
**Cryogenic vessels — Pressure-relief
accessories for cryogenic service —**

**Part 1:
Reclosable pressure-relief valves**

*Réipients cryogéniques — Dispositifs de sécurité pour le service
cryogénique —*

Partie 1: Soupapes de sûreté pour service cryogénique

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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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 second edition cancels and replaces the first edition (ISO 21013-1:2008), which has been technically revised.

The main changes are as follows:

- update of the terms and definitions;
- revision of cryogenic tests, in particular, the test setup.

A list of all parts in the ISO 21013 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 — Pressure-relief accessories for cryogenic service —

Part 1: Reclosable pressure-relief valves

1 Scope

This document specifies the requirements for the design, manufacture and testing of pressure relief valves for cryogenic service, i.e. for operation with cryogenic fluids below -10°C in addition to operation at ambient temperatures from ambient to cryogenic.

This document is applicable to valves not exceeding a size of DN 150 designed to relieve single-phase vapours or gases. A valve can be specified, constructed and tested such that it is suitable for use with more than one gas or with mixtures of gases.

NOTE This document does not provide methods for determining the capacity of relief valve(s) for a particular cryogenic vessel. Such methods are provided in ISO 21013-3.

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 4126-1:2013, *Safety devices for protection against excessive pressure — Part 1: Safety valves*

ISO 11114-1, *Gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials*

ISO 11114-2, *Gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 2: Non-metallic materials*

ISO 15761, *Steel gate, globe and check valves for sizes DN 100 and smaller, for the petroleum and natural gas industries*

ISO 20421-1:2019, *Cryogenic vessels — Large transportable vacuum-insulated vessels — Part 1: Design, fabrication, inspection and testing*

ISO 21009-1:2008, *Cryogenic vessels — Static vacuum-insulated vessels — Part 1: Design, fabrication, inspection, and tests*

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

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

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

ISO 21029-1:2018, *Cryogenic vessels — Transportable vacuum insulated vessels of not more than 1 000 litres volume — Part 1: Design, fabrication, inspection and tests*

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

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

DN

nominal size

alphanumeric designation of size for components of a pipe work system, which is used for reference purposes

Note 1 to entry: It comprises the letters DN followed by a dimensionless whole number which is indirectly related to the physical size, in millimetres, of the bore or outside diameter of the end connections.

[SOURCE: ISO 6708:1995, 2.1, modified — Moved additional information from the definition into a Note 1 to entry and deleted the previous two Notes to entry.]

3.2

pressure

gauge pressure

pressure for which the value is equal to the algebraic difference between the absolute pressure and the atmospheric pressure

3.3

rated minimum temperature

lowest temperature for which the pressure relief valve is rated by the manufacturer

3.4

category A valve

relief valve which can be expected to relieve pressure during normal operation of the cryogenic vessel

Note 1 to entry: The procedure for the seat-tightness test is described in [5.2.1.2](#).

3.5

category B valve

relief valve which is not expected to relieve pressure during normal operation due to the provision of an alternative relieving or control device, e.g. a pressure regulating vent valve designed for frequent operation

Note 1 to entry: The procedure for the seat-tightness test is described in [5.2.1.2](#).

3.6

cryogenic fluid

refrigerated liquefied gas

gas which is partially liquid because of its cold temperature

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

3.7

PS

maximum allowable pressure

maximum pressure for which the equipment is designed as specified by the manufacturer

Note 1 to entry: Overpressure and relieving pressure are defined in ISO 4126-1.

3.8 rated pressure PR

maximum pressure difference between the inside and outside of any pressure retaining boundary for which the boundary is designed to be operated at 20 °C

Note 1 to entry: The PR of the relief valve is the lowest PR of any component of the relief valve.

4 Requirements

4.1 General

The valve shall satisfy all the requirements of ISO 4126-1 except in the event of different requirements, where this document takes precedence.

In the context of this document, for cryogenic fluids and mixtures of them, the user shall refer to the list of cryogenic fluids in ISO 21029-1:2018, Table 1 or ISO 21009-1:2008, Table 1 or ISO 20421-1:2019, Table K.1.

4.2 Design

4.2.1 Design temperature

The valve shall be suitable for operation at all temperatures between the rated minimum temperature and +65 °C within the intended pressure range.

4.2.2 Drainage

Unless otherwise specified in the purchase order, the valve shall avoid accumulation of water within it, even when the expected outlet connection is fitted.

4.2.3 Stem guiding

The design of guiding shall avoid malfunction of the valve due to deposition and freezing of atmospheric moisture on and within the valve during normal operation. The valve shall be sufficiently robust such that the effectiveness of the guiding cannot be defeated by normal handling.

4.2.4 Inserts

Where a disc soft-insert is used to ensure leak-tight shut off, the design shall be such as to prevent cold flow of the insert to a degree that results in the valve failing to operate correctly.

4.2.5 Sublimating fluids service

Where the valve is specified as suitable for service with products that, when vented at valve operating conditions, condense from gas or vapour directly to solid, e.g. carbon dioxide (CO₂), the design shall be such as to avoid the valve failing to operate correctly due to deposition of solid product within the valve body or its outlet.

4.2.6 Electric continuity

For valves in oxidising and flammable fluids service, the maximum electrical resistance shall not exceed 1 000 Ω with no more than 28 V between the ports in order to ensure electrical continuity to prevent build-up of static electricity.

4.2.7 Set pressure

Set pressure of the valve shall not exceed its PS.

4.2.8 Minimum shell thickness

The valves shall fulfil their function in a safe manner within the temperature range from +65 °C to their rated minimum temperature and the pressure range intended for use.

The minimum shell thickness for valve bodies shall be as specified in ISO 15761 or ASME B16.34 for the pressure rating and size of the valve. These standards may be used as informative references for design not specifically covered in this document.

The minimum shell thickness can also be determined by calculation methods in EN 12516-2, AD2000-Merkblatt or comparable for pressure rating.

4.3 Materials

4.3.1 General

Materials shall either be in conformance with an internationally recognized standard and be compatible with the process fluid. Galling, frictional heating, and galvanic corrosion shall also be considered in the selection of materials. Materials shall also be oxygen compatible if relevant (see [4.3.5.1](#)).

For materials not listed in an internationally recognized standard, the materials shall be controlled by the manufacturer of the pressure-relief valve by a specification ensuring control of chemical content and physical properties and quality at least equivalent to an internationally recognized standard. A test certificate providing the chemical content and physical property test results shall be provided with the pressure-relief valve.

4.3.2 Metallic materials

4.3.2.1 Metallic materials to be used in the construction of cryogenic pressure relief valves shall meet the requirements of ISO 21028-1 or ISO 21028-2 as appropriate for the rated minimum temperature.

4.3.2.2 These requirements apply only to the valve parts exposed to low temperatures in normal service. Metallic materials which do not exhibit ductile/brittle transition, and non-ferrous materials which can be shown to have no ductile/brittle transition do not require additional impact tests.

4.3.2.3 Forged, rolled, wrought and fabricated valve components from raw materials from these processes need not be impact tested if the rated minimum temperature is higher than the ductile/brittle transition range temperatures of the material. Castings meeting the requirements of ASME B16.34:2017, Appendices I and IV or II and III (for forgings and rolled or wrought material) need not be impact tested if the rated minimum temperature is higher than the ductile/brittle transition range temperatures of the material. At least one randomly selected valve body material (including bonnet, if applicable) from each production-lot casting, not meeting the requirements of [4.3.2.3](#), shall be impact tested at the rated minimum temperature.

4.3.3 Non-metallic materials

Non-metallic materials are well established only for use for inserts on the disc or seat to provide leak tightness across the seat when the valve is closed. If such materials are to be used for structural parts, they shall have the properties appropriate to the application and be in accordance with ISO 21028-1 or ISO 21028-2, as appropriate to the rated minimum temperature.

Non-metallic materials shall also:

- have mechanical properties that allow the valve to pass the type approval test defined in [5.2](#);

- be resistant to sunlight, weather and aging;
- be in accordance with [4.3.5](#).

4.3.4 Corrosion resistance

In addition to resistance to normal atmospheric corrosion, particular care shall be taken to ensure that the valve cannot be rendered inoperative by accumulation of corrosion products. Some copper alloys are susceptible to stress corrosion cracking. Consequently, careful consideration shall be given before selection of these materials for components under stress.

4.3.5 Gas material compatibility

4.3.5.1 Oxygen compatibility

If the rated minimum temperature is equal to or below the boiling point of air or the valve is intended for service with oxygen or oxidizing products, the materials in contact with liquid air or oxidizing products shall be oxygen compatible in accordance with ISO 21010.

4.3.5.2 Hydrogen

For hydrogen service, the requirements of ISO 11114-1 and ISO 11114-2 shall apply.

4.3.6 Acetylene compatibility

Metallic materials shall contain less than 70 % copper if specified for use with mixtures containing acetylene.

5 Qualification and testing

5.1 Type approval

5.1.1 Verification of the design

A valve from the first production batch of each size and design shall be inspected and tested to ensure that the valve is in accordance with the design documentation and the requirements of this document. The sample valve shall pass the tests as described in [5.2](#). The design of the valve shall be in accordance with the requirements of ISO 4126-1 as applicable.

5.1.2 Model number

A unique model number shall be assigned to the valve which passed the type approval requirements.

5.2 Type approval tests

5.2.1 Ambient condition tests

5.2.1.1 Operating and flow characteristics tests

The tests shall be performed in accordance with the requirements of ISO 4126-1. The leak rate shall not exceed 3×10^{-3} Std cc/s \times DN at 90 % of the set pressure.

NOTE Std cc = cubic centimetres at standard conditions of 1,013 bar (0,101 3 MPa) and 15 °C.

5.2.1.2 Test of the repeatability of seat tightness at re-seat

Adjustment or maintenance of the sample relief valves is not permitted during these tests. The relief valves tested in 5.2.1.1 shall be tested additionally such that each category A valve is lifted to its full open position and re-seated a minimum of 1 000 times. The valves shall then be re-tested in accordance with 5.2.1.1 and shall meet the appropriate tolerances and limits and the leak rate shall not exceed 6×10^{-3} Std cc/s \times DN at 90 % of the set pressure.

NOTE Std cc = cubic centimetres at standard conditions of 1,013 bar (0,101 3 MPa) and 15 °C.

For each category B valve, the number of cycles is reduced to 20.

5.2.2 Cryogenic tests

5.2.2.1 General

Adjustment or maintenance of the sample relief valves is not permitted during these tests.

5.2.2.2 Test setup (see Figure 1)

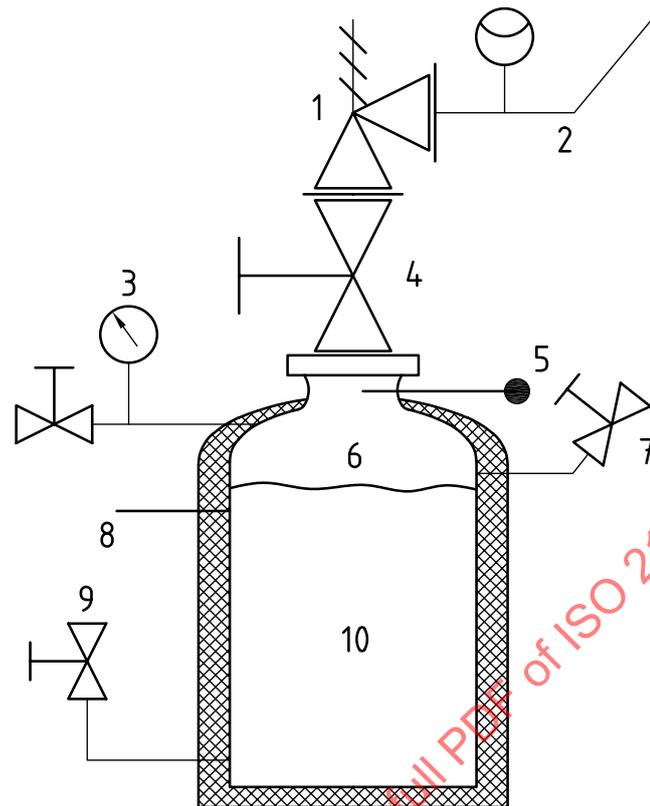
Each relief valve tested in 5.2.1.1 and 5.2.1.2 shall be subjected to a cryogenic test. The sample relief valve shall be connected to a reservoir, containing a cryogenic fluid, which may be controlled to achieve and maintain a pressure in excess of set pressure. The reservoir should be fitted with a proven pressure protection system with a set pressure in excess of the sample. The reservoir shall be of a design which ensures that the cryogenic fluid relieved by the sample valve will be at a temperature which does not exceed by more than 30 °C the equilibrium temperature of its contents.

An isolation valve may be installed between the reservoir and the sample relief valve to interrupt flow to the sample relief valve to cause it to re-seat. Where so fitted the volume of the piping between the isolation valve and the sample relief valve shall be not less than 10 l. It is thus ensured that there is an adequate quantity of gas available upstream of the sample relief valve to demonstrate its audible leak tightness.

The orientation of the valve during the test shall be in accordance with the installation instructions on the manufacturer's data sheet. If the manufacturer specifies more than one acceptable orientation of the valve, then the cryogenic testing shall be repeated for each orientation. The valve shall be fitted with any outlet pipe which the manufacturer has specified as necessary for the satisfactory operation of the valve.

The following safety precautions shall be taken:

- The use of ear protection and eye protection shall be required.
- Keep personnel not involved with the pressure relief valve (PRV) testing out of the area – preferably by testing in a room or area with limited access.
- Calculate the reaction force from the PRV and ensure that outlet piping is properly supported for that force.



Key

1	valve to be tested	6	gas phase
2	leakage meter/flow meter	7	venting valve
3	pressure meter	8	supply of test liquid
4	full bore valve	9	supply of test gas
5	test temperature	10	liquid phase

Figure 1 — Test setup under cryogenic condition

5.2.2.3 Test medium

The test cryogenic fluid shall be selected from those for which the valve is to be approved and shall be that which has the lowest equilibrium temperature at a pressure of 1 bar (0,1 MPa) absolute. Alternatively, the test fluid within the reservoir may be liquid nitrogen irrespective of the rated minimum temperature of the valve. In the case where the valve is intended to release a fluid that can condense from gas or vapour directly to solid, e.g. CO₂, at a relieving pressure and temperature within the range for which the valve is to be approved, the valve shall in addition be tested with this fluid at a pressure and temperature where the fluid will readily condense from gas or vapour directly to solid.

For low test pressures, the natural "boil-off" vapour from the cryogenic liquid can be enough to generate the required pressure. For higher pressures, it is acceptable to pressurize the vessel with high pressure gas. In this case, the gas can be identical to the cryogenic fluid used in the reservoir, or another fluid with a lower equilibrium temperature compatible with the cryogenic fluid in the reservoir.

5.2.2.4 Operational testing

5.2.2.4.1 General

All tests shall be completed sequentially and there shall be no delay between tests. Specified times have a tolerance of ± 1 min. The sample valve shall open without restriction and re-seat audibly leak tight within its specified pressure tolerances throughout the following tests.

If agreed between the relevant parties, water spraying may be eliminated during operational testing if an assessment of the operational characteristics of the valve reveals that the valve operation is unaffected by rain. The assessment shall be done by reviewing drawings and any other suitable information.

5.2.2.4.2 Test 1 — Effect of rainwater if deposited on or retained in the valve when warm

The sample valve shall be sprayed externally from above and on all sides with water from a horticultural watering can rose or alternative device that will simulate heavy rainfall for a period of 3 min. The water spray shall then be stopped and the sample valve permitted to drain for a period of 5 min.

If the intended installation of the valve is such that no water can accumulate in the outlet of the valve (refer to 4.2.2), the outlet of the valve shall be kept free of water during spraying.

Immediately thereafter the pressure shall be raised in the cryogenic reservoir to the valve set pressure to open and close the valve at least five times. The time between two openings shall be recorded. No variation of set pressure (± 4 % tolerance) is allowed. At the end of the test, the valve should be left closed at 90 % of set pressure for 5 min. After this period, the leak rate at the valve outlet shall not exceed 3×10^{-3} Std cc/s x DN at 90 % of the set pressure. There should be no visible or audible leakage at any other location on the valve.

NOTE Std cc = cubic centimetres at standard conditions of 1,013 bar (0,101 3 MPa) and 15 °C.

5.2.2.4.3 Test 2 — Effect of rainwater if deposited on or retained in the valve when cold

After successful completion of test 1, the pressure shall be raised in the cryogenic reservoir to the valve set pressure to open and close the valve at least 5 times. While the sample valve is cycling it shall be sprayed externally from above and on all sides with water from a horticultural watering can rose or alternative device that will simulate heavy rainfall. No variation of set pressure (± 3 % tolerance) is allowed. At the end of the test, the valve should be left closed at 90 % of set pressure for 5 min, while still maintaining the external water spraying. After this period the leak rate at the valve outlet shall not exceed 3×10^{-3} Std cc/s x DN at 90 % of the set pressure. There should be no visible or audible leakage at any other location on the valve.

NOTE Std cc = cubic centimetres at standard conditions of 1,013 bar (0,101 3 MPa) and 15 °C.

If the intended installation of the valve is such that no water can accumulate in the outlet of the valve (refer to 4.2.2), the outlet of the valve shall be kept free of water during spraying.

5.2.3 Alternate cryogenic tests

5.2.3.1 General

Valves which will not let water and ice in through the assembly and which will be required to be protected from accumulation of water and ice by adding 5.2.3 to type approval number may use the alternate cryogenic tests instead of those specified in 5.2.2.

5.2.3.2 Set pressure

The sample relief valve shall be connected to a pressure source which may be controlled to achieve and maintain a pressure in excess of set pressure plus over pressure of the valve. Install the valve