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Zaprte ekspanzijske posode z vgrajeno membrano za vgradnjo v vodne inštalacije

Closed expansion vessels with built in diaphragm for installation in water

Ausdehnungsgefäße mit eingebauter Membrane für den Einbau in Wassersystemen

Vases d'expansion fermés avec membrane incorporée pour installation dans des systemes a eau

Ta slovenski standard je istoveten z: EN 13831:2007

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91.140.10	Sistemi centralnega ogrevanja	Central heating systems

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Contents

Page

Foreword

This document (EN 13831:2007) has been prepared by Technical Committee CEN/TC 54 “Unfired pressure vessels”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2008, and conflicting national standards shall be withdrawn at the latest by February 2008.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

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Introduction

Closed expansion vessels with built in diaphragm made their commercial début in the early 1950s. They were employed in heating systems, or for fresh water supply systems.

When used in heating systems they take up the increase of the water volume due to the heating up. The gas pressure (on the other side of the diaphragm) pushes the water back into the system when due to cooling down the water volume in the heating system is decreasing. Expansions vessels with built in diaphragm are an undisputed standard in European heating engineering. When used in fresh water circuits, vessels with built in diaphragm serve to accommodate the extra volume caused by water heaters warming up,, thus saving valuable drinking water from flowing down the drain. The other main application is to store water under pressure in connection with booster systems allowing an energy efficient pump operation.

Though the development of the closed expansion vessel with built in diaphragm constituted a real revolution in the domains of heating and drinking water, industry in general took only limited note of it. Nevertheless this has not prevented the manufacturers from refining the product and the manufacturing technique over the last 40 years, often charting entirely new paths. As a consequence, the production of closed expansion vessels can differ considerably from conventional pressure vessel production. This is especially true in respect to the highly developed deep drawing technology.

1 Scope

This European Standard specifies requirements for the design, manufacture and testing of closed expansion vessels with built in diaphragm, which will hereinafter be called "vessels", and

a) whose diaphragm serves to separate water on the one hand and air / nitrogen on the other hand in heating/cooling systems or fresh water systems;

b) which are manufactured singly or in series;

c) which may consist partly or entirely of (cold) deep-drawn parts;

d) whose parts may be joined by welding, clenching or flanges;

e) whose size is not limited;

f) whose maximum allowable pressure is greater than 0,5 bar, yet not exceeding 30 bar;

g) whose upper wall thickness is limited to 12 mm for austenitic steels and 15 mm for ferritic steels;

h) whose minimum operating temperature is not below –10 °C and whose maximum operating temperature is not above 70 °C.

NOTE The maximum operating temperature of 70 °C is determined by the characteristics of the diaphragm materials. It may be higher, if suitability of diaphragm material is proven.

Whatever the temperature in the heating system, for the vessel operation the decisive factor is the maximum operating temperature of the diaphragm. It is the system designer's responsibility to prescribe measures to protect the diaphragm from unsuitable temperatures (e.g. connection to the coldest part of the system in a heating system, to the warmest in a refrigeration circuit; thermostatic monitoring of connection to vessel or intermediate vessel).

For cases where operating temperatures above 70 °C cannot be avoided the suitability of the diaphragm material is to be proven (see Clause 8).

When reference is made in this European Standard to EN 13445-1, EN 13445-2, EN 13445-3, EN 13445-4 and EN 13445-5 respectively, all relevant provisions in the concerned clauses of these standards need to apply.

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.

EN 287-1:2004, *Qualification test of welders — Fusion welding — Part 1: Steels*

EN 473:2000, *Non destructive testing — Qualification and certification of NDT personnel — General principles*

EN 764-1:2004, *Pressure equipment — Part 1: Terminology — Pressure, temperature, volume, nominal size*

EN 764-2:2002, *Pressure equipment: terminology — Part 2: Quantities, symbols and units*

EN 764-3:2002, *Pressure equipment — Part 3: Definition of parties involved*

EN 895:1995, *Destructive tests on welds in metallic materials — Transverse tensile test*

EN 910:1996, *Destructive test on welds in metallic materials — Bend tests*

EN 1418:1997, *Welding personnel — Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials*

EN 1435:1997, *Non-destructive examination of welds — Radiographic examination of welded joints*

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

EN 10269:1999, *Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties*

EN 13445-1:2002, *Unfired pressure vessels — Part 1: General*

EN 13445-2:2002, *Unfired pressure vessels — Part 2: Materials*

EN 13445-3:2002, *Unfired pressure vessels — Part 3: Design*

EN 13445-4:2002, *Unfired pressure vessels — Part 4: Fabrication*

EN 13445-5:2002, *Unfired pressure vessels — Part 5: Inspection and testing*

EN ISO 898-1:1999, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs (ISO 898-1:1999)*

EN ISO 15609-1:2004, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding (ISO 15609-1:2004)*

EN ISO 15613:2004, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test (ISO 15613:2004)*

EN ISO 15614-1:2004, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2004)*

ISO 898-2:1998, *Mechanical properties of fasteners — Part 2: Nuts with specified proof load values — Coarse thread*

3 Terms and conditions

For the purposes of this document, the terms and definitions given in EN 764-1:2004, EN 764-2:2002, EN 764-3:2002 and the following apply.

3.1
automatic welding
welding in which all the parameters are automatically controlled, some of these parameters may be adjusted to a limited amount (manually or automatically by mechanical or electronic devices) during welding to maintain the specified welding conditions

3.2
clench joints
separate metal ring holding together two vessel parts or a rolled joint holding together two vessel parts in a permanent way. Its design is always done according to the experimental design method

3.3
expansion vessel
vessel to take up the volume variations of a liquid due to changes of temperature. The expansion vessel is called "closed", if the liquid contained is not in contact with any gaseous or liquid medium

3.4
deep drawing
forming of vessel parts from a flat state into a three dimensional state by means of a press and tools whereby no material is taken off or added

3.5
diaphragm
flexible and / or elastic wall which is fastened into the vessel inside in a gas tight way and separates the vessel into a water and a gas space

3.6
experimental test
any kind of test used to substitute for the calculation of a vessel part or the whole vessel, within the framework of the experimental design method

3.7
inspection document
document according to EN 10204:2004

3.8
family of welded joints
welded joints covered by a specific welding procedure approval document

3.9
vessel family
vessels belong to one vessel family if they have similar geometrical proportions, same design and fall within the validity of one weld procedure approval

3.10
freshwater
water coming from a supply system (mains, well etc.), untreated apart from possible hygienic measures, with natural content of oxygen

4 Symbols and units

For the purposes of this document, the symbols and units given in EN 13445-1:2002, EN 13445-2:2002, EN 13445-3:2002, EN 13445-4:2002 and EN 13445-5:2002, EN 764-1:2004 and EN 764-2:2002 and the following apply.

Other symbols used in specific clauses of this European Standard are tabulated there.

Symbol	Description	Unit
A	Area	mm^2
A	elongation after fracture	%
d, D	Diameter	mm
e	Thickness	mm
f	nominal design stress for design conditions	MPa or N/mm^2
f_{test}	nominal design stress for testing conditions	MPa or N/mm^2
l	Length	mm
p	design pressure	bar, MPa or N/mm^2 1)
PS	maximum allowable pressure	bar, MPa or N/mm^2 1)
PT	test pressure	bar, MPa or N/mm^2 1)
r, R	Radius	mm
R_e	yield strength	MPa or N/mm^2
R_{eH}	upper yield strength	MPa or N/mm^2
R_m	tensile strength	MPa or N/mm^2
$R_{m/t}$	tensile strength at temperature t °C	MPa or N/mm^2
$R_{p0,2/t}$	0,2 % proof strength at temperature t °C	MPa or N/mm^2
$R_{p1,0/t}$	1,0 % proof strength at temperature t °C	MPa or N/mm^2
TS	temperature	°C
t_c	calculation temperature	°C
t_t	test temperature	°C
V	volume, capacity	m^3, L, (l)
z	weld joint coefficient	[ ]

The unit bar is needed to meet the general terminology, and thus to be used on nameplates, certificates, drawings, pressure gauges and instrumentation.

1) MPA or N/mm^2 for calculation purpose only.

5 Materials

5.1 General

The grouping according to Table 5.1-1 is based on materials corresponding to steel groups 1; 1.1; 8.1 as defined in EN 13445-2:2002.

Table 1 — Definitions of steel groups (CEN ISO/TR 15608:2005)

Group/ Subgroup	Type of steel
1	Steels with a minimum yield strength $R_{eH} \leq 460$ N/mm^2 [a] and with analysis in % (ladle analysis): C ≤ 0,25; Cu ≤ 0,40 [b] Si ≤ 0,60; Ni ≤ 0,5 [b] Mn ≤ 1,70; Cr ≤ 0,3 (0,4 for castings) [b] Mo ≤ 0,70; Nb ≤ 0,05 S ≤ 0,045; V ≤ 0,12 [b] P ≤ 0,045; Ti ≤ 0,05
1.1	Steels with a minimum yield strength $R_{eH} \leq 275$ N/mm^2 and composition as indicated under 1
8.1	Austenitic stainless steels with Cr ≤ 19 % (content used in steel designation)

[a] In accordance with the specification of the steel product standards, R_{eH} may be replaced by $R_{p0,2}$ or $R_{t\,0,5}$.

[b] A higher value is accepted provided that Cr + Mo + Ni + Cu + V ≤ 0,75 %.

For a complete overview of steel grades falling into the above mentioned groups reference is made to EN 13445-2:2002.

5.2 Materials proven by experience and current use

The following materials do not fulfil all the requirements of groups 1, 1.1 and 8.1, but may be used for this type of product under the condition that there is sufficient ductility of the material after forming as it will be used is proven:

— EN 10025-2[2)] grades S 235 J2, S 235 JR;

— EN 10130[3)] grades Dc01, Dc03, Dc04;

— EN 10111[3)] grades DD11, DD12, DD13, DD14.

2) See 6.3.2.5.

3) Restricted use, see 6.2.

5.3 Fasteners

Fasteners (bolts, nuts, studs) shall not be made from free cutting steel. Used steels shall have an elongation after fracture, A, of at least 14 %.

Bolts and screws in accordance with EN ISO 898-1:1999 property classes 5.6 or 8.8 and nuts to ISO 898-2:1998 property classes 5 or 8 but with an elongation of at least 12 %, shall be considered suitable.

EN 10269:1999 shall be taken into account.

5.4 Non-pressurised parts

For non-pressure parts welded to pressure vessels, materials shall be used which are supplied to material specifications covering at least the requirements for the chemical composition and the tensile properties. These materials shall not limit the operating conditions of the material to which they are attached.

6 Design and calculation

6.1 Design

6.1.1 Requirements pertaining to the diaphragm

Sharp edges and corners (grooves, welding beads etc.) are not permitted in those areas of the inside surface which will come into contact with the diaphragm.

Parts projecting into the vessel in such a way, that damage of the diaphragm can occur are not permitted.

Local concavities on the inner surface are only permitted if the maximum possible linear stretching of the diaphragm being pressed into the concavity is not above 10 % of the elongation at rupture of the diaphragm material.

Openings in the vessel wall shall be designed in such a way that the diaphragm cannot be damaged through impingement.

The gaps of joggled welds shall nowhere be bigger than twice the diaphragm wall-thickness.

The dimensions of the vessel and the diaphragm shall match so as to ensure that irrespective of charge pressure the diaphragm cannot be stretched to the point where it is damaged.

6.1.2 Requirements pertaining to fresh water application

Metal parts in contact with the water during normal operation of the vessel shall be of stainless steel, corrosion resistant or adequately protected against corrosion.

6.1.3 Outside finish

The vessel and its outside parts shall be so finished as to avoid injury (e.g. from burs and sharp edges). Vessels made of carbon steel shall be protected against ambient corrosion.

6.1.4 Inspection openings

6.1.4.1 Vessels with fixed diaphragms do not require openings.

6.1.4.2 Vessels with a removable diaphragm shall have an opening of sufficient size to exchange the diaphragm. This opening serves also for inspection purposes.

6.1.4.3 Vessels with removable diaphragm, with additional compartments, shall have an inspection opening of ≥ 30 mm inside diameter in the additional compartment such that the vessel can be inspected.

6.1.5 Connections

6.1.5.1 Minimum size of water connections shall be according to Table 2.

Table 2 — Minimum size of water connections

Vessel volume [*L*]	Connection
V ≤ 12	DN 12 (0,375 ")
12 < V ≤ 25	DN 15 (0,5 ")
25 < V ≤ 600	DN 20 (0,75 ")
600 < V ≤ 1 000	DN 25 (1 ")
1 000 < V ≤ 2 000	DN 32 (1,25 ")
2 000 < V	DN 40 (1,5 ")

NOTE For vessels used in freshwater applications larger connections could be required, depending on the flow rate.

6.1.5.2 If the water connection is covered by any kind of sieve, its total free section shall be a least equal to the free section of the connection pipe as specified in 6.1.5.1.

6.1.6 Clenched joints

In the case of clenched joints the experimental design method shall be used to determine minimum wall thickness. There is therefore no calculation method for them in the European Standard.

Within the framework of a type approval, in deviation from 6.2.2, at least 6 vessels have to be tested according to 6.2.3 or 6.2.4.

In the case of different vessel sizes within a family, a minimum of 2 vessels per vessel size have to be tested according to 6.2.3 or 6.2.4 if PS × V ≤ 1 000 bar × L.

In the case of different vessel sizes within a family, a minimum of 1 vessel per vessel size has to be tested according to 6.2.3 or 6.2.4 if 1 000 bar × L < PS × V < 6 000 bar × L.

Circumferential measurements have to be carried out in the cylindrical part of the vessel above and below the clenched joint. The maximum allowable permanent deformation shall not be higher than 1 % (see 6.2.3 and 6.2.4).

NOTE Owing to the wide variety of versions and designs of this type of joint it is impossible to indicate further dimensions or physical properties.

6.1.7 Volume tolerance of vessels

The actual volume of the vessel measured without the diaphragm, shall be a minimum of 95 % of the (nominal) volume declared by the manufacturer.

6.1.8 Fatigue

Expansion vessels as covered by this European Standard are operated in such a way that no relevant fatigue load occurs.

6.1.9 Loadings

Expansion vessels are normally installed inside buildings and external loadings are not significant. For vessels where weight or static head of the fluid have to be taken into account, reference should be made to EN 13445-3:2002. The same applies where the specification for the vessel stipulates conditions which lead to special loadings (e.g. earthquake loadings).

6.2 Experimental design method

6.2.1 General

The design for adequate strength may be determined by the use of the experimental design method for vessels with a $PS \times V$ < 6 000 bar L.

EN 10130, grades Dc01, Dc03 and Dc04 and EN 10111, grades DD11, DD12, DD13 and DD14 may only be used in accordance with 5.2 when the design is verified according to the experimental design method in this subclause. Since these are intended for deep drawing the mechanical values in their respective standards do not lend themselves to the calculation method of 6.3.

The minimum wall thickness shall not be less than 0,8 mm at any point.

6.2.2 Preparations

The experimental test is performed on that vessel size within a family which will give the least favourable results under pressure (normally the one with the biggest diameter).

Vessels to be submitted to the test have to be identical to normal production with the exception that they shall not contain a complete diaphragm.

If for production reasons the complete diaphragm has to be built into the vessel, holes shall be made into the diaphragm to ensure that there is water on both sides of the diaphragm, so that leaks will then be visible irrespective of their position relative to the diaphragm.

If the vessel selected fails, two more vessels of the same size shall be submitted to the same test. The design is only acceptable if both vessels then pass the test. The water used for testing shall be at room temperature. The permanent deformation (elongation of shell) shall be measured along the shortest circumference of the vessel.

A report of the test shall be drawn up giving all necessary information so as to validate the test results including material certificates for the main parts of the vessel.

6.2.3 Vessels with $PS \times V \leq$ 1 000 bar $\times L$

The vessels to be tested shall be completely filled with water, then pressurised up to $2 \times PS$ (– 0 % + 5 %) and held at this pressure for 5 min. No leaks shall occur during this time. The permanent deformation shall not be higher than 1 %.

6.2.4 Vessels with 1 000 bar $\times L$ < $PS \times V$ < 6 000 bar $\times L$

The vessels to be tested shall be completely filled with water, then pressurised up to $3 \times PS$ (– 0 % + 5 %) and held at this pressure for 5 min. No leaks shall occur during this time. The permanent deformation shall not be higher than 1 %.

6.2.5 Vessel parts and components

When the experimental design method is used for vessel parts and components that are pressurized, they shall be subjected to an experimental test of $3 \times PS$ (– 0 % + 5 %) and held at this pressure for 5 min. No leaks shall occur during this time.