SLOVENSKI STANDARD

SIST EN 1251-2:2001

01-januar-2001

Kriogene posode - Premične vakuumsko izolirane posode s prostornino, ki ni večja od 1 000 litrov - 2. del: Konstrukcija, izdelava, nadzor in preskus

Cryogenic vessels - Transportable vacuum insulated vessels of not more than 1000 litres volume - Part 2: Design, fabrication, inspection and testing

Kryo-Behälter - Ortsbewegliche, vakuumisolierte Behälter mit einem Fassungsraum von nicht mehr als 1000 Liter - Teil 2: Bemessung, Herstellung und Prüfung

Récipients cryogéniques - Récipients transportables, isolés sous vide, d'un volume n'excédant pas 1000 litres - Partie 2: Conception, fabrication, inspection et essai

Ta slovenski standard je istoveten z: EN 1251-2:2000

ICS:

23.020.40 Proti mrazu odporne posode (kriogenske posode) Cryogenic vessels

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EUROPEAN STANDARD

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English version

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This European Standard was approved by CEN on 19 June 1999.

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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

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Contents

Foreword

This European Standard 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 July 2000, and conflicting national standards shall be withdrawn at the latest by July 2000.

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, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

The standard has been submitted for reference into the RID and/or in the technical annexes of the ADR.

Therefore the standards listed in the normative references and covering basic requirements of the RID/ADR not addressed within the present standard are normative only when the standards themselves are referred to in the RID and/or in the technical annexes of the ADR.

The other parts of EN 1251 are :

— Part 1: Fundamental requirements ;

— Part 3: Operational requirements.

The Standard covers validation of design by calculation or by an experimental method.

1 Scope

This European Standard is applicable to the design, fabrication, inspection and testing of transportable vacuum insulated cryogenic vessels of not more than 1 000 litres volume and designed for a maximum allowable pressure greater than atmospheric.

This standard applies to transportable vacuum insulated cryogenic vessels for fluids as specified in EN 1251-1 and is not applicable to such vessels designed for toxic fluids.

For details of acceptable materials see clause 8 of EN 1251-1.

Additional requirements for flammable fluids are given in annex C.

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.

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, *Specification and approval of welding procedures for metallic materials - Part 3: Welding procedure tests for arc welding of steels*

EN 288-4, *Specification and approval of welding procedures for metallic materials - Part 4: Welding procedure tests for 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 729-2, *Quality requirements for welding - Fusion welding of metallic materials – Part 2: Comprehensive quality requirements*

EN 729-3, *Quality requirements for welding - Fusion welding of metallic materials – Part 3: Standard quality requirements*

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

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

EN 962, *Transportable gas cylinders - Valve protection devices caps and valve guards for industrial and medical gas cylinders – Design, construction and tests*

EN 970, *Non-destructive examination of fusion welds - Visual examination*

EN 1251-1, *Cryogenic vessels - Transportable vacuum insulated vessels of not more than 1 000 litres volume - Part 1: Fundamental requirements*

EN 1251-3, *Cryogenic vessels - Transportable vacuum insulated vessels of not more than 1 000 litres volume - Part 3: Operational requirements*

EN 1252-1, *Cryogenic Vessels – Materials - Part 1: Toughness requirements for temperatures below –80°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, *Cryogenic Vessels - Valves for cryogenic service*

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

EN 1797-1, *Cryogenic vessels - Gas/material compatibility - Part 1 : Oxygen compatibility*

EN 10045-1, *Metallic materials - Charpy impact test - Part 1: Test method*

EN 10204, *Metallic products - Types of inspection documents*

EN 12213, *Cryogenic vessels - Evaluation methods of thermal insulation performance*

EN 12300, *Cryogenic vessels - Cleanliness for cryogenic service*

EN 22244:1992, *Packaging - Complete, filled transport packages - Horizontal impact tests (horizontal or inclined plane tests - Pendulum test) (ISO 2244:1985)*

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, Welding and allied processes - Classification of geometric imperfections in metallic materials - Part 1: Fusion welding (ISO 6520-1:1998)

3 Definitions and symbols

3.1 Definitions

For the purposes of this standard, the following definitions apply in addition to those given in EN 1251-1:

3.1.1
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

3.1.2
maximum allowable pressure, *Ps*
the maximum pressure which may be exerted under normal conditions of use

3.1.3
volume of the inner vessel
the volume of the shell, excluding nozzles, pipes, etc. determined at minimum design temperature and atmospheric pressure

3.2 Symbols

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

c	allowance for corrosion, in millimetres
d_i	internal diameter of tube or nozzle, in millimetres
f	narrow side of rectangular or elliptical plate, in millimetres
l_b	buckling length, in millimetres

n	Number
p	design pressure, in bar
p_e	allowable external pressure limited by elastic buckling, in bar
p_p	allowable external pressure limited by plastic deformation, in bar
r	radius e.g. inside knuckle radius of dished end and cones, in millimetres
s	required wall thickness including allowances, in millimetres
s_e	actual wall thickness, in millimetres
v	factor indicative of the utilisation of the permissible design stress in joints or factor allowing for weakening
x	(decay-length zone) distance over which governing stress is assumed to act, in millimetres
A	Area, in square millimetres
C, β	design factors
D	shell diameter, in millimetres
D_a	outside diameter e.g. of a cylindrical shell, in millimetres
D_i	internal diameter e.g. of a cylindrical shell, in millimetres
E	Young's modulus, in Newton per square millimetres
I	moment of inertia of stiffening ring, in millimetres ^{4}
K	material property used for design, in Newton per square millimetres
R	radius of curvature e.g. inside crown radius of dished end, in millimetres
S	safety factor at design pressure
S_k	safety factor against elastic buckling at design pressure
S_p	safety factor against plastic deformation
Z	auxillary value
υ	Poisson's ratio
u	out of roundness

4 Design

4.1 Design validation options

Each type of vessel shall be subject to validation of the design in accordance with one of the options given in 4.1.1, 4.1.2 or 4.1.3. The manufacturer shall consider the nature of the individual design, particularly the degree of novelty; a method of validation appropriate to that design; and the limitation of that method.

4.1.1 Validation by calculation

This option requires calculation of all pressure and load bearing components. The pressure part thicknesses of the inner vessel and outer jacket shall not be less than required by 4.3. Additional calculations are required to validate the design for the operating conditions including an allowance for dynamic loads.

4.1.2 Validation by experimental method

This option requires the pressure retaining capacity and structural integrity to be validated by experiment as detailed in 4.4.

4.1.3 Validation by calculation and experimental method

This option requires validation of the pressure retaining capacity by calculation except that the minimum wall thickness requirements of tables 1 and 2 do not apply. Structural integrity shall be validated by experiment as detailed in 4.4.

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 validation option used. In the event of an increase in at least one of the following parameters :

- maximum allowable pressure ;
- 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,

or, in the event of any change relative

- to the type of material or grade (e.g. stainless steel to aluminium or change of stainless steels grades) ;
- to the fundamental shape ;
- to the decrease in the minimum mechanical properties of the material being used ;
- to the modification of the design of an assembly method concerning any part under stress, particularly as far as the support systems between the inner vessel and the outer jacket or the inner vessel itself or the protective frame, if any, are concerned.

The initial design validation programme shall be repeated to take account of these modifications.

In addition, if any changes affect the handling method or the stacking condition, the appropriate tests (complying respectively with 4.4.4.2 and 4.4.4.3) or the relevant calculations, shall be repeated to take account of these changes.

4.2.2 Design specification

To enable the design to be prepared the following information which defines a vessel type shall be available :

- maximum allowable pressure ;
- fluids intended to be used ;
- liquid capacity ;
- volume of the inner vessel ;
- method of handling and securing ;
- stacking arrangement.

A design document in the form of drawings and/or written text shall be prepared, it shall contain the information given above plus the following where applicable :

- definition of which components are validated by calculation and which are validated by experiment ;
- 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 in accordance with EN 10204 ;
- 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 validation 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.

4.2.3 Design loads

4.2.3.1 General

The transportable cryogenic vessel shall be able to withstand safely the mechanical and thermal loads and the chemical effects encountered during pressure test and normal operation.

4.2.3.2 Inner vessel

With the exception of a) the following loads shall be considered to act in combination where relevant :

a) pressure test : The following value shall be used for validation purposes :

$$P_T \geq 1{,}3\,(P_S + 1)\ \text{bar} \qquad \ldots (1)$$

where :

P_S is the maximum allowable working pressure, in bar.

The 1 bar is added to allow for the external vacuum.

b) pressure during operation, P_C, where :

$$P_C = P_S + P_L + 1\ \text{bar} \qquad \ldots (2)$$

P_L is the pressure, in bars, exerted by the liquid contents when the vessel is filled to capacity and subject to dynamic load ;

c) reaction at the support points of the inner vessel due to the mass of the inner vessel and its contents when subject to dynamic load ;

d) load imposed by the piping due to the differential thermal movement of the inner vessel, the piping and the outer jacket.

The following cases shall be considered :

— cooldown (inner vessel warm - piping cold) ;

— filling and withdrawal (inner vessel cold - piping cold) ; and

— transhipment and storage (inner vessel cold - piping warm) ;

e) load imposed on the inner vessel at its support points when cooling from ambient to operating temperature and during operation.

4.2.3.3 Outer jacket

The following loads shall be considered to act in combination where relevant :

a) an external pressure of 1 bar ;

b) an internal pressure equal to the set pressure of the outer jacket pressure relief device ;

c) load imposed by the inner vessel and its contents at the support points in the outer jacket when subject to dynamic load ;

d) load imposed by piping as defined in 4.2.3.2 d) ;

e) load imposed at the inner vessel support points in the outer jacket when the inner vessel cools from ambient to operating temperature and during operation ;

f) reactions at the outer jacket support points due to the mass of the transportable cryogenic vessel and its contents when filled to capacity and subject to dynamic load (see 4.3.8).

4.2.3.4 Inner vessel supports

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

4.2.3.5 Outer jacket supports

The outer jacket supports shall be suitable for the load defined in 4.2.3.3 f).

4.2.3.6 Lifting points

Lifting points shall be suitable for lifting the transportable cryogenic vessel when filled to capacity and subject to vertical dynamic load, when lifted in accordance with the specified procedure (see 4.3.8).

4.2.3.7 Frame

Where a frame is part of the transportable cryogenic vessel it shall be suitable for the static and dynamic loads imposed during storage, lifting and transport. This shall include loads due to stacking vessels where applicable (see 4.3.8).

4.2.3.8 Protective guards

Guards fitted for the protection of fittings and external pipework shall be designed to withstand a load equal to the mass of the transportable cryogenic vessel filled to capacity applied in the horizontal or vertical direction.

The load shall be equal to twice the total mass if any of the following conditions is met :

— capacity less than 100 l ;

— total mass less than 150 kg ;

— the height of the centre of gravity of the transportable cryogenic vessel, when filled to capacity, including any framework elements, is more than twice the smaller horizontal dimension of its base.

4.2.3.9 Piping

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 : Not less than the allowable working pressure P_S plus one bar for piping inside the vacuum jacket ;

b) pressure during operation : Not less than the set pressure of the system pressure relief device ;

c) thermal loads defined in 4.2.3.2 d) ;

d) dynamic loads ;

e) set pressure of thermal relief devices where applicable ;

f) loads generated during pressure relief discharge.

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 inner vessel or the outer jacket.

NOTE 1 Due to the combination of materials of construction and operating fluids, internal corrosion will not occur.

NOTE 2 The inner vessel is inside the evacuated outer jacket and hence external corrosion of the inner vessel will not occur.

NOTE 3 The elimination of inspection openings also assists in maintaining the integrity of the vacuum in the interspace.

4.2.6 Pressure relief

4.2.6.1 General

Relief devices for inner vessels shall be in accordance with the appropriate European standards.

Relief devices for outer jackets shall be in accordance with annex D.

Systems shall be designed to meet the following requirements.

4.2.6.2 Inner vessel

The inner vessel shall be provided with at least two pressure relief devices to protect the vessel against excess pressure due to the following :

a) normal heat leak ;

NOTE Insulation performance evaluated as described in EN 12213 shall be sufficient to satisfy the holding time requirement of EN 1251-3.

b) heat leak with loss of vacuum ;

c) failure in the open position of a pressure build up system.

Excess pressure means a pressure in excess of 110 % of the maximum allowable pressure for condition a) and in excess of the test pressure for condition b) or c).

An exception is made for vessels less than 450 litres capacity where at least one pressure relief device shall be provided.

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

The pressure relief system shall be sized so that the pressure drop during discharge does not cause the valve to reseat instantly.

4.2.6.3 Outer jacket

A pressure relief device shall be fitted to the outer jacket. The device shall be set to open at a pressure of not more than 0,5 bar. The discharge area of the pressure relief device shall be not less than 0,34 mm^2/l capacity of the inner vessel but not less than 10 mm diameter.

4.2.6.4 Piping

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

4.2.7 Valves

Valves shall be in accordance with EN 1626.

4.3 Design validation by calculation

4.3.1 General

When design validation is by calculation in accordance with 4.1.1 or 4.1.3 the dimensions of the inner vessel and outer jacket shall not be less than that determined in accordance with this sub-clause.

4.3.2 Inner vessel

4.3.2.1 Wall thickness

The following shall be used to determine the pressure part thicknesses in conjunction with the calculation formulae of 4.3.7.

The actual wall thickness shall be not less than shown in table 1 unless either

a) the design has been validated by experiment ; or

b) a stress analysis has been carried out, and assessed in accordance with annex A.

Table 1 — Inner vessel minimum wall thickness

Inner vessel Diameter D (mm)	Minimum wall thickness s_0 for reference steel 1) (mm)
$D \leq 400$	1
$400 < D \leq 1\,800$	$1 + \frac{D - 400}{700}$

1) Reference steel material is material having a product $R_m \times A_5$ of 10 000.
For other materials calculate the minimum thickness using the following formula :

$$s = \frac{21{,}4 s_0}{\sqrt[3]{R_m \times A_5}}$$

where
R_m is the ultimate tensile strength, in Newtons per square millimetre ;
A_5 is the elongation at fracture, in per cent.

4.3.2.2 Design pressure *p*

The internal design pressure p shall be equal to P_T as defined in 4.2.3.2.

The inner vessel need not be designed for external pressure.

4.3.2.3 Material property *K* at 20°C

The material property K to be used in the calculations shall be as follows :

— for austenitic stainless steel and aluminium, 1 % proof strength ;

— for aluminium alloys, 0,2 % proof strength.

K shall be the minimum value at 20 °C taken from the material standard. In the case of austenitic stainless steels the specified minimum value may be exceeded by up to 15% provided this higher value is attested in the inspection certificate.

Higher values of K may be used provided that the following conditions are met :

— the material manufacturer shall guarantee compliance with this higher value, in writing, when accepting the order ;

— the increased properties shall be verified by testing each rolled plate or coil of the material to be delivered ;

— the increased properties shall be attested in the inspection certificate.

For austenitic stainless steel a strength value obtained in work hardened material may be used in the design provided this value and adequate ductility is maintained in the finished component.

4.3.2.4 Safety factors S, S_p and S_k

The safety factors to be used are as follows :

— internal pressure (pressure on the concave surface) :

$$S = 1,33$$

— external pressure (pressure on the convex surface) :

- — cylindrical shells $S_p = 1,4$

  $S_k = 2,6$

- — spherical region $S_p = 2,1$

  $S_k = 2,6 + 0,0018 R / s$

- — knuckle region $S_p = 1,6$.

4.3.2.5 Weld joint factors v

For internal pressure (pressure on the concave surface) $v = 0,85$ or $1,0$ - see clause 6.

For external pressure (pressure on the convex surface) $v = 1,0$.

4.3.2.6 Allowances c

$c = 0$

NOTE No allowance is required for austenitic stainless steel, aluminium and aluminium alloys.

4.3.3 Outer jacket

4.3.3.1 General

The following shall be used to determine the pressure part thicknesses in conjunction with the calculation formulae of 4.3.7.