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CRYOGENIC VESSELS - STATIC VACUUM INSULATED VESSELS - PART 2: DESIGN, FABRICATION, INSPECTION AND TESTING

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This European Standard was approved by CEN on 12 August 2002.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

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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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

This document (EN 13458-2:2002) has been prepared by Technical Committee 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of an identical text or by endorsement, at the latest by May 2003, and conflicting national standards shall be withdrawn at the latest by May 2003.

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.

In this European Standard the annexes A, B E, G, I and K are normative and the annexes C, D, F, H and J are informative.

EN 13458 consists of the following Parts under the general title, *Cryogenic vessels – Static vacuum insulated vessels*

— *Part 1: Fundamental requirements*

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

— *Part 3: Operational requirements*

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, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

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

This European Standard is applicable to static vacuum insulated cryogenic vessels for fluids as specified in EN 13458-1, and does not apply to vessels designed for toxic fluids.

For static vacuum insulated cryogenic vessels designed for a maximum allowable pressure of not more than 0,5 bar this standard can 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, *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 895:1995, *Destructive tests on welds in metallic materials – Transverse tensile test*.

EN 910:1996, *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 mechanised and automatic welding of metallic materials*.

EN 1435, *Non-destructive examination of welds – Radiographic examination of welded joints.*

EN 1626, *Cryogenic vessels – Valves for cryogenic service*.

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*.

prEN 10216-5, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 5: Stainless steel tubes.*

prEN 10217-7, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 7: Stainless steel tubes.*

EN 12300, *Cryogenic vessels – Cleanliness for cryogenic service.*

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

EN 13133, *Brazing – Brazer approval.*

EN 13134, *Brazing – Procedure approval.*

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

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

EN 13458-1:2002, *Cryogenic vessels – Static vacuum insulated vessels - Part 1: Fundamental requirements*.

prEN 13458-3, *Cryogenic vessels – Static vacuum insulated vessels – Part 3: Operational requirements*.

prEN 13648-1, *Cryogenic vessels – Safety devices for protection against excessive pressure – Part 1: Fundamental requirements*

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

prEN ISO 4126-2, *Safety devices for protection against excessive pressure – Part 2: Bursting disc safety devices (ISO/DIS 4126-2:1996).*

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

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

SA-353/A353M, *Specification for pressure vessel plates, alloy steel, 9 percent nickel, double-normalized and tempered.*

SA-479/SA-479M, *Specification for stainless steel bars and shapes for use in boilers and other pressure vessels.*

SA-522/SA-522M, *Specification for forged or rolled 8 and 9% nickel alloy steel flanges, fittings, valves and parts for low-temperature service.*

SA-553/SA-553M, *Specification for pressure vessel plates, alloy steel quenched and tempered 8 and 9 percent nickel.*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this European Standard, the following terms and definitions 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
inner vessel
pressure vessel proper intended to contain the cryogenic fluid

3.1.3
outer jacket
gas-tight enclosure which contains the inner vessel and enables a vacuum to be established

3.1.4
automatic welding
welding in which the parameters are automatically controlled. Some of these parameters may 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.

3.1.6
relief plate/plug
plate or plug retained by atmospheric pressure only which allows relief of excess internal pressure

3.1.7
bursting disc device
non-reclosing pressure relief device ruptured by differential pressure. It is the complete assembly of installed components including where appropriate the bursting disc holder

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 j) and 4.3.3.2	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 g))	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 utilisation 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
I	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	-
v	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 E 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 inner vessel and outer jacket 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 inner 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 in 4.3. 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 4.2.8 are applicable to all vessels irrespective of the design option used.

In the event of an increase in at least one of the following parameters:

— maximum allowable pressure;

— specific mass (density) of the densest gas for which the vessel is designed;

— maximum tare weight of the inner vessel;

— nominal length and/or diameter of the inner shell;