SLOVENSKI STANDARD

SIST EN 14197-2:2004

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Kriogene posode – Stabilne, vakuumsko neizolirane posode - 2. del: Konstruiranje, izdelava, kontrola in preskus

Cryogenic vessels - Static non-vacuum insulated vessels - Part 2: Design, fabrication, inspection and testing

Kryo-Behälter - Ortsfeste, nicht vakuum-isolierte Behälter - Teil 2: Bemessung, Herstellung und Prüfung

Récipients cryogéniques - Récipients statiques, non isolés sous vide - Partie 2: Conception, fabrication, inspection et essais

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Cryogenic vessels - Static non-vacuum insulated vessels - Part 2: Design, fabrication, inspection and testing

Récipients cryogéniques - Récipients fixes, non isolés sous vide - Partie 2: Conception, fabrication, inspection et essais

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This European Standard was approved by CEN on 1 September 2003.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
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Contents

Foreword

This document (EN 14197-2:2003) has been prepared by CEN /TC 268, "Cryogenic vessels", the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by May 2004, and conflicting national standards shall be withdrawn at the latest by May 2004.

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.

EN 14197 consists of the following parts under the general title, "*Cryogenic vessels – Static non-vacuum insulated vessels*" :

— *Part 1: Fundamental requirements*;

— *Part 2: Design, fabrication, inspection and testing;*

— *Part 3: Operational requirements.*

Annexes A, B, F, G and I are normative. Annexes C, D, E, H and J are informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies requirements for the design, fabrication, inspection and testing of static non-vacuum insulated cryogenic vessels designed for a maximum allowable pressure of more than 0,5 bar.

This European standard applies to static non-vacuum insulated cryogenic vessels for fluids as specified in EN 14197-1 and does not apply to vessels designed for toxic fluids.

For static non-vacuum insulated cryogenic vessels designed for a maximum allowable pressure of not more than 0,5 bar this European Standard may be used as a guide.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 287-1, *Approval testing of welders - Fusion welding – Part 1: Steels*.

EN 287-2, *Approval testing of welders - Fusion welding – Part 2: Aluminium and aluminium alloys*.

EN 288-3:1992, *Specification and approval of welding procedures for metallic materials – Part 3: Welding procedure tests for the arc welding of steels*.

EN 288-4:1992, *Specification and approval of welding procedures for metallic materials – Part 4: Welding procedure tests for the arc welding of aluminium and its alloys*.

EN 288-8, *Specification and approval of welding procedures for metallic materials – Part 8: Approval by a pre-production welding test*.

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

EN 875:1995, *Destructive tests on welds in metallic materials – Impact tests – Test specimen location, notch orientation and examination*.

EN 895, *Destructive tests on welds in metallic materials – Transverse tensile test*.

EN 910, *Destructive tests on welds in metallic materials – Bend tests.*

EN 1252-1:1998, *Cryogenic vessels - Materials – Part 1: Toughness requirements for temperatures below - 80 °C*.

EN 1252-2, *Cryogenic vessels - Materials – Part 2: Toughness requirements for temperatures between –80 °C and –20 °C*.

EN 1418, *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, *Non-destructive examination of welds – Radiographic examination of welded joints.*

EN 1626:1999, *Cryogenic vessels - Valves for cryogenic service*.

EN 1708-1:1999, *Welding - Basic weld joint details in steel - Part 1: Pressurized components*

EN 1797, *Cryogenic vessels – Gas/material compatibility.*

EN 10028-4, *Flat products made of steels for pressure purposes – Part 4: Nickel alloy steels with specified low temperature properties.*

EN 10028-7:2000, *Flat products made of steels for pressure purposes – Part 7: Stainless steels.*

EN 13068-3, *Non-destructive testing – Radioscopic testing – Part 3: General principles of radioscopic testing of metallic materials by X- and gamma rays*.

EN 13445-3, *Unfired pressure vessels – Part 3: Design.*

EN 13445-4, *Unfired pressure vessels – Part 4: Fabrication.*

EN 13648-1, *Cryogenic vessels - Safety devices for protection against excessive pressure - Part 1 : Safety valves for cryogenic service.*

EN 13648-3, *Cryogenic vessels – Safety devices for protection against excessive pressure – Part 3: Determination of required discharge - Capacity and sizing .*

EN 14197-1, *Cryogenic vessels – Static non-vacuum insulated vessels – Part 1: Fundamental requirements*.

prEN 14197-3, *Cryogenic vessels – Static non-vacuum insulated vessels – Part 3: Operational requirements*.

EN ISO 6520-1:1998, *Welding and allied processes - Classification of geometric imperfections in metallic materials – Part 1 : Fusion welding.*

ISO 1106-1:1984, *Recommended practice for radiographic examination of fusion welded joints – Part 1: Fusion welded butt joints in steel plates up to 50 mm thick.*

3 Terms and definitions and symbols

3.1 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 14197-1 and the following apply.

3.1.1
static vessel
stationary unit capable of receiving, storing (under pressure) and dispensing cryogenic fluids. The vessel is not intended to be used for transporting liquid product

3.1.2
vessel
pressure vessel proper intended to contain the cryogenic fluid

3.1.3
outer jacket
gas-tight enclosure which contains the vessel

3.1.4
automatic welding
welding in which the parameters are automatically controlled. Some of these parameters can be adjusted to a limited extent, either manually or automatically, during welding to maintain the specified welding conditions

3.1.5
maximum allowable pressure, p_s
maximum pressure for which the equipment is designed, as specified by the manufacturer, defined at a location specified by the manufacturer, being the location of connection of protective or limiting devices or the top of the equipment.

NOTE p_s is equivalent to *PS* used in article 1, 2.3 of the PED.

3.2 Symbols

NOTE Throughout this European Standard p_s is equivalent to PS used in article 1, 2.3 of the PED and p_T is equivalent to PT used in annex I of the PED.

For the purposes of this standard, the following symbols apply:

c	allowances	mm
d_i	diameter of opening	mm
d_a	outside diameter of tube or nozzle	mm
f	narrow side of rectangular or elliptical plate	mm
l_b	buckling length	mm
n	number	-
p	design pressure as defined by 4.2.3.2 f)	bar
p_e	allowable external pressure limited by elastic buckling	bar
p_k	strengthening pressure	bar
p_p	allowable external pressure limited by plastic deformation	bar
p_T	pressure test (see 4.2.3.2))	bar
r	radius e.g. inside knuckle radius of dished end and cones	mm
s	minimum wall thickness	mm
s_e	actual wall thickness	mm
v	factor indicative of the utilization of the permissible design stress in joints or factor allowing for weakenings	-
x	(decay-length zone) distance over which governing stress is assumed to act	mm
A	area	mm^2
A_5	elongation at fracture	
C	design factors	-
D	shell diameter	mm
D_a	outside diameter e.g. of a cylindrical shell	mm
D_i	internal diameter e.g. of a cylindrical shell	mm
E	Young's modulus	N/mm^2
l	moment of inertia of stiffening ring	mm^4
K	material property (see 4.3.2.3.1)	N/mm^2
K_{20}	see 4.3.2.3.2	
K_t	see 4.3.2.3.3	
K_{design}	a value defined by the manufacturer for a particular design case	
R	radius of curvature e.g. inside crown radius of dished end	mm
S	safety factor at design pressure	-
S_k	safety factor against elastic buckling at design pressure	-
S_p	safety factor against plastic deformation at design pressure	-
S_T	safety factor against plastic deformation at proof test pressure	-
Z	auxiliary value	-
υ	Poisson's ratio	-
u	out of roundness	
σ_k	design stress value	N/mm^2

4 Design

4.1 Design options

4.1.1 General

The design shall be carried out in accordance with one of the options given in 4.1.2, 4.1.3 or 4.1.4.

In the case of 9 % Ni steel, the additional requirements of annex B shall be satisfied.

For carbon and low alloy steels the requirements of EN 1252-2 shall be satisfied.

When further use of cold properties is considered the requirements of annex H shall be satisfied.

4.1.2 Design by calculation

Calculation of all pressure and load bearing components shall be carried out. The pressure part thicknesses of the vessel shall not be less than required by 4.3. Additional calculations may be required to ensure the design is satisfactory for the operating conditions including an allowance for external loads (e.g. seismic).

4.1.3 Design by calculation when adopting pressure strengthening

The pressure retaining capability of vessels manufactured from austenitic stainless steel, strengthened by pressure, is calculated in accordance with the informative annex C.

4.1.4 Design by calculation supplemented with experimental methods

Where it is not possible to design by calculation alone planned and controlled experimental means may be used providing that the results confirm the standards of design required by this European Standard. An example would be the application of strain gauges to assess stress levels.

4.2 Common design requirements

4.2.1 General

The requirements of 4.2.2 to 4.2.7 are applicable to all vessels irrespective of the design option used.

4.2.2 Design specification and documentation

To enable the design to be prepared, the following information shall be available:

— maximum allowable pressure;

— fluids intended to be used;

— liquid capacity;

— volume of the vessel;

— configuration;

— method of handling and securing during transit and site erection;

— site conditions e.g. ambient temperatures, seismic etc;

— fill and withdrawal rates ;

— operation temperature range.

A design document in the form of drawings with text if any shall be prepared, it shall contain the information given above plus the following where applicable:

— definition of which components are designed by calculation, by pressure strengthening, by experiment and by satisfactory in-service experience;

— drawings with dimensions and thicknesses of load bearing components;

— specification of all load bearing materials including grade, class, temper, testing etc. as relevant;

— type of material test certificates;

— location and details of welds and other joints, welding and other joining procedures, filler, joining materials etc. as relevant;

— calculations to verify compliance with this standard;

— design test programme;

— non destructive testing requirements;

— pressure test requirements;

— piping configuration including type, size and location of all valves and relief devices;

— details of lifting points and lifting procedure;

— wind, seismic loads.

4.2.3 Design loads

4.2.3.1 General

Static vessels are not considered to be in cyclic service, therefore fatigue analysis needs normally not to be performed.

The static cryogenic vessel shall be able to safely withstand the mechanical and thermal loads encountered during normal operation and pressure test, as specified in 4.2.3.2 to 4.2.3.7.

4.2.3.2 Vessel

The following loads shall be considered to act in the combinations specified in 4.2.3.2 f):

a) pressure during operation when the vessel contains cryogenic liquid product:

$$pc_L = p_s + p_L$$

where

p_s maximum allowable pressure (bar);

p_L pressure (bar) exerted by the weight of the liquid contents when the vessel is filled to capacity with either:

1) boiling liquid at atmospheric pressure; or

2) cryogenic fluid at its equilibrium triple point or melting point temperature at atmospheric pressure.

p_L may be neglected if less than 5 % of p_s. Otherwise the pressure in excess of 5 % of p_s shall be used.

b) reactions at the support points of the vessel during operation when the vessel contains cryogenic liquid product. The reactions shall be determined by the weight of the vessel, the weight of the maximum contents of the cryogenic liquid and vapour and seismic loadings where appropriate;

c) load imposed on the vessel at its support points when cooling from ambient to operating temperature;

d) pressure test : the value used for design purposes shall be the higher of:

$p_t = 1{,}43\ p_s$ bar or

$p_T = 1{,}25\ (p_s + p_L)$

considered for each element of the vessel e.g. shell, head, etc;

e) loads imposed during transit and site erection;

f) the vessel shall be capable of withstanding the following combinations of loadings. The design pressure p is equal to pressure specified therein, in each combination 1, 2 and 3:

1) operation at maximum allowable working pressure when vessel is filled with cryogenic liquid: a) + b) + c);

2) pressure test: d);

3) shipping and lifting: e).

The vessel shall, in addition, be capable of holding the pressure test fluid without gross plastic deformation.

4.2.3.3 Vessel supports

The vessel supports shall be suitable for the load defined in 4.2.3.2 b) plus loads due to differential thermal movements.

4.2.3.4 Lifting points

Lifting points shall be suitable for lifting the static cryogenic vessel when empty and lifted in accordance with the specified procedure.

4.2.3.5 Piping and accessories

Piping including valves, fittings and supports shall be designed for the following loads. With the exception of a) the loads shall be considered to act in combination where relevant:

a) pressure test: in accordance with 6.5.4;

b) pressure during operation: not less than the set pressure of the system pressure relief devices, e.g. set pressure of the thermal relief device;

c) loads generated during pressure relief discharge;

d) a design pressure not less than the maximum allowable pressure p_s of the vessel plus any appropriate liquid head.

4.2.4 Corrosion allowance

Corrosion allowance is not required on surfaces in contact with the operating fluid. Corrosion allowance is not required on other surfaces if they are adequately protected against corrosion.

4.2.5 Inspection openings

Inspection openings are not required in the vessel, providing the requirements of prEN 14197-3 are followed.

NOTE Due to the combination of materials of construction and operating fluids, internal corrosion cannot occur.

4.2.6 Pressure relief

4.2.6.1 General

Relief devices shall be in accordance with EN 13648-1.

Relief systems shall be designed to meet the requirements specified in 4.2.6.2 and 4.2.6.3.

4.2.6.2 Vessel

The vessel shall be provided with a pressure limiting system to protect the vessel against excessive pressure. Examples of current practice are shown in annex D. The system shall:

— be designed so that it is fit for purpose;

— be independent of other functions, unless its safety function is not affected by such other functions;

— limit short duration pressure surges in the vessel to not more than 110 % of maximum allowable pressure ;

— fail safely;

— contain redundant features;

— contain non-common mode failure mechanisms (diversity).

The capacity of the protection system shall be established by considering all of the probable conditions contributing towards internal excess pressure. For example:

a) normal vessel heat leak with failure of any refrigeration fitted;

b) failure in the on position of the make-up pressure system;

c) any other valve in a line connecting a high pressure source to the vessel;

d) recycling of any possible combination of pumps;

e) flash gas, plus liquid, from maximum plant capacity fed into a tank which is at operating temperature.

The excess pressure created by any combination of conditions "a" to "c" shall be limited to not more than the maximum allowable pressure by at least one re-closable device. The required capacity of this re-closable device may be calculated in accordance with EN 13648-3:-.

NOTE Where, in addition, a non re-closable, fail open device is fitted, its operating pressure should be chosen such that its ability to retain pressure is unaffected by the operation of the re-closable device at 110 % of maximum allowable pressure and is, in any case, not more than the top of vessel strength test pressure less 1 bar. The required capacity of any device provided for redundancy shall be equal to the required capacity of the primary device.

An external fire condition only to be considered if determined by location of the cryogenic vessel.

Shut off valves or equivalent may be installed upstream of pressure relief devices, provided that interlocks are fitted to ensure that the vessel has sufficient relief capacity at all times.

The relief valve system piping shall be sized such that the pressure drops during discharge are fully taken into account so that the vessel pressure is not excessive and also that the valve does not reseal instantly, i.e. chatter.

The maximum pressure drop of the pipework of the pressure relief valve should not exceed that specified in EN 13648-3:-.

4.2.6.3 Piping

Any section of pipework containing cryogenic fluid which can be isolated shall be protected by a relief valve or other suitable relief devices.

4.2.7 Valves

4.2.7.1 General

Valves shall conform to EN 1626.

4.2.7.2 Isolating valves

To prevent any large spillage of liquid, a secondary means of isolation shall be provided for those lines emanating from below the liquid level that are:

— greater than 9 mm bore and exhausting to atmosphere; or

— greater than 50 mm bore when forming part of a closed system.

The secondary means of isolation may be within the user installation and shall provide an equivalent level of protection.

The secondary means of isolation, where provided, may be achieved, for example, by the installation of a second valve, positioned so that it can be operated safely in emergency, an automatic fail-closed valve or a non-return valve or fixed or removable cap on the open end of the pipe.

4.3 Design by calculation

4.3.1 General

When design is by calculation in accordance with 4.1.2, the dimensions of the vessel shall not be less than that determined in accordance with this sub-clause.

4.3.2 Vessel

4.3.2.1 General

The information given in 4.3.2.2 and 4.3.2.3 shall be used to determine the pressure part thicknesses in conjunction with the calculation formulae of 4.3.5.

4.3.2.2 Design loads and allowable stresses

a) In accordance with 4.2.3.2 f) 1)

Material properties determined either in accordance with 4.3.2.3.2 or 4.3.2.3.3 shall be adopted at the discretion of the vessel manufacturer.

b) In accordance with 4.2.3.2 f), 2), 3)

Material properties determined in accordance with 4.3.2.3.2 shall be adopted.