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Cryogenic vessels - Static vacuum-insulated vessels - Part 1: Design, fabrication, inspection and tests (ISO/DIS 21009-1:2024)

Kryo-Behälter - Stationäre vakuumisolierte Behälter - Teil 1: Konstruktion, Herstellung, Kontrolle und Prüfung (ISO/DIS 21009-1:2024)

Réipients cryogéniques - Réipients fixes isolés sous vide - Partie 1: Conception, fabrication, inspection et essais (ISO/DIS 21009-1:2024)

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Cryogenic vessels — Static vacuum-insulated vessels —

Part 1: Design, fabrication, inspection and tests

Réceptacles cryogéniques — Réceptacles isolés sous vide statiques —

Partie 1: Exigences de conception de fabrication, d'inspection, et d'essais

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 220, *Cryogenic vessels*.

This third edition cancels and replaces the second edition (ISO 21009-1:2022), which has been technically revised.

The main changes are as follows:

- [Subclause 11.6.1](#) Correction and specification of Welding Manufacture;
- [Subclause 12.2.2](#); Correction of References and [Table 5](#);
- [Subclause C.3.1](#) Dividing the [Table C.1.1](#) for European Material and [C.1.2](#) Non-European Material;
- [Subclause C.3.3](#) Correction for Test Plates related Cold strengthening;
- [Subclause C.3.4](#) Correction of preparing of Test Plate;
- [Subclause C.3.5](#) shifted;
- [Subclause C.3.6](#) shifted;
- Subclause C.3.7 shifted;
- [Annex K](#) Dividing the [Table K.1.1](#) for European Material and [K.1.2](#) Non-European Material and [Table K.2.1](#) for European Material and [K.2.2](#) Non-European Material.

A list of all parts in the ISO 21009 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Cryogenic vessels — Static vacuum-insulated vessels —

Part 1: Design, fabrication, inspection and tests

1 Scope

This document 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 document applies to static vacuum-insulated cryogenic vessels for fluids and does not apply to vessels designed for toxic fluids.

This document also gives guidance for static vacuum-insulated cryogenic vessels designed for a maximum allowable pressure of not more than 0,5 bar.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements*

ISO 3834-3, *Quality requirements for fusion welding of metallic materials — Part 3: Standard quality requirements*

ISO 4126-2, *Safety devices for protection against excessive pressure — Part 2: Bursting disc safety devices*

ISO 4136, *Destructive tests on welds in metallic materials — Transverse tensile test*

ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

ISO 9016, *Destructive tests on welds in metallic materials — Impact tests — Test specimen location, notch orientation and examination*

ISO 9328-4, *Steel flat products for pressure purposes — Technical delivery conditions — Part 4: Nickel-alloy steels with specified low temperature properties*

ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 10474:2013, *Steel and steel products — Inspection documents*

ISO 10675-1, *Non-destructive testing of welds — Acceptance levels for radiographic testing — Part 1: Steel, nickel, titanium and their alloys*

ISO 14732, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

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

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ISO 15614-1:2017, *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 17635, *Non-destructive testing of welds — General rules for metallic materials*

ISO 17636-1, *Non-destructive testing of welds — Radiographic testing — Part 1: X- and gamma-ray techniques with film*

ISO 17636-2, *Non-destructive testing of welds — Radiographic testing — Part 2: X- and gamma-ray techniques with digital detectors*

ISO 21009-2, *Cryogenic vessels — Static vacuum insulated vessels — Part 2: Operational requirements*

ISO 21010, *Cryogenic vessels — Gas/material compatibility*

ISO 21011, *Cryogenic vessels — Valves for cryogenic service*

ISO 21013-3, *Cryogenic vessels — Pressure-relief accessories for cryogenic service — Part 3: Sizing and capacity determination*

ISO 21028-1, *Cryogenic vessels — Toughness requirements for materials at cryogenic temperature — Part 1: Temperatures below -80 degrees C*

ISO 21028-2, *Cryogenic vessels — Toughness requirements for materials at cryogenic temperature — Part 2: Temperatures between -80 degrees C and -20 degrees C*

ISO 23208, *Cryogenic vessels — Cleanliness for cryogenic service*

EN 13445-3, *Unfired pressure vessels — Design*

ASME Boiler and Pressure Vessel Code, Section VIII, Division 2: *Alternative Rules*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/>

3.1

accessories

service equipment which has a safety-related function with respect to either pressure containment or control or both

EXAMPLE Protective or limiting devices, controlling and monitoring devices, valves and indicators.

3.2

automatic welding

welding in which all operations are performed without welding operator intervention during the process

Note 1 to entry: Manual adjustment of welding variables by the welding operator during welding is not possible.

[SOURCE: ISO 14732:2013, 3.1]

3.3

bursting disc device

non-reclosing pressure relief device ruptured by differential pressure

Note 1 to entry: The bursting disc device is the complete assembly of installed components including, where appropriate, the bursting disc holder.

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3.4

cryogenic fluid

refrigerated liquefied gas

gas which is partially liquid because of its low temperature

Note 1 to entry: This includes totally evaporated liquids and supercritical fluids.

Note 2 to entry: In the ISO 21009 series, the refrigerated, but non-toxic gases, and mixtures of them, shown in [Table 1](#), are referred to as cryogenic fluids.

Table 1 — Refrigerated but non-toxic gases

Classification code	Identification number, name and description
3° A	Asphyxiant gases 1 913 Neon, refrigerated liquid 1 951 Argon, refrigerated liquid 1 963 Helium, refrigerated liquid 1 970 Krypton, refrigerated liquid 1 977 Nitrogen, refrigerated liquid 2 187 Carbon dioxide, refrigerated liquid 2 591 Xenon, refrigerated liquid 3 136 Trifluoromethane, refrigerated liquid 3 158 Gas, refrigerated liquid, not otherwise specified (NOS)
3° O	Oxidizing gases 1 003 Air, refrigerated liquid 1 073 Oxygen, refrigerated liquid 2 201 Nitrous oxide, refrigerated liquid, oxidizing 3 311 Gas, refrigerated liquid, oxidizing, NOS
3° F	Flammable gases 1 038 Ethylene, refrigerated liquid 1 961 Ethane, refrigerated liquid 1 966 Hydrogen, refrigerated liquid (medium resistance criteria considered for Hydrogen) 1 972 Methane, refrigerated liquid or natural gas, refrigerated liquid, with high methane content 3 138 Ethylene, acetylene and propylene mixture, refrigerated liquid, containing at least 71,5 % ethylene with not more than 22,5 % acetylene and not more than 6 % propylene 3 312 Gas, refrigerated liquid, flammable, NOS
<p>The flammable gases, and mixtures of them, may be mixed with: helium, neon, nitrogen, argon, carbon dioxide.</p> <p>Oxidizing and flammable gases shall not be mixed.</p> <p>NOTE The classification code, identification number, name and description are according to UN codes.</p>	

3.5

documentation

technical documents delivered by the manufacturer to the owner

Note 1 to entry: Documentation consists of:

- all certificates establishing the conformity with this document (e.g. material, pressure test, cleanliness, safety devices);
- a short description of the vessel (e.g. including characteristic data);
- a list of fluids and their net mass for which the cryogenic vessel is designed;
- an operating manual (for the user) that contains:
 - a short description of the vessel (e.g. including characteristic data),

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- a statement that the vessel is in conformity with this document, and
- the instructions for *normal operation* (3.10).

3.6

gross volume

<*inner vessel*> (3.7) internal volume of the inner vessel determined at minimum design temperature and atmospheric pressure

3.7

inner vessel

pressure vessel intended to contain the *cryogenic fluid* (3.4) to be stored

3.8

manufacturer of the static cryogenic vessel

company that carries out the final assembly, including the final acceptance test, of the *static cryogenic vessel* (3.17)

3.9

maximum allowable pressure

maximum *pressure* (3.13) permissible at the top of the vessel in its normal operating position

3.10

normal operation

intended operation of the vessel either up to the *maximum allowable pressure* (3.9) or subjected to handling loads

Note 1 to entry: Handling loads are exerted on the *static cryogenic vessel* (3.17) in all normal transport operations including, e.g. loading, unloading, pressure loading during transportation, installation.

3.11

outer jacket

gas-tight enclosure which contains the *inner vessel* (3.7) and enables the vacuum to be established

3.12

pipng system

tubes, pipes and associated components which can come in contact with *cryogenic fluids* (3.4) including valves, fittings, pressure relief devices, and their supports

3.13

pressure gauge pressure

pressure relative to atmospheric pressure

3.14

pressure strengthened vessel

pressure vessel, which has been subjected to a calculated and controlled internal pressure (strengthening pressure) after completion

Note 1 to entry: The wall thickness of such a vessel is calculated on the basis of the stress at the strengthening pressure and not on the basis of the conventional design stress value of the material used.

Note 2 to entry: Pressure vessels made from solution heat treated material will be subject to a controlled plastic deformation during the strengthening operation as its yield point is raised. Pressure vessels made from work-hardened material will be subject to little or no plastic deformation.

3.15

relief plate

plate retained by atmospheric pressure which allows relief of excess internal pressure, generally from the vacuum jacket

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3.16

service equipment

accessories, equipment or instruments that will be used to measure the level, to fill or discharge the tank, to vent the tank, to protect the tank against overpressure and to raise the tank pressure and its thermal insulation

Note 1 to entry: The thermal insulation is a vacuum inter-space between the *inner vessel* (3.7) and the *outer jacket* (3.11).

3.17

static cryogenic vessel

thermally insulated vessel intended for use with one or more *cryogenic fluids* (3.4) in a stationary condition

Note 1 to entry: Static cryogenic vessels consist of *inner vessel(s)* (3.7), an *outer jacket* (3.11) and the *pipng system* (3.12).

4 Symbols

A	cross sectional area of reinforcing element	mm ²
A	area of reinforcing ring	mm ²
A_s	elongation at fracture	%
b	width of pad, ring or shell reinforcement	mm
C_β	design factors	—
c	allowances for corrosion	mm
D	shell diameter	mm
D_a	outside diameter e.g. of a cylindrical shell	mm
D_{a1}	outside diameter of connected cylinder (see Figure 7)	mm
D_{a2}	outside diameter at effective stiffening (see Figure 9)	mm
D_1, D_2	flat end diameters	mm
D_i	internal diameter e.g. of a cylindrical shell	mm
D_k	design diameter (see Figure 7)	mm
D_s	shell diameter at nozzle (see Figure 8)	mm
d_a	outside diameter of tube or nozzle	mm
d_i	diameter of opening	mm
d_1, d_2	opening diameter	mm
E	Young's modulus	N/mm ²
f	narrow side of rectangular or torispherical plate	mm
H	Safety coefficient for pressure test	—
h	thickness of pad-reinforcement	mm
I	moment of inertia of reinforcing element	mm ⁴
K	material property used for design (see 10.3.2.3.1)	N/mm ²

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K_t	material property at t °C used for design (e.g. K_{20} for material property at 20 °C) (see 10.3.2.3.2)	N/mm ²
L	cone length between effective stiffenings (see Figure 9)	mm
l	ligament (web) between two nozzles	mm
l_b	buckling length	mm
l'_s	length of nozzle reinforcement outstandings	mm
l_s	length of nozzle reinforcement in stand	mm
m	protruding length of nozzle	mm
n	number	—
p	design pressure as defined by 10.2.3.2.1 and 10.3.3.2	bar (or MPa)
p_e	external pressure	bar (or MPa)
p_{e1}	allowable external pressure limited by elastic buckling	bar (or MPa)
p_{e2}	allowable external pressure limited by elastic buckling including reinforcement	bar (or MPa)
p_k	strengthening pressure	bar (or MPa)
p_p	allowable external pressure limited by plastic deformation	bar (or MPa)
p_s	maximum allowable gauge pressure	bar (or MPa)
p_T	test pressure [see 10.2.3.2.3]	bar (or MPa)
R	radius of curvature e.g. inside crown radius of dished end	mm
r	inside radius of knuckle	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	—
s	minimum wall thickness	mm
s_A	required wall thickness at opening edge	mm
s_e	actual wall thickness	mm
s_g	required wall thickness outside corner area	mm
s_l	required wall thickness within corner area	mm
s_S	wall thickness of nozzle	mm
T	temperature	°C
t	wall thickness of nozzle	mm