel was preferred to P295GH to have a smaller weight (approximately 15 % or 120 kg for all plate made materials) with a slightly higher price (approximate price difference in Western Europe is 100 € per metric ton).

P280 GH of the European harmonized standard EN 10222-2 was selected for the main flange upper and lower side.

Table 1 — Materials and main material characteristics in example 2

Vessel part	Material	Material designation	EN 13445-2 reference	Dimensions (mm) (see also Annex C)	Material group to CR ISO 15608	Main material characteristics				
						Tensile min/max MPa	Min yield MPa	Min elong A5 at room temp	Min impact energy KV, J at - 20 °C	Min impact energy KV, J at +20 °C
Cylindrical shell upper, lower	Ferritic steel plate for high temperature service	EN 10028-2 P355 GH (1.0473)	See Table E.2-1 of EN 13445-2	e < 16 mm e_n = 12 for lower part, e_n = 10 for upper part	1.2	510-650	355	20	27	40
Conical shell	Ferritic steel plate for high temperature service	EN 10028-2 P355 GH (1.0473)	See Table E.2-1 of EN 13445-2	e < 16 mm e_n = 12	1.2	510-650	355	20	27	40
Dished end	Ferritic steel plate for high temperature service	EN 10028-2 P355 GH (1.0473)	See Table E.2-1 of EN 13445-2	e < 16 mm e_n = 14	1.2	510-650	355	20	27	40
Main flange upper and lower side	Forging	EN 10222-2 P280 GH (1.0426)	See Table E.2-1 of EN 13445-2	50,00 < t < 160 mm e_n = 95 for lower part, e_n = 103 for upper part	1.2	490-610	280-305	22		27
Bolts(fasteners) main flange:	25CrMo4(+QT)	EN 10269 (dia.< 100 mm)	See Table E.2-1 of EN 13445-2	Number=68 M22x2,5 M22x2,5	— a)	800-950	Upper 0,2%600	15		27-32
Gasket	Spirally wound mineral filled stainless steel -Monel			Gasket parameters m=3, y=69 MPa	— a)					