BS ISO 21013-4:2012

BSI Standards Publication

Cryogenic vessels — Pilot operated pressure relief devices

Part 4: Pressure-relief accessories for cryogenic service

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National foreword

This British Standard is the UK implementation of ISO 21013-4:2012.

The UK participation in its preparation was entrusted to Technical Committee PVE/18, Cryogenic vessels.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Cryogenic vessels — Pilot operated pressure-relief devices —

Part 4: Pressure-relief accessories for cryogenic service

Récipients cryogeniques — Dispositifs de sécurité pour le service cryogénique —

Partie 4: Dispositifs de sécurité pour la pression à pilotage automatique

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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.

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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.

ISO 21013-4 was prepared by Technical Committee ISO/TC 220, *Cryogenic vessels*.

ISO 21013 consists of the following parts, under the general title *Cryogenic vessels — Pressure-relief accessories for cryogenic service*:

— *Part 1: Reclosable pressure-relief valves*

— *Part 2: Non-reclosable pressure-relief devices*

— *Part 3: Sizing and capacity determination*

— *Part 4: Pressure-relief accessories for cryogenic service*

INTERNATIONAL STANDARD **ISO 21013-4:2012(E)**

Cryogenic vessels — Pilot operated pressure-relief devices —

Part 4: Pressure-relief accessories for cryogenic service

1 Scope

This part of ISO 21013 specifies the requirements for the design, manufacture and testing of pilot operated pressure-relief valves for cryogenic service, i.e. for operation with cryogenic fluids in addition to operation at temperatures from ambient to cryogenic. This part of ISO 21013 is restricted to valves not exceeding a size of DN 300 designed to relieve single phase vapours, gases, or mixtures of gases and/or vapours.

This part of ISO 21013 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 referenced documents are indispensable for the application 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 4126-4:2004, *Safety devices for protection against excessive pressure — Part 4: Pilot operated safety valves*

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

ISO 21010, *Cryogenic vessels — Gas/materials 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 23208, *Cryogenic vessels — Cleanliness for cryogenic service*

ASME B16.34, *Valves flanged, threaded and welding end*

EN 12516-2:2004, *Industrial valves — Shell design strength — Part 2: Calculation method for steel valve shells*

EN 12516-3:2002, *Valves — Shell design strength — Part 3: Experimental method*

EN 12516-4:2008, *Industrial valves — Shell design strength — Part 4: Calculation method for valve shells manufactured in metallic materials other than steel*

3 Terms and definitions

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

3.1
valve
complete assembly consisting of the main valve and its pilot valve

3.2
DN (nominal size)
alphanumeric designation of size for components of a pipework system, which is used for reference purposes

NOTE 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]

3.3
pressure
algebraic difference between the absolute pressure and the atmospheric pressure

NOTE This is also known as gauge pressure.

3.4
rated minimum temperature
lowest temperature for which the pressure-relief valve is rated by the manufacturer

3.5
cryogenic fluid
refrigerated liquefied gas which is partially liquid because of its low temperature

NOTE 1 This includes totally evaporated liquids and supercritical fluids.

NOTE 2 In the context of this part of ISO 21013, the refrigerated but non-toxic gases and gas mixtures given in Table 1 are referred to as cryogenic fluids.

Table 1 — Refrigerated but non-toxic gases

Classification Code	Identification number, name and description [a]	
3 °A	**Asphyxiant gases**	
	1913	Neon, refrigerated liquid
	1951	Argon, refrigerated liquid
	1963	Helium, refrigerated liquid
	1970	Krypton, refrigerated liquid
	1977	Nitrogen, refrigerated liquid
	2187	Carbon dioxide, refrigerated liquid
	2591	Xenon, refrigerated liquid
	3136	Trifluoromethane, refrigerated liquid
	3158	Gas, refrigerated liquid, N.O.S. (not otherwise specified)
3 °O	**Oxidizing gases**	
	1003	Air, refrigerated liquid
	1073	Oxygen, refrigerated liquid
	2201	Nitrous oxide, refrigerated liquid, oxidizing
	3311	Gas, refrigerated liquid, oxidizing, N.O.S.

Table 1 *(continued)*

Classification Code	Identification number, name and description [a]	
3 °F	**Flammable gases**	
	1038	Ethylene, refrigerated liquid
	1961	Ethane, refrigerated liquid
	1966	Hydrogen, refrigerated liquid
	1972	Methane, refrigerated liquid or natural gas, refrigerated liquid with high methane content
	3138	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
	3312	Gas. Refrigerated liquid, flammable, N.O.S.

[a] Classification codes, identification number, name and description according to the United Nations.

3.6
rated pressure
PR
maximum pressure difference between the inside and outside of any pressure retaining boundary for which it is designed to be operated at 20 °C

NOTE PR of the valve is the lowest PR of any component of the valve.

3.7
type 1 valve
relief valve which will open below a specified multiple of set pressure (e.g. 1.3 × set pressure) with the pilot disabled

3.8
type 2 valve
relief valve which will not open below a specified multiple of set pressure (e.g. 1.3 × set pressure) with the pilot disabled

3.9
valve category A
relief valve type which passed the test of the repeatability of seat tightness at re-seat of 1 000 cycles

3.10
valve category B
relief valve type which passed the test of the repeatability of seat tightness at re-seat of 20 cycles

4 Requirements

4.1 General

The valve shall satisfy all the requirements of ISO 4126-4 except in the event of conflicting or different requirements, when this part of ISO 21013 shall take precedence over ISO 4126-4.

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 Disc 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.

4.2.3 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.

4.2.4 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. CO_2, 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. In particular, the pilot shall be provided with some means to ensure its safe operation in case of deposition of solids within it.

4.2.5 Electric continuity

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

4.2.6 Set pressure

Set pressure of the valve shall not exceed its PR.

4.2.7 Minimum shell thickness

The minimum shell thickness shall be as specified in ISO 15761, ASME B16.34 or EN 12516-2, EN 12516-3 or EN 12516-4 as applicable for the pressure rating and size of the valve.

4.3 Materials

4.3.1 General

Material shall be in conformance with an internationally recognized standard and be compatible with the 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).

Materials not listed in an internationally recognized standard 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

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

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.

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 one of the applicable mandatory Appendices I and IV or II and III for forgings and rolled or wrought material of ASME B16.34 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 (including bonnet, if applicable) material from each production lot casting not meeting the requirements of this subclause 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 significant structural parts, they shall have the properties appropriate to the application. The ductile/brittle transition temperature of the material shall be below the rated minimum temperature of the valve, so as to

— have mechanical properties that will allow the valve to pass the type approval test defined in 5.2,

— be resistant to sunlight, weather and aging, and

— be compliant with 4.3.5.

4.3.4 Corrosion resistance

In addition to resistance to normal atmospheric corrosion, particular care must 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

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, see ISO 11114-1 and 11114-2.

4.3.5.3 Acetylene

Metallic materials shall contain less than 70 % copper if specified for use with mixtures containing acetylene. See also ISO 11114-1.

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 complies with the design documentation and the requirements of this part of ISO 21013. The sample valve shall pass the tests in 5.2. The design of the valve shall comply with the requirements of ISO 4126-4 as applicable.

5.1.2 Model number

A unique model number shall be assigned to the valve (equipped with all accessories, see 5.2) which has passed the type approval requirements. Any variation in configuration, including accessories, shall require a new model number.

5.2 Type approval tests

The configuration of the valve during all the tests shall be identical to the configuration corresponding to the model number in which it is intended to be used. Particularly, any accessories that will be fitted to the valve in service should also be fitted during all the tests, for example, but not limited to

— accessory for testing the set pressure on site,

— accessory to prevent back-flow in case of backpressure higher than inlet pressure,

— means of protecting non-metallic materials against extreme minimum rated temperature,

— pilot venting connected to the main valve outlet, and

— any other device or accessory.

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 4126-4. The leak rate shall not exceed 3×10^{-3} Cm^3S^{-1} (standard conditions) $\times$ DN at 90 % of the set pressure.

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 above shall be tested additionally such that each Category A valve is lifted 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} cm^3S^{-1} (standard conditions). DN at 90 % of the set pressure.

For category B valves 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 set up

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 rated minimum temperature of the relief valve or the temperature of liquid nitrogen at 110 % set pressure of the valve.

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.

If the valve to be tested has such a large capacity that, in the event of it releasing its full capacity suddenly and in an uncontrolled manner, this can create a serious hazard to the people or equipment nearby (for example by the reaction force or the noise created), it is acceptable to place a restricting orifice plate between the reservoir and the valve to be tested in order to limit the maximum capacity.

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 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 relieve a fluid that can condense from gas or vapour directly to solid, e.g. CO_2, at a relieving pressure and temperature within the range for which the valve is to be approved, the valve must 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 may 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 $\pm$ 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 tests 1 and 2 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. However, if the design is such that the pilot valve will vent directly to atmosphere, water spraying shall be performed during the tests.

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 three minutes. The water spray shall then be removed and the sample valve permitted to drain for a period of five minutes.

If the intended installation of the valve is such that no water can accumulate in the outlet of the valve, 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. There shall be no variation of set pressure ($\pm$3 % tolerance). At the end of the test, the valve should be left closed at 90 % of set pressure for five minutes. After this period, the leak rate at the valve outlet shall not exceed 3×10^{-3} cm^3S^{-1} DN. There should be no visible or audible leakage at any other location on the valve. The standard condition is 0 °C, 1 atmosphere.

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 five 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 ($\pm$3 % tolerance) is allowed. At the end of the test, the valve should be left closed at 90 % of set pressure for five minutes, while still maintaining the external water spraying. After this period, the leak rate at the valve outlet shall not exceed 3×10^{-3} cm^3S^{-1}. There should be no visible or audible leakage at any other location on the valve.

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

5.3 Production testing

Production testing shall be performed in accordance with the requirements of Clause 6 of ISO 4126-4:2004. Where a pressure test is required the test medium shall be clean water for hydraulic tests or dry oil free air or an inert gas such as nitrogen for pneumatic tests. Pneumatic testing is recommended. But if water is used as a test medium, the valve must be thoroughly dried after the test, taking particular care about any recesses and pockets.

6 Determination of the certified coefficient of discharge (K_{dr})

The performance of the safety valve shall be determined in accordance with ISO 4126-4.

The maximum value of the certified coefficient of discharge (K_{dr}) on an individual test shall not exceed 0.90.

7 Set pressure tolerances

Set pressure tolerances of pressure-relief valves shall not exceed 0.15 bar for pressures up to and including 5 bar and $\pm$ 3 % of set pressure for pressures above 5 bar.

8 Re-seating pressure

The value of inlet static pressure at which the disc (plug) re-establishes contact with the seat or at which lift becomes zero shall not be less than 90 % of the set pressure of the pressure-relief valve, unless otherwise agreed by the parties.

9 Cleanliness

Before assembly of the valve, all parts shall be clean such that they satisfy the requirements of ISO 23208.

The assembled valve shall satisfy the requirements of ISO 23208.

10 Marking

10.1 Marking on the shell body of the main valve

Marking on the body of the main valve may be integral with the body or on a plate securely fitted on the body. The following minimum information shall be marked on all main valves:

a) size designation of inlet;

b) material of the body;

c) manufacturer’s name or trademark;

d) an arrow sign ($\rightarrow$) showing the direction of flow, where the inlet and outlet connections have the same dimensions or the same pressure rating;

e) rated pressure (PR);

f) serial number.

10.2 Marking on the body of the pilot valve

Marking on the body of a pilot valve may be integral with the body or on a plate securely fitted on the body. The following minimum information shall be marked on the body of each pilot valve:

a) material designation of the body of the pilot valve;

b) manufacturer's name or trademark;

c) identification of the various ports directly on the body;

d) set pressure in bar gauge or pascals;

e) serial number.

10.3 Marking on an identification plate

The following minimum information shall be given on an identification plate securely attached to the pressure-relief valve, ideally by welding or riveting if possible or using stainless steel wire as a minimum:

a) the limiting operating temperature(s), in degrees Celsius or Kelvin, for which the valve has been type tested;

b) set pressure, in bar or pascals;

c) the designation ISO 21013-4 with the letter B in case of Category B valve;

d) type approval number of valve or model number of valve (see 5.1.2);

e) a unique serial number that allows identification of the individual valve, and if alternate cryogenic tests were used for type approval (see 5.2.2);

f) the date when the final production acceptance test of the fully assembled valve was completed and the valve was sealed;

g) rated coefficient of discharge or certified discharge capacity (stating units) indicating reference fluid and its state: G for gas, S for steam, and L for liquid. The designation of the fluid state shall be placed before the rated coefficient of discharge or certified discharge capacity. Overpressure, as a percentage of set pressure, required for the rated certified discharge capacity shall also be marked, for example

   — G100 kg/h of air @OP120,

   — G-0,815;

h) orifice (flow) area, in square millimetres;

i) minimum value of the lift, in mm, and corresponding overpressure, expressed as, e.g. a percentage of set pressure;

j) fail-safe lift pressure, in bar or pascals.

10.4 Additional marking

Additional marking may be required by applicable regulation, e.g. CE, UV marking.

11 Sealing

All external adjustments shall be sealed. The pilot valves shall be sealed to the main valve. Sealing shall be done by a body authorized to do so.

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