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Ships and marine technology — Safety valve for cargo tanks of LNG carriers — Design and testing requirements

Navires et technologie maritime — Soupape de sûreté pour les réservoirs de cargaison des méthaniers — Exigences de conception et d'essai

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Foreword

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This document was prepared by ISO Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 3, *Piping and machinery*.

Ships and marine technology — Safety valve for cargo tanks of LNG carriers — Design and testing requirements

1 Scope

This document specifies the requirements of design, test and inspection methods for diaphragm-type pilot operated safety valves, which are used in cargo tanks of LNG carriers in order to keep the pressure inside the tank below maximum allowable working pressure.

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 4126-4, *Safety devices for protection against excessive pressure — Part 4: Pilot operated safety valves*

IMO, *The International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)*

API STD 527, *Seat Tightness of Pressure Relief Valves*

ASME B16.34, *Valves-Flanged, Threaded and Welding End*

3 Terms and definitions

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

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
blowdown
difference between the set and reseating pressures

Note 1 to entry: Blowdown is normally stated as a percentage of set pressure, except for pressures of less than 3 bar, when the blowdown is expressed in bar.

3.2
flow area
cross-sectional area (but not the curtain area) between inlet and seat that is used to calculate the theoretical flow capacity of the main valve, with no deduction for any obstruction

3.3
lift
actual travel of the main valve disk away from the closed position

3.4
pilot operated safety valve
automatic, self-actuated device comprising a main valve and an attached pilot valve

Note 1 to entry: The pilot responds to the pressure of the fluid without any other energy source than the fluid itself, and controls the operation of the main valve. The valve opens when the fluid pressure increases to the pilot valve set point. The valve re-closes when the fluid pressure is reduced to reseating pressure. See Figure 1.

3.5
reseating pressure
value of the inlet static pressure at which the disk re-establishes contact with the seat or at which the lift becomes zero

3.6
set pressure
tank pressure at which the main valve of a pilot operated safety valve under operating conditions begins to open

3.7
theoretical discharge capacity
calculated capacity expressed in mass or volumetric units of a theoretically perfect nozzle having a cross-sectional flow area equal to the flow area of a main valve

3.8
vacuum set
negative tank pressure value at which the valve starts to open under working conditions

4 Main valve components

4.1 Body

The body inlet is connected directly to the tank, and the exit is connected to a discharge pipe. It keeps the pressure contained and endures the reaction of pressurized fluid discharged from the system.

4.2 Nozzle

It jets out pressurized fluid to the discharge pipe.

4.3 Disk

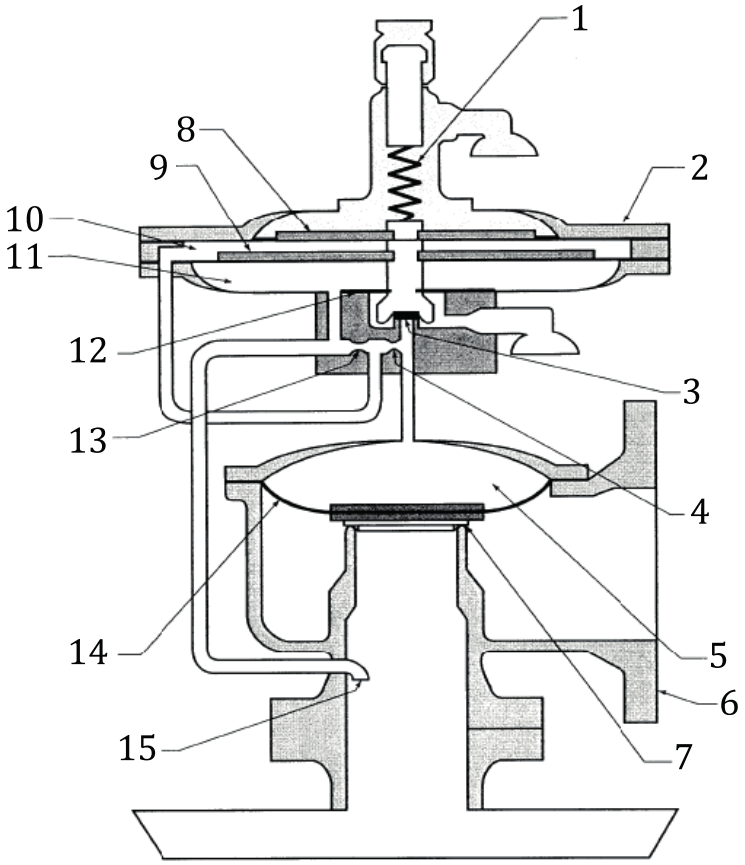
It works with the seat to provide sealing function to prevent leakage when it is closed. It is in direct contact with the working fluid, and may be damaged part if the fluid contains solids or foreign material.

4.4 Cover

It is connected to the body and makes a pressure space where flow can occur.

4.5 Diaphragm

It is a main component assembled between the main valve body and the cover. It delivers the fluid pressure to the disk.



Key

1	pilot spring	9	boost diaphragm
2	pilot valve	10	sense cavity
3	pilot seat	11	boost cavity
4	fixed orifice	12	spindle seal diaphragm
5	dome	13	blowdown adjustment orifice (variable)
6	main valve	14	main valve diaphragm
7	main valve seat	15	pilot pickup
8	sense diaphragm		

Figure 1 — Main components of pilot operated safety valve (Diaphragm type)

5 Design

5.1 The design shall incorporate guiding arrangements necessary to ensure consistent operation and seat tightness.

5.2 The nozzle of the main valve, other than when it is an integral part of the valve body, shall be fastened securely to prevent the seat from becoming loose in service.

5.3 Valve operation shall be designed to provide consistent, proper function in very low pressure and cryogenic services.

5.4 Means shall be provided to lock and/or to seal all external adjustments to prevent unauthorized adjustments of the pilot operated safety valve.

5.5 In the case of main valves with restricted lift, the lift restricting device shall limit the main valve lift but shall not otherwise interfere with the operation of the main valve. The lift restricting device shall be designed, installed and sealed by the valve manufacturer.

5.6 Pilot operated safety valves for flammable fluids shall discharge to a non-hazardous location.

5.7 Valves shall be designed so that tear or damage to the diaphragm can be checked without disassembly.

5.8 It shall be designed that fluid can be fully released under 1,1 times of the maximum allowable pressure of the protection system.

5.9 The fitting of any additional device to a pilot and valve combination shall not prevent the pressurized system from being protected under any circumstances.

6 Materials

6.1 Materials of the valve used near slippery surfaces, such as disk, disk guide and holder/spindle, shall be corrosion resistant and wear resistant. These materials shall also have durability in very low temperature environments.

6.2 Gaskets that have sealing functions shall be constructed of materials having durability in –163 °C environment.

6.3 Materials of the body and nozzle that are directly exposed to very low temperature environments shall be equal to CF3M.

6.4 The spring materials shall be equal to CF3M for durability in very low temperatures.

6.5 The materials of all other components shall have durability in very low temperatures.

7 Production testing and inspection

7.1 Purpose

The purpose of these tests is to ensure that pressure retaining components, especially castings, meet the requirements for which they have been designed and manufactured without exhibiting any form of quality defect.

7.2 Impact test

Castings, such as body and nozzle etc., shall satisfy the V-notch criteria of Charpy impact testing in accordance with IGC code 6.1.4.

7.3 Non-destructive inspection

If the material is casting, the inside or outside of the material shall be tested by non-destructive inspection. Normally, a radiographic test (RT) is conducted, but alternative non-destructive inspection can be conducted by requirement of the purchasers.

7.4 Pressure test

7.4.1 General requirement

It is conducted on castings such as the nozzle, body and cover. These components shall not have deformation, leakage or any other unusual condition when 1,5 times of set pressure is applied according to ASME B16.34.

7.4.2 Fluid

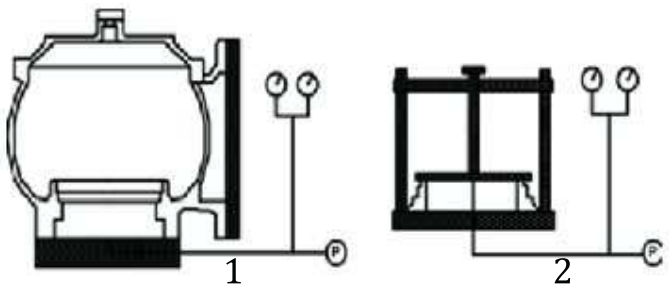
Pressure test shall be conducted by water or air pressure. The working fluid shall be fresh water and conducted in ambient temperature.

7.4.3 Duration

It shall be for 15 min after applying test pressure.

7.4.4 Test equipment

An example of the equipment is shown in Figure 2.



Key

1 body and cover

2 nozzle

Figure 2 — Water pressure test equipment

7.5 Surface inspection

It shall be checked and verified that there are no shrinkage cavities, burrs, sand inclusions or cracks on the inside and outside of the casting surface. If there are cracks, the decision shall satisfy ISO 4126-4.

7.6 Visual inspection

7.6.1 Forgings shall be checked for evidence of cracks.

7.6.2 There shall not be any defects on machined surfaces directly contacting the gasket. Corners or edges shall be rounded out and chamfered.

8 Performance test

8.1 Performance test in ambient temperature

8.1.1 Purpose

The purpose is to check that the valve is working well under set pressure and tolerance in ambient temperature.

The set pressure and tolerance shall satisfy Table 1.

Table 1 — Tolerance of set pressure

Service	Set pressure		Tolerance
Cargo tank	Set pressure	25 kPa[ab]	±10 % of set pressure

[a] Actual set pressure shall satisfy purchasers' specification.

[b] Tolerance for negative pressure is ±25 %.

8.1.2 Number of test times

The manufacturers and the purchasers may reach an agreement for the number of performance test times, but the test shall be conducted at least 50 times for performance consistency.

8.1.3 Fluid

Inert gas and air shall be used.

8.1.4 Acceptance criteria

The valve shall be open under the tolerance of set pressure.

8.2 Leakage test in ambient temperature

8.2.1 Purpose

The purpose of this test is to verify the air tightness on the seat when the valve is closed in ambient temperature.

8.2.2 Fluid

Air or N_2 shall be used.

8.2.3 Test pressure

It shall be started at 90 % of the set pressure.

8.2.4 Duration

It shall be retained for at least 5 min.

8.2.5 Acceptance leakage rate

Leakage rate of the safety valve between the disk and seat shall be less than 0,06 ml/min/mm (1,5 cm^3/min/inch diameter).

8.2.6 Test equipment

Inspection method is shown in Figure 3. Leakage measurement shall be conducted using 1,0 mm wall thickness and 8,0 mm outer diameter pipe according to API STD 527.

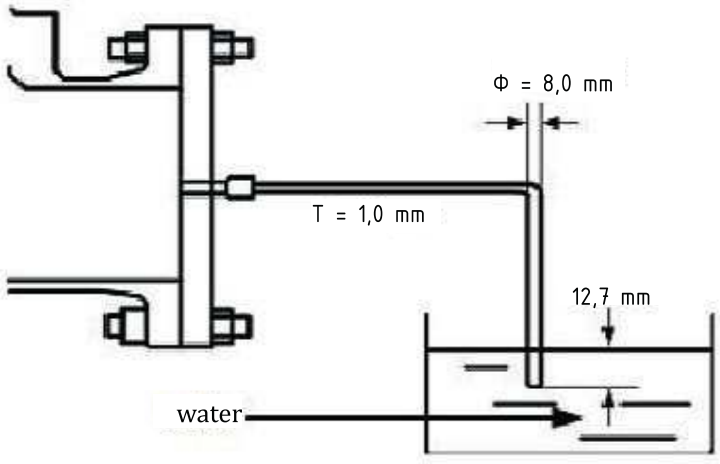


Figure 3 — Leakage inspection method

8.3 Performance test in low temperature

8.3.1 Purpose

The purpose of this test is to check that the valve is working accurately under the set pressure and the tolerance. The set pressure and tolerance shall satisfy Table 1.

8.3.2 Number of test times

The manufacturers and the purchasers may reach an agreement for the number of performance test times, but the test shall be conducted at least three times.

8.3.3 Fluid

Helium gas shall be used.

8.3.4 Acceptance criteria

The valve shall open under the tolerance of set pressure.

8.4 Preparation for the performance test in low temperature

8.4.1 Start temperature for the test

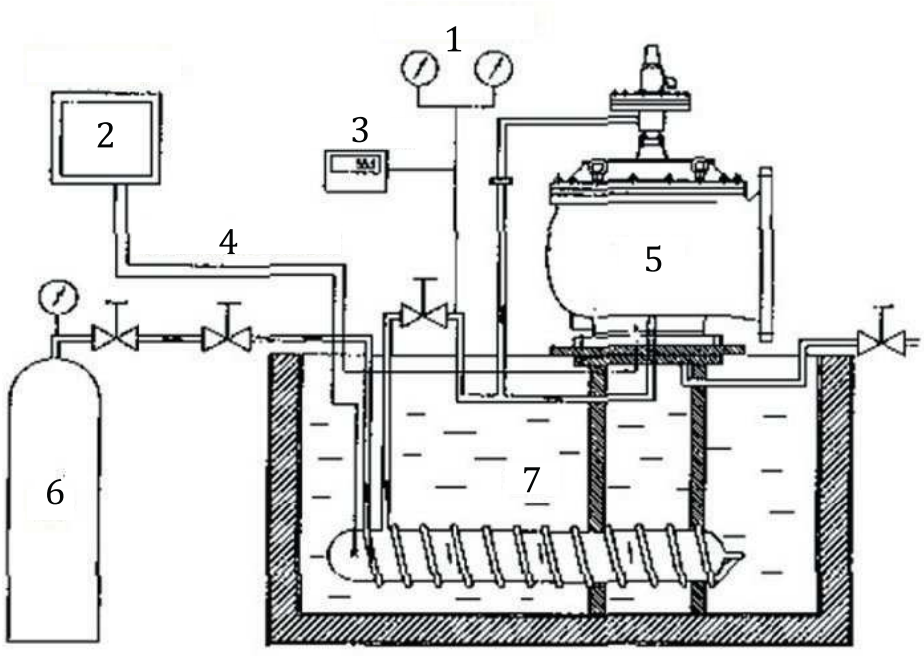
The test shall be started after the inside of the nozzle temperature reaches –163 °C; the temperature shall be measured by a thermocouple. Also, the temperature shall be dropped by LN_2 or similar liquid to LN_2.

8.4.2 Safety requirement

Protective gear must be used during the test.

8.4.3 Test system

The test system may be constructed as shown in Figure 4. Other suitable test systems may be applied.



Key

1 pressure gauge
2 thermocouple
3 digital manometer
4 temperature sensor
5 POV
6 He
7 LN2

Figure 4 — System for performance test in low temperature (example)

8.5 Leakage test in low temperature

8.5.1 Purpose

The purpose of this test is to verify the air tightness on the seat when the valve is closed in low temperatures.

8.5.2 Fluid

Helium gas, which is below –163 °C, shall be used.

8.5.3 Test pressure

It shall be started at 90 % of the set pressure.

8.5.4 Duration

It shall be retained for at least 5 min.

8.5.5 Acceptance tolerance

Leakage tolerance of the safety valve between the disk and seat shall be less than 0,06 ml/min/mm (1,5 cm^3/min/inch diameter).

8.5.6 Test equipment

Inspection method is as shown in Figure 3. Leakage measurement shall be conducted using 1,0 mm wall thickness and 8,0 mm outer diameter pipe according to API STD 527.

9 Vacuum test

9.1 Purpose

In the case of safety valve for cargo tank of LNG carriers, the function shall be satisfied in a vacuum environment. The purpose of this test is to check the relief function of the valve under the given vacuum condition.

In the case of safety valve for cargo tank of LNG carriers, it is possible to check the result when the vacuum set is satisfied in a vacuum environment.

9.2 Vacuum condition

The degree of vacuum and tolerance shall satisfy Table 2.

Table 2 — Degree of vacuum and tolerance

Service	Degree of vacuum		Tolerance
Cargo tank	Vacuum set	1 kPa, Gauge[a]	±25 % of Vacuum set
[a] Actual set pressure shall satisfy purchasers' specification.			

9.2.1 Test temperature

The test shall be conducted in ambient temperature.

9.2.2 Vacuum set test

The vacuum test shall be conducted at vacuum set pressure.

9.2.3 Number of test times

The manufacturers and the purchasers may reach an agreement for the number of performance test times, but the test shall be conducted at least three times.

9.2.4 Fluid

Air or inert gas shall be used.

10 Type test

It shall satisfy ISO 4126-4.

11 Determination of pilot operated safety valve performance

It shall satisfy ISO 4126-4.

12 Sizing of pilot operated safety valves

It shall satisfy ISO 4126-4.

13 Marking and sealing

It shall satisfy ISO 4126-4.

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