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**Ships and marine technology —  
Pressure-vacuum valves for cargo  
tanks and devices to prevent the  
passage of flame into cargo tanks**

*Navires et technologie maritime — Soupapes de pression/dépression pour citernes à cargaison et dispositifs pour empêcher le passage des flammes vers les citernes à cargaison*

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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](http://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](http://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 WTO principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

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

This fourth edition cancels and replaces the third edition (ISO 15364:2016), which has been technically revised.

The main changes compared to the previous edition are as follows:

- expansion of the Scope to include devices to prevent the passage of flame into cargo tanks;
- inclusion of requirements for flame transmission tests.

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](http://www.iso.org/members.html).

# Ships and marine technology — Pressure-vacuum valves for cargo tanks and devices to prevent the passage of flame into cargo tanks

## 1 Scope

This document is applicable to pressure-vacuum valves and to devices to prevent the passage of flame, both protecting cargo tanks, that can be subject to explosive gas/vapour and/or to gas/vapour pressure or vacuum beyond the design parameters of the system/tank. It specifies the minimum requirements for performance and testing. It also specifies design and in-service performance criteria, operational testing and maintenance requirements. Design or manufacturing in accordance with this document does not imply suitability for any given installation, it indicates that certain minimum requirements have been considered and that information necessary for determination of suitability is provided to the buyer of the equipment.

The flame test procedures of ISO 16852:2016 are incorporated in this document.

NOTE Minimum requirements for devices to prevent the passage of flame are found in the International Maritime Organization (IMO) “International Convention for the Safety of Life at Sea, as amended” (SOLAS), Chapter II-2, Regulation 4, and IMO Maritime Safety Committee (MSC) Circular No. 677 (MSC/Circ. 677), “Revised Standards for the Design, Testing and Locating of Devices to Prevent the Passage of Flame into Cargo Tanks in Tankers”, as amended.

## 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 16852:2016, *Flame arresters — Performance requirements, test methods and limits for use*

International Maritime Organization Maritime Safety Committee circular 677 (MSC/Circ. 677), *Revised Standards for the Design, Testing and Locating of Devices to Prevent the Passage of Flame into Cargo Tanks in Tankers*, as amended by IMO MSC/Circ. 1009 and MSC/Circ. 1324

## 3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

### 3.1

#### flame arrester

device fitted to the opening of an enclosure, or to the connecting pipe work of a system of enclosures, and whose intended function is to allow flow but to prevent the transmission of flame

**3.2**

**dual nozzle valve**

pressure relief valve that features two high velocity vents with different opening settings integrated into one valve, the flow characteristics of which can be of one or more of the designs *full opening valve* (3.3), *modulating valve* (3.7) or *transition point valve* (3.11)

**3.3**

**full opening valve**

design that opens fully at maximum 2 % above the set pressure

**3.4**

**high velocity vent valve**

pressure relief valve designed always to have efflux velocities that prevent the flame propagation against the flow direction

**3.5**

**maximum experimental safe gap**

**MESG**

maximum gap of a joint of 25 mm in width which prevents any transmission of an explosion during tests

Note 1 to entry: ISO/IEC 80079-20-1 specifies the test apparatus and the test method.

**3.6**

**maximum intended pressure drop**

largest pressure drop generated over a device for which the test laboratory verifies the corresponding flow capacity

**3.7**

**modulating valve**

design that opens proportionally with rise in pressure

**3.8**

**pressure-vacuum valve**

device to relieve the pressure or vacuum formed inside the cargo tanks by opening the valves at the designated setting value to protect the tank from over-pressure or vacuum exceeding the design parameters of the tanks

**3.9**

**standard conditions**

dry air at 288,15 K (15,00 °C; 59,00 °F) and 101,325 kPa

**3.10**

**third party inspection body**

organization independent from the manufacturer and user, that is qualified to perform or witness the tests and inspections

**3.11**

**transition point valve**

design where the valve characteristics change from modulating to full opening at a particular pressure

**3.12**

**verified drawing**

drawing certified to be authentic and complete by the *third party inspection body* (3.10) issuing the test report

**3.13**

**verified flow chart**

pressure versus flow volume presented in a chart certified by the *third party inspection body* (3.10) issuing the test report

#### 4 Symbols and abbreviated terms

|                       |  |
|-----------------------|--|
| $D$                   | pipe inner diameter at device connection   |
| $D_{\min}$            | minimum inner diameter of the piping between the device and the tank allowed for non-oscillating performance   |
| $L_{\max}$            | maximum length of the piping between the device and the tank allowed for non-oscillating performance   |
| $L_1$                 | pipe length between the test tank and the device for flow testing  |
| $L_2$                 | pipe length between the test tank and the device during non-oscillation testing  |
| $P_{\text{closing}}$  | value of inlet pressure at which the valve disk re-establishes contact with the seat or at which lift becomes zero, when the valve is closing and pressure is decreasing       |
| $P_{\text{closing1}}$ | value of inlet pressure at which the valve disk re-establishes contact with the seat or at which lift becomes zero, when the main valve is closing and pressure is decreasing  |
| $P_{\text{closing2}}$ | value of inlet pressure at which the valve disk re-establishes contact with the seat or at which lift becomes zero, when the extra valve is closing and pressure is decreasing |
| $P_{\max}$            | maximum pressure corresponding to the maximum flow volume ( $Q_3$ )  |
| $P_{\text{set}}$      | gauge pressure at the device inlet at which the valve is designed to start opening   |
| $P_{\text{set1}}$     | gauge pressure at the device inlet at which the main valve is designed to start opening  |
| $P_{\text{set2}}$     | gauge pressure at the device inlet at which the extra valve is designed to start opening   |
| $P_{1\text{-tpv}}$    | pressure at which a transition point valve changes from modulating to full opening   |
| $Q_{1\text{-fov}}$    | flow volume needed to open a full opening valve  |
| $Q_1$                 | flow volume needed to open the second nozzle   |
| $Q_2$                 | flow volume needed for a valve to remain fully open  |
| $Q_{2\text{-fov}}$    | flow volume needed to maintain a full opening valve fully open at $P_{\text{set}}$   |
| $Q_{1\text{-mv}}$     | flow volume needed to open a modulating valve  |
| $Q_{2\text{-mv}}$     | flow volume needed to maintain a modulating valve fully open   |
| $Q_{1\text{-tpv}}$    | flow volume at which a transition point valve changes from modulating to full opening  |
| $Q_{2\text{-tpv}}$    | flow volume needed to maintain a transition point valve fully open at $P_{1\text{-tpv}}$   |
| $Q_3$                 | flow volume corresponding to the maximum intended pressure drop over the device  |
| $Q_{\text{close}}$    | minimum flow required to keep the valve partially open with no contact between the disc and the seat   |
| $Q_{2\text{ total}}$  | flow volume needed to maintain the main and extra valves fully open at $P_{\text{set1}}$   |
| $Q_{3\text{ total}}$  | flow volume corresponding to the maximum intended pressure drop over the dual nozzle valve   |
| $V_{\min}$            | minimum volume of the tank allowed for non-oscillating performance   |

## 5 Materials

**5.1** The device housing, and other parts or bolting used for pressure retention, shall be constructed of materials suitable for the intended service and listed in a recognized national standard or International Standard. Housings, discs, spindles, seats, springs, gaskets, seals, flame arresters (when included in the design) and all other integral parts, including parts with coatings to prevent corrosion, shall be resistant to attack by sea water and the liquids and vapours contained in the tank being protected (see [Annex D](#) for guidance on the material selection). Springs plated with corrosion resistant material are not acceptable.

**5.2** Non-metallic materials, other than gaskets, seals and diaphragms as allowed by [6.11](#), shall not be used in the construction of pressure retaining components of the device. Resilient seals may be installed only if the device is still capable of effectively performing its flame arresting function when the seals are worn down, partially or completely damaged or burned. Non-metallic gaskets shall be made of non-combustible material and suitable for the service intended.

**5.3** The possibility of galvanic corrosion shall be considered in the selection of materials (see [Annex E](#) for additional considerations on corrosion protection).

**5.4** The verified drawings shall include a complete bill of materials showing conformity with this subclause and any other material requirements listed in [Clause 6](#).

## 6 Other requirements

**6.1** The maximum gas leakage rate shall be provided and expressed as the volume in standard conditions that can leak from the valve at 75 % of the nominal setting as determined by the manufacturer. Maximum leakage rates are given in [Annex J](#).

**6.2** Housings, elements, and seal gasket materials shall be capable of withstanding the maximum and minimum pressures and temperatures to which the device may be exposed under normal operating conditions. Flat surfaces of flanges shall be machined to provide for adequate joint integrity.

**6.3** Where welded construction is used for pressure retaining components, welded joint design details, welding and non-destructive testing shall be in accordance with national standards or International Standards. Welding procedures should be in accordance with the ISO 15607 series. Welders should be qualified according to the ISO 9606 series. Non-destructive testing should comply with ISO 5817.

Alternative equivalent national standards or International Standards may be used.

**6.4** Pressure-vacuum valves shall be designed, such that condensed vapour and water in the pressure-retaining zone drain from the device into the tank and do not impair the efficiency of the device. The design shall also prevent the accumulation of water inside the device and subsequent blockage due to freezing. The design shall prevent pockets of water or product from accumulating.

**6.5** All fasteners essential to the operation of the device shall be protected against loosening.

**6.6** Devices shall be designed and constructed to minimize the effect of fouling under normal operating conditions.

**6.7** Devices shall be capable of operating over the full range of ambient air temperatures anticipated and in freezing conditions, provided that the check-lift is operated to break the ice layer. If a heating

arrangement is applied, the surface temperature developed may not exceed the maximum design temperature.

Where a valve is intended to be fitted in a ship that will be operated in climate conditions that might hamper its operation, e.g. seawater icing, the instruction manual shall contain appropriate information to ensure continued operation.

**6.8** End-of-line devices are required to direct the efflux vertically upward. Further, for high velocity vent valves, the minimum average velocity of efflux through a cross section of the valve's outlet to atmosphere shall not be less than 30 m/s for all flow rates.

**6.9** A manual means (e.g. check-lift) shall be provided to verify that any valve disc and other moving elements lift freely and fully and do not remain in the open position. The manual means shall be part of the valve assembly and be operated without the need to add or remove parts. The design shall be such that the device is verified not to be inoperable due to corrosion, residue build-up or icing, when the aforementioned manual means is used in combination with the manufacturer's requirements for visual inspection.

**6.10** Valve discs and other moving parts shall be guided by a suitable means to prevent binding and to ensure proper self-closing (seating), taking into account the possible build-up of condensed vapours.

NOTE Maintenance in accordance with the manufacturer's requirements is normally necessary to ensure proper valve operation.

Valve discs and other moving parts shall close against the valve seat by metal to metal contact. Where the valve closes against a metal seat and a resilient seal is added to reduce gas leakage, the valve's performance in terms of flow shall not be affected if the seal is destroyed, damaged or is otherwise carried away.

Valve discs may be solid or made hollow so that weight material can be added to vary the lifting pressure. If hollow discs are employed, a watertight bolted cover shall be fitted to encase the weight material. A clear indication, visible from the outside of the valve, shall be employed to indicate the position of the valve disc(s). The indicator shall be visible from below and from the side of the valve at deck level.

**6.11** Valves may be actuated by non-metallic diaphragms except where failure would result in unrestricted flow of tank vapours to the atmosphere or in an increase in the pressure or vacuum at which the valve normally releases.

**6.12** Relief pressure adjusting mechanisms shall be permanently secured by lockwire, locknuts, or other suitable means to prevent devices from becoming misadjusted due to handling, installation, or vibration.

**6.13** The design shall be such that the device can be examined for any build-up of residue due to vapour condensation. For certain cargoes that solidify, heating arrangements may be necessary.

**6.14** Devices shall not be bypassed or blocked open unless they are tested in the bypassed or blocked open position in accordance with [Annex C](#).

**6.15** Flame arrester elements shall fit in the housing in such a way that flame cannot pass between the element and the housing.

**6.16** Resilient seals shall be installed only if their design is such that if the seals are partially or completely damaged or burned, the device is still capable of effectively preventing the passage of flame.

**6.17** Devices shall allow for efficient drainage of moisture without impairing their efficiency to prevent the passage of flame.

**6.18** The casing and element and gasket materials shall be capable of withstanding the highest pressure and temperature to which the device may be exposed under both normal and specified fire test conditions.

**6.19** Detonation arresters shall be able to withstand, without damage or permanent deformation, the internal pressure resulting from detonation when tested in accordance with [Annex C](#).

**6.20** Flame arresting elements shall be:

- 1) designed in such a manner that they cannot be inserted improperly in the opening;
- 2) securely fitted in openings so that flames cannot circumvent the screen;
- 3) protected against mechanical damage.

**6.21** Means to offset the opening of a pressure or vacuum valve beyond the set pressure shall be designed in a failsafe manner and shall not prevent any required inspection procedures to be carried out. The offset opening pressure shall be verified and clearly marked.

## 7 Type tests

**7.1** Type tests shall be conducted by a laboratory acceptable to a third party inspection body. The laboratory shall be qualified to conduct the tests provided for by this document and shall have (or shall have access to) the apparatus, facilities, personnel and calibrated instruments necessary for the tests. Alternatively, the tests provided for by this document may be conducted by the manufacturer when the tests are witnessed by a third party inspection body who can certify that the tests are conducted in accordance with this document.

**Note** For certain tankers, the Laboratory must be acceptable to the Administration under whose authority the ship operates and/or a valve is intended to be fitted.

**7.2** One of each model device and each size shall be tested in accordance with [Clauses 7, 8](#) and [9](#). A change of material or coating system that negatively affects the corrosion resistance shall be considered a change of model for the purpose of this paragraph. A change of design or construction shall be considered a change of model for the purpose of this paragraph. Each size of each model shall be submitted for type testing. For end-of-line deflagration flame arresters of the same design series, testing may be limited to the smallest and the largest sizes. Devices should have the same dimensions and most unfavourable clearances expected in the production model. If a device is modified during the test programme, or at a later date, such that the functions of the valve or its performance characteristics are affected, the third party inspection body shall be informed. An appropriate test related to the modified part may be required by the third party inspection body.

Devices shall be tested in accordance with [7.2.1](#) and [7.2.2](#) and thereafter shown to meet the test requirements of [Annex C](#), as appropriate.

**7.2.1** A corrosion test shall be conducted. In this test, a complete device shall be exposed to a 5 % sodium chloride solution spray at a temperature of 25 °C (77 °F) for a period of 240 h, and allowed to dry for 48 h. Following this exposure, all movable parts shall operate properly and there shall be no corrosion deposits that cannot be washed off.

**7.2.2** The pressure retaining boundary of the device shall be subjected to a hydrostatic pressure test of at least 150 % of maximum rated pressure or a minimum pressure of 345 kPa gauge (50 psig<sup>1)</sup>), whichever is greater, for 10 min without rupturing, leaking, or showing permanent distortion. For the purposes of this test, the disc may be gagged or blocked.

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1) 1 psig = 1 lbf/in<sup>2</sup> gauge.

**7.2.3** Performance characteristics as declared by the manufacturer, such as flow rates under both positive and negative pressure, operating sensitivity, working stability for dual nozzle valve, leakage, flow resistance and velocity, shall be verified by laboratory tests.

**7.2.4** An external ice test shall be conducted for pressure-vacuum valves to verify the allowable accumulation of an external layer of ice at which the valve check-lift will still operate. In this test, a complete device shall be exposed to a temperature of -10 °C (14 °F) for a period of 24 h. Following this initial exposure, 1 l (1,7 pints) of water at no more than 2 °C (35,6 °F) shall be sprayed every 10 min on to the outside of the valve until the specified ice thickness is achieved. After achieving the specified thickness, proper operation of the valve check-lift shall be verified. The maximum ice thickness at which the valve check-lift will operate properly shall be noted in the instruction manual (see [Clause 11](#)).

**7.2.5** Devices to prevent the passage of flame shall also be tested for flame transmission according to ISO 16852:2016 (see [Annex C](#)).

**7.3** A test report with documentation for each prototype test shall be prepared by the laboratory. Further to the requirements given in ISO/IEC 17025:2017, 7.8, the test report shall as a minimum, include:

- types of test conducted, and results obtained with such recorded data to allow verification of the tests. Where detonation arresters are tested, this information shall include the maximum pressures and velocities observed in the test;
- assessment of the mechanical design requirements in accordance with [Clause 5](#) and [6](#);
- drawings of the test rig, including a description of the inlet and outlet piping attachments;
- an instruction manual;
- detailed drawings of the device;
- specific advice on approved attachments;
- types of cargo for which the device is approved;
- in the case of high velocity vents, the pressures at which the device opens and closes and the efflux velocity;
- all the information marked on the device in accordance with [Clause 12](#).

## 8 Flow and velocity tests

### 8.1 Determination of capacity

The capacity of the device shall be established by flow testing of at least one production model of every type and size of venting device, under the conditions specified in [8.2](#) to [8.4](#).

Where a pressure or vacuum valve is used with a flame arrester, the capacity of the overall assembly is different than the capacity of a standalone valve. The capacity test shall be conducted on the combined assembly.

Capacity measurements for flame arresters in accordance with ISO 16852 is also acceptable.

### 8.2 Capacity data

The following requirements shall be met when establishing capacity data:

- a) the pipes, as well as the connections between the pipes and the device, shall be without obstructions causing additional turbulence;

- b) the inner diameter of the test pipe shall be of the same or larger diameter than the connection flange of the device being tested;
- c) all pressure measuring points shall be arranged normal to the pipe axis and shall not influence the flow;
- d) the test medium shall be air at ambient conditions; ambient pressure and temperature shall be recorded to convert flow rate to standard conditions;
- e) all measuring instruments shall be calibrated.

### 8.3 Test apparatus

The test apparatus is shown in [Figure 1](#). The dimensions of the tank (key 3) shall be sufficient to allow a mean flow velocity of less than 0,5 m/s in the tank. All tank pressure data shall be recorded under these conditions.

The test pipe  $L_1$  shall have a length of no more than  $5D$  and a length no less than  $1,5D$  of the test specimen. The tank penetration should be at a location of the tank where it is essentially flat and the rounding of the penetration shall be in accordance with a recognized national standard or International Standard to provide uniform pressure drop influence.

Vacuum valves shall have the flow direction reversed.

**CAUTION — It should be observed that the blower or fan may cause oscillation in the system if the fan wings are not aligned or damaged. This should be avoided.**

### 8.4 Flow measurements

**8.4.1** Flow measurements for pressure-vacuum valves shall be made using the lowest and highest setting for the specific model. Flow charts for in-between settings may be interpolated.

**NOTE** If the setting can be changed without making any changes to the form and shape of the valve housing and the physical appearance of any component (e.g. by changing the magnet power, spring compression, etc.), this does not constitute a change of model. The spring wire diameter needs not be taken into consideration.

**8.4.2** The pressure at which the valve opens shall be established using a flow rate resulting in a pressure rise no greater than  $0,01 \text{ N/mm}^2/\text{min}$  (10 kPa/min or 0,2953 in Hg). The set-pressure is designated as  $P_{\text{set}}$  and shall be within  $\pm 3 \%$  of the calculated set-pressure expressed as the correlation between the closing force and the area of the disc against which tank pressure is projected.

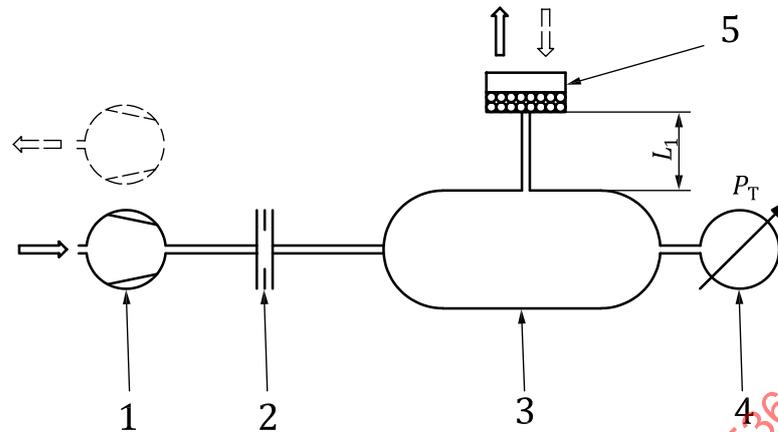
**Note** For certain tankers, there can be a specified minimum opening pressure that does not allow for negative tolerances in operation.

**8.4.3** Depending on the device type, the flow measurement shall consist of the steps described in [Annex B](#). See [Annex G](#) for corresponding examples of flow diagrams. For high velocity vents, during each of the measuring periods in accordance with [Annex B](#), the average velocity of air through a cross section of the valve's outlet to atmosphere shall be recorded.

**NOTE** Manufacturers can choose to provide information regarding the dispersion of the discharged gas.

**8.4.4** Flow graphs shall be drawn showing the readings from the steps specified in [Annex B](#). [Annex G](#) provides examples of appropriate formats of flow graphs.

**8.4.5** Flow testing shall be conducted adhering to the test rig provided in [Figure 1](#). All instrumentation shall be calibrated and have an uncertainty of no more than  $\pm 5\%$ .



#### Key

- 1 blower or fan
- 2 flow meter
- 3 tank
- 4 pressure measurement
- 5 pressure-vacuum valve
- $L_1$  length of connection pipe

NOTE Blower or fan flow is reversible depending on pressure or vacuum test.

**Figure 1** — Flow test rig

## 9 Undamped oscillation tests

High velocity vents, including dual nozzle valves, shall be tested for undamped oscillations. The test apparatus is shown in [Figure 2](#). All instrumentation shall be calibrated.

This test shall be carried out with the lowest and the highest opening setting available for the particular model, without a change of setting constituting a modification as mentioned in the note in [8.4.1](#). If the highest opening setting does not exceed 130 % of the lowest opening setting, the highest setting needs not be tested.

If a closing pressure value is established to be satisfactory, valves of the same model with higher set pressure but the same closing pressure needs not be tested.

The length and inner diameter of the pipe and the volume of the tank shall be requested by the manufacturer.

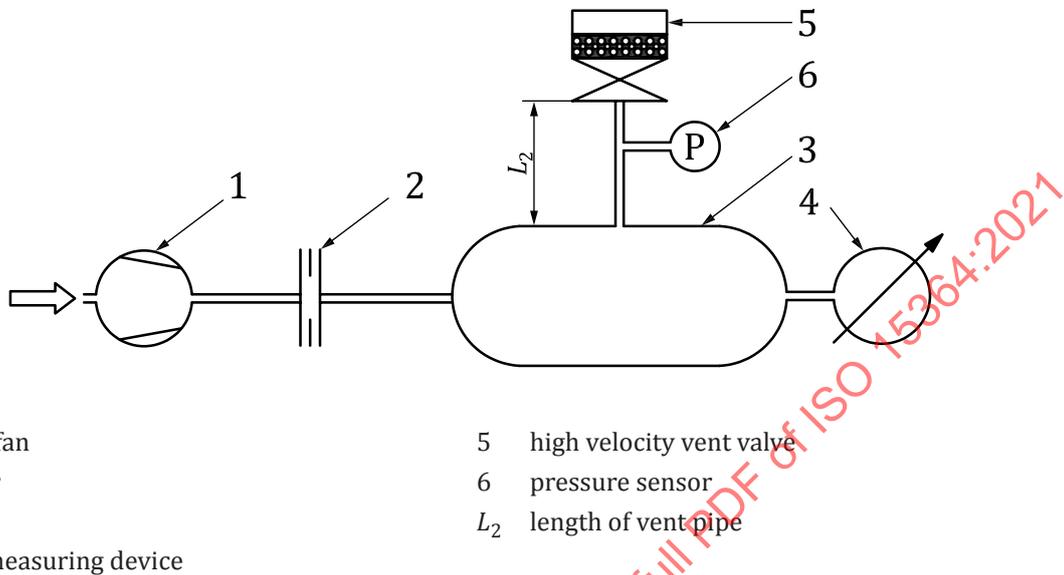
The tests shall be carried out for 3 min each at 10 about-equally spaced flow rates starting at  $0,2Q_{close}$  and using this rate as the step width (maximum flow in this test:  $2Q_{close}$ ).

Some valve designs perform open/close cycles that cause periodic changes on the flowmeter reading ([Figure 2](#)). In these cases, the average flow recorded in the 3 min span shall reflect the step-value in question.

If the disc location sensor indicates contact with either seat or upper stops with a frequency of more than 0,5 Hz, the pipe length,  $L_2$ , shall be shortened until this value is not exceeded. That length shall be recorded as  $L_{max}$  and the diameter of the piping as  $D_{min}$  while the tank volume is recorded as  $V_{min}$ .

The use shall be limited to pipe length on the protected side not exceeding  $L_{max}$  and the diameter shall not be less than  $D_{min}$ , while the minimum pre-volume available at any time in the tank protected (ullage space) shall not be less than  $V_{min}$ .

For modulating valves, where there is no flow volume at the closing pressure, the first step shall start at 10 % of the flow volume, at which the valve is fully open.



- Key**
- 1 blower or fan
  - 2 flow meter
  - 3 tank
  - 4 pressure measuring device
  - 5 high velocity vent valve
  - 6 pressure sensor
  - $L_2$  length of vent pipe

Figure 2 — Test rig for undamped oscillations

## 10 Production control and inspections

The manufacturer shall afford the purchaser's representative all reasonable facilities necessary to satisfy him/her that the material is being furnished in accordance with this document. Inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations. All examinations and inspections shall be made at the place of manufacture, unless otherwise, agreed upon.

Each finished device shall be visually and dimensionally checked to ensure that the device complies with this document, including with the specification information recommended in [Annex F](#) and the markings specified in [Clause 12](#). Special attention shall be given to the adequacy of welds and the proper fit-up of joints.

Each finished device shall be tested using air to verify that the leakage is below the maximum leakage rate specified according to [6.1](#).

The set pressure(s) of each finished device shall be tested with air and recorded.

## 11 Documentation

### 11.1 General

An instruction manual shall be provided. The instruction manual shall include the items described in [Table 1](#) and in [11.2](#).

The manufacturer shall supply a copy of the instruction manual, that shall be kept on board.

Table 1 — Product data to be included in the instruction manual

| Specification information  | Purpose  | A. Data location<br>B. Description of test data/ application note   |
|--|--|---|
| 1. Inner pipe diameter, configuration of piping, and pipe length   | Compliance with design parameters for tank pressure limits, and for high velocity vents, compliance with non-hammering conditions. (See <a href="#">Annex I</a> .)   | A: Type testing certificate.<br>B: For high velocity vents: test records indicating piping limitations for safe, non-hammering performance [ $D_{\min}$ , $L_{\max}$ , $V_{\min}$ ].  |
| 2. Maximum gas density considered  | Compliance with design parameters for tank pressure limits.  | B: Convert to standard conditions.  |
| 3. Lowest MESH   | Suitability for the application.   | A: Type testing certificate.<br>B: The lowest MESH.   |
| 4. Set opening points for pressure and vacuum  | Suitability for the application.   | A: Type testing certificate.<br>B: The upper and lower values applied during flow testing shall not be exceeded.  |
| 5. Maximum pressure drop   | Compliance with design parameters for tank pressure limits and the selected opening setting of the device. In the case of transition point valves, the minimum pressure drop value to be used for pressure drop calculations is $P_{1-tpv}$ according to <a href="#">Annex G</a> , while the value relevant for a full-opening valve is $P_{closing}$ or higher depending on the required flow rate according to <a href="#">Annex E</a> . | A: Verified flow charts.<br>B: The flow chart format shall show the maximum pressure drop over the valve for any flow volume. This value is essential for pressure drop calculations.   |
| 5a. Pressure drop at maximum flow  | Compliance with design parameters for tank pressure limits and the selected opening setting of the device. (See <a href="#">Annex K</a> .)   | A: Verified flow charts.<br>B: The flow chart shall show the pressure drop over the device at the maximum required flow rate to be established.   |
| 6. Minimum reseating pressure  | Suitability for the application with regard to minimizing the loss of cargo vapour. (See <a href="#">Annex H</a> .)  | A: Verified flow charts.<br>B: The flow chart format shall indicate the reseating pressure.   |
| 7. Maximum and minimum ambient temperature   | Suitability for the application.   | A: Instruction manual.<br>B: The manufacturer's recommendations shall not be exceeded.  |
| 8. Materials of construction   | Suitability for the application.   | A: Verified drawing.<br>B: The combination of materials chosen may not have lower corrosion resistance than the version tested. The drawing shall include a bill of materials in accordance with <a href="#">Clause 5</a> .   |
| 9. Surface treatment and coating   | Suitability for the application.   | A: Instruction manual.<br>B: The surface treatment and coating, if any, shall be decided by the buyer with due consideration to <a href="#">Annex E</a> .   |
| 10. Maximum gas flow in standard conditions, pressure drop of the piping system, and maximum tank pressure | Suitability for the application and compliance with design parameters for tank pressure limits, alarms, liquid-filled breakers, filling limitations for high density cargoes.  | A: Verified flow chart.<br>B: The maximum tank pressure allowed in normal operations less an appropriate fouling factor and margin for alarm and breaker settings, etc., shall not be exceeded when calculating the combined pressure caused by the valve and the pressure drop over the piping system. |

**Table 1** (continued)

| Specification information  | Purpose                          | A. Data location<br>B. Description of test data/ application note   |
|--|----------------------------------|---|
| 11. Maximum outer ice layer thickness for check-lift operation   | Suitability for the application. | A. Type testing certificate.<br>B. Due consideration shall be given to vessel service conditions and facilities available for on-deck de-icing before cargo operations and during voyage.                       |
| 12. For high velocity vents: the minimum average velocity required for cross section of the valve's outlet to atmosphere | Suitability for the application. | A: Recorded in test report.<br>B: The ability to disperse gas above deck relates to the velocity through the cross section of the valve's outlet to atmosphere.   |
| 13. Maximum air leakage rate   | Suitability for the application. | A: Instruction manual.<br>B: The verified product data shall state the maximum leakage rate expressed in air of a new valve at 75 % of the nominal setting. The leakage rate is expected to increase over time. |
| 14. Warning regarding accumulation of ice  | Suitability for the application. | A warning to the operator shall be in the instruction manual, noting that significant ice accumulation may prevent proper operation of the valve.   |
| 15. Use of resilient seals, where employed   | Suitability for the application  | A: Instruction manual.<br>B: Inspection and maintenance of installed resilient seals.   |

**11.2 Installation instructions**

The following shall be provided.

- a) Operating instructions, including any service restrictions imposed for safe functioning of the device (see [Annex A](#)).
- b) Maintenance requirements, including information on maintenance of any corrosion prevention system (see [Annex E](#)).
- c) Instructions on when cleaning is required due to the inside build-up of residue. The instruction manual shall also describe the method for cleaning using a diagram.
- d) Verified exploded view drawings with indication for each component as to the order of disassembling and re- assembling for inspection, cleaning, repair or removal of internal elements for replacement. The design shall not allow the device to be incorrectly reassembled following inspection, cleaning or repair, be it due to wrong order of parts or missing parts. Information on sizes for all components shall be included on the drawings to ensure that the specified gas-tightness is achieved, and for the device to be restored to the original, as-purchased condition and for valves also with regard to set pressure and flow rate.
- e) Full work descriptions, including drawings, on how replacement of wearing parts is achieved in-service without removing the device.
- f) Instructions for the user to check valve lift prior to each cargo loading and cargo unloading operation in order to
  - 1) verify unobstructed movement of the moving parts, and
  - 2) ensure that fouling conditions are controlled to establish safe operation and full capacity.

A diagram shall be included, showing the parts either moved or cleared when the check-lift is operated.

- g) The test reports.
- h) Diagrams showing the weight of all parts over 10 kg (22 lb) that need be dismantled for inspection, cleaning and replacement of wearing parts, so that precautions for crane support can be allocated, if necessary, and appropriate working schedules are prepared.

## 12 Marking

Each device shall be permanently marked, or have a permanently fixed tag made of stainless steel or other corrosion-resistant material, indicating the following:

- a) manufacturer's name or trademark;
- b) style, type, model or other manufacturer's designation for the device, that shall form a unique identification of the device;
- c) size of the inlet (and outlet, if applicable);
- d) serial number;
- e) direction of flow through the device;
- f) test laboratory and report number(s);
- g) pressure and vacuum setting;
- h) a reference to this document, i.e. ISO 15364;
- i) approved location for installation, including maximum or minimum length of pipe, if any, between the device and the atmosphere;
- j) the minimum MESH valve that the device is approved for (only for devices to prevent the passage of flame);
- k) if an inert gas system is required.

If the set-pressure is changed, the marking shall be updated accordingly.

## 13 Quality assurance

- a) Devices shall be designed, manufactured and tested in a manner that ensures they meet the characteristics of the prototype tested in accordance with this document. No changes or modifications are allowed without adhering to [7.2](#).
- b) The device manufacturer shall maintain the quality of the devices that are designed, tested and marked in accordance with this document. At no time shall a device be delivered with this document designation that does not meet the requirements herein.

## **Annex A** (informative)

### **Installation requirements for ships subject to the International Convention for the Safety of Life at Sea, as amended (SOLAS)**

#### **A.1 General**

The International Convention for the Safety of Life at Sea, as amended (SOLAS), Chapter II-2, Regulation 4, provides requirements for the arrangement and installation of cargo tank venting systems on board ships.

#### **A.2 Examination of cargo tank pressure-vacuum valves on board ships**

The latest applicable IMO Resolution on the Harmonized System of Survey and Certification provides requirements for the examination of cargo tank pressure-vacuum valves on ships.

#### **A.3 Access arrangements for examining pressure-vacuum valves**

For the purpose of ensuring that any pressure-vacuum valve lifts easily and cannot remain in the open position (as per manufacturer's instructions), appropriate access arrangements to the valve to facilitate this operation, such as a stand or platform at deck level, should be fitted when necessary, with provisions allowing for inspection of inside accumulation of cargo residue and parts replacement.

## Annex B (normative)

### Flow test measurements

#### B.1 General

Depending on device type, the flow measurement shall consist of the following steps (see [Annex G](#) for the corresponding diagrams).

#### B.2 Transition point valves

##### **Step 1: The opening phase from shut to the transition point where the valve characteristics change from modulating to full open**

The flow measurement is made to establish the maximum pressure drop of the valve and the corresponding flow rate, at which the valve characteristics change from modulating to full open (transition point). This intersection is designated as  $P_{1\text{-tpv}}$  and  $Q_{1\text{-tpv}}$ . Ten equally spaced pressure measurements between zero capacity and  $Q_{1\text{-tpv}}$  shall be recorded. Each flow increment shall be maintained under stabilized conditions for at least 5 s with logged flow and corresponding pressure readings at least 10 times per second.

##### **Step 2: The flow rate for which the pressure does not rise above the minimum level required for the valve to remain fully open**

The flow measurement is made to establish the flow rate needed for the valve to remain fully open at  $P_{1\text{-tpv}}$ . This intersection is designated  $Q_{2\text{-tpv}}$ . On the flow chart representation, a horizontal line shall be drawn from  $Q_{1\text{-tpv}}$  to  $Q_{2\text{-tpv}}$ .

##### **Step 3: The maximum intended pressure drop over the valve**

The flow measurement is made to establish the flow rate corresponding to the maximum intended pressure drop over the valve. This is designated  $P_{\text{max}}$  and  $Q_3$ . Ten equally spaced flow measurements between  $Q_{2\text{-tpv}}$  and  $Q_3$  shall be recorded. Each flow increment shall be maintained under stabilized conditions for at least 5 s with logged flow and corresponding pressure readings at least 10 times per second.

##### **Step 4: The closing phase from fully open at the maximum intended pressure drop to shut**

The flow measurement is made to establish the closing pressure of the device,  $P_{\text{closing}}$ . The flow range between  $Q_3$  and the flow value corresponding to  $P_{\text{closing}}$  shall be divided into ten equally spaced flow rates. Each flow increment shall be maintained under stabilized conditions for at least 5 s with logged flow and corresponding pressure readings at least 10 times per second.

#### B.3 Full opening valves

##### **Step 1: The opening phase from shut to where the valve is constantly fully open**

The flow rate needed to open the valve,  $Q_{1\text{-fov}}$  shall be ignored for the purpose of the flow chart. The flow measurement is done to establish the flow rate needed for the valve to remain fully open at  $P_{\text{set}}$ . This intersection is designated  $Q_{2\text{-fov}}$ . On the flow chart representation, a horizontal line shall be drawn from  $Q_{1\text{-fov}}$  to  $Q_{2\text{-fov}}$  horizontally from  $P_{\text{set}}$ .

##### **Step 2: The maximum intended pressure drop over the valve**

The flow measurement is made to establish the flow rate corresponding to the maximum intended pressure drop over the valve. This is designated  $P_{\max}$  and  $Q_3$ . Ten equally spaced flow measurements between  $Q_{2-\text{fov}}$  and  $Q_3$  shall be recorded. Each flow increment shall be maintained under stabilized conditions for at least 5 s with logged flow and corresponding pressure readings at least 10 times per second.

**Step 3: The closing phase from fully open at the maximum intended pressure drop to shut**

The flow measurement is made to establish the closing pressure of the device,  $P_{\text{closing}}$ . The flow range between  $Q_3$  and the flow value corresponding to  $P_{\text{closing}}$  shall be divided into ten equally spaced flow rates. Each flow increment shall be maintained under stabilized conditions for at least 5 s with logged flow and corresponding pressure readings at least 10 times per second.

## B.4 Modulating valves

**Step 1: The opening phase from shut to the maximum intended pressure drop over the valve**

The flow rate needed to open the valve,  $Q_{1-\text{mv}}$ , and the flow rate needed for the valve to remain fully open,  $Q_{2-\text{mv}}$ , shall be ignored for the purpose of the flow chart. The flow measurement is made to establish the flow rate corresponding to the maximum intended pressure drop over the valve. This is designated  $P_{\max}$  and  $Q_3$ . Ten equally spaced flow measurements between zero capacity and  $Q_3$  shall be recorded. Each flow increment shall be maintained under stabilized conditions for at least 5 s with logged flow and corresponding pressure readings at least 10 times per second.

**Step 2: The closing phase from fully open at the maximum intended pressure drop to shut**

The flow measurement is made to establish the closing pressure of the device,  $P_{\text{closing}}$ . The flow range between  $Q_3$  and the flow value corresponding to  $P_{\text{closing}}$  shall be divided into ten equally spaced flow rates. Each flow increment shall be maintained under stabilized conditions for at least 5 s with logged flow and corresponding pressure readings at least 10 times per second.

## B.5 Dual nozzle valves

The flow test measurements shall be carried out in accordance with the appropriate valve characteristics as specified above in [B.1](#) to [B.4](#).

## B.6 Static flame arresters

**Step 1: The maximum intended pressure drop over the device**

The flow rate shall be increased in suitable steps up to the maximum by the flow rate  $Q_3$ . The pressure drop for each step shall be recorded. Each flow increment shall be maintained under stabilized conditions for at least 5 s with logged flow and corresponding pressure reading at least 10 times per second.

## Annex C (normative)

### Devices to prevent the passage of flame

#### C.1 General

This annex covers the testing of devices to prevent the passage of flame into cargo tanks (hereafter called "devices") of tankers carrying cargo having a flashpoint of 60 °C (closed cup) or less, and a Reid vapour pressure below atmospheric pressure and other products having a similar fire hazard.

#### C.2 Type testing

Flame tests of the devices shall be carried out in accordance with ISO 16852:2016.

The devices shall be tested with an appropriate media suitable for the MESH (see IEC 60079-20-1) of the product to be carried. Flame arresters shall be tested with vapours/gases of the respective explosion group according to IMO MSC/Circ. 677 as amended and ISO 16852, and shall be marked accordingly. The application is limited to mixtures with an MESH equal to or greater than that tested.

For flame arresters fitted at vacuum inlets through which vapours cannot be vented, the endurance burn tests need not be carried out.

Where end-of-line devices are fitted with cowls, weather hoods and deflectors, etc., these attachments shall be fitted for the tests.

When venting to atmosphere is not performed through an end-of-line device or a detonation flame arrester, the in-line device shall be specifically tested with the inclusion of all pipes, tees, bends, cowls, weather hoods, etc., that may be fitted between the device and the atmosphere. The testing should consist of the deflagration test and, if for the given installation it is possible for a stationary flame to rest on the device, the testing should also include the endurance burning test. If the endurance burning test is not achievable for technical reasons, other measures shall be taken to avoid stabilized burning phenomena.

After the relevant tests, the device should not show mechanical damage that affects its original performance.

#### C.3 Summary of required testing

[Table C.1](#) provides a listing of the tests required for devices to prevent the passage of flame.

**Table C.1 — Tests required for devices to prevent the passage of flame**

| Devices  | Tests to be conducted in accordance with ISO 16852:2016  | Remarks                     |
|--|--|-----------------------------|
| end of line vacuum valve with flame arrester   | atmospheric deflagration 7.3.2.1<br>endurance burn 7.3.5 | When required <sup>a)</sup> |
| end of line pressure valve with flame arrester | atmospheric deflagration 7.3.2.1<br>endurance burn 7.3.5 | When required <sup>a)</sup> |
| end of line flame arrester/ screen             | atmospheric deflagration 7.3.2.1                         |                             |

<sup>a)</sup> Exemptions for endurance burning given in IMO MSC/Circ. 677 as amended, apply for this annex.

**Table C.1** (continued)

| Devices     |                     | Tests to be conducted in accordance with ISO 16852:2016 |         | Remarks  |
|-------------|---------------------|---|---------|--|
|             |                     | endurance burn  | 7.3.5   | When required <sup>a)</sup>  |
| end of line | gas freeing cover   | atmospheric deflagration                                | 7.3.2.1 |  |
|             |                     | endurance burn  | 7.3.5   | When required <sup>a)</sup>  |
| end of line | high velocity valve | atmospheric deflagration                                | 9.2.3   |  |
|             |                     | low flow  | 9.2.1   |  |
|             |                     | open close  | 9.2.2   |  |
|             |                     | endurance burn  | 9.2.4   | When required <sup>a)</sup>  |
| in-line     | detonation          | deflagration  | 7.3.2.2 |  |
|             |                     | detonation  | 7.3.3.2 |  |
|             |                     | endurance burn  | 7.3.5   | When required <sup>a)</sup>  |
| in-line     | deflagration        | deflagration  | 7.3.2.2 | Arrester should be tested scale 1:1 (see <a href="#">Annex C</a> )                     |
|             |                     | endurance burn  | 7.3.5   | When required <sup>a)</sup> and depends on installation (see <a href="#">Annex C</a> ) |

<sup>a)</sup> Exemptions for endurance burning given in IMO MSC/Circ. 677 as amended, apply for this annex.

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## Annex D (informative)

### Materials selection guidelines

#### D.1 General

The purpose of these guidelines is to recommend general criteria for the selection, application and maintenance of materials used in the pressure-vacuum valves within the scope of this document.

These guidelines are not intended to replace the technical aspects of any specific design or type of equipment that is under the responsibility of ship owners, manufacturers and shipyards. The selection of equipment is based on the specification information provided by the buyer in accordance with [Annex E](#). The manufacturer shall provide details to the buyer on the necessary system to ensure an adequate level of corrosion protection of the pressure-vacuum valves.

#### D.2 Selection of materials

The materials chosen for the construction of pressure-vacuum valves shall reflect the expected working conditions and environment in terms of being subjected to various cargoes and their vapours. Depending on application (e.g. end-of-line or in-line installation and type of cargoes), cast iron, ductile iron, bronze and different grades of stainless steel may be used. Refer to [Clause 5](#) for allowed use of non-metallic parts. For wearing parts, such as seats and discs, material selection should reflect the expected working conditions associated with the predicted functional characteristics of the particular valve design.

The working conditions can negatively influence the lifetime of the wearing parts as a consequence of frequent seat and disc contact due to the following:

- a) oversizing, which prevents the valve from opening fully during normal operation;
- b) excessive maximum pressure drop over the valve, which keeps the lift of the disc reduced at low filling rates;
- c) inadvertent relation between the venting rate during normal operations and the valve's transition point, where it becomes fully open.

## Annex E (informative)

### Corrosion protection guidelines

#### E.1 Corrosion protection systems

The grade of surface preparation, design features, expected working conditions, maintenance scheme, and desired protection time should be taken into account for the selection of suitable corrosion protection systems.

Available methods for corrosion protection are hard coatings, soft coatings with optional corrosion inhibitors, and powder treatments.

When repairs are necessary due to corrosion, maintenance coatings should be carried out with the same coating system originally used, provided the surface treatment and working conditions required for a satisfactory result are obtainable. The valve manufacturer shall furnish, with the instruction manual, instructions for carrying out repair works on the corrosion protection system including details on surface treatment, procedures, and type of coatings allowed.

#### E.2 Selection of corrosion protection system

In selecting the corrosion protection system, the parties involved should consider the current situation, foreseeable service conditions and planned maintenance programme. The following aspects should be considered:

- current surface condition;
- possible surface preparation;
- valve design and intended service;
- required surface cleanliness and dryness;
- required ambient conditions during preparation;
- frequency of loading operations causing the valve to be subjected to aggressive compounds and their temperatures;
- aspired durability;
- maintenance features.

#### E.3 Coatings

The durability of coatings applied for corrosion protection is influenced by factors, such as surface conditions, surface penetration, coating selection, application and maintenance.

Common types of coating used for surface protection are

- a) epoxy formulations for high surface protection, and
- b) combinations of natural or synthetic oils and grease formulations containing corrosion inhibitors.

Observing the coating process and in-service inspection is best served by using a light-coloured coating.

The provided technical product data sheet and job specification should be carefully followed, including required ambient and working conditions.

A record of the ambient and working conditions during the coating application process should be entered.

#### **E.4 Surface preparation**

The performance of a coating system is highly affected by the condition of the treated surface. Over time, the grade of surface preparation has a direct influence on the selection of protective coatings and their performance.

Recognized national standards or International Standards for good practice concerning methods for surface preparation should be observed along with the manufacturer's recommendations.

Possible surface preparation methods include the following:

- blast cleaning;
- hand and power tool cleaning;
- flame cleaning;
- high pressure water blasting;
- electrolytic cleaning.

The method chosen should take into consideration the necessary requirements for cleanliness, humidity and grade of surface preparation.

Remaining particles such as blasting abrasives, dust, rust flakes and water should be removed as appropriate. A record of the result of the surface preparation should be entered.

#### **E.5 Application**

The application of a coating should be carried out in accordance with the manufacturer's recommendations.

Coatings, liquid or powders may be applied by spraying under documented working conditions. Additional repair work, if required, should be applied by brush or roller.

Each coating layer should have the maximum/minimum thickness required in accordance with the job specification. Eighty percent of all measurements should be higher than or equal to the nominal coat thickness, and none of the balance should be below 80 % of the required nominal thickness.

Depending on the type of coating, the thickness may be measured either on wet or dry surfaces.

Instructions should indicate the dry-to-recoat periods and limits of ambient conditions during the application process.

#### **E.6 Testing**

Destructive testing should be avoided.

Coat thickness testing should be carried out after each coat layer is applied, by means of appropriate thickness gauges.

## E.7 Inspection

Surface preparation and coating application should be inspected as relevant in accordance with prior agreement between the parties involved. Inspections should be logged in an agreed format to be signed at the conclusion of each stage of the process. Items to be inspected may include the following:

- working conditions;
- ambient conditions, i.e. temperature and humidity;
- surface preparation processes;
- coating application equipment;
- thickness of layers drying period for the different layers;
- final drying time;
- coating repairs.

During inspection, defective areas should be marked and appropriately repaired.

## E.8 Maintenance

**E.8.1** A corrosion protection system should be maintained throughout the lifetime of the valves. Maintenance should be in accordance with the manufacturer's recommendations for the most effective way to preserve the efficiency of the corrosion protection system.

**E.8.2** The type of cargo carried should be taken into consideration when deciding for the appropriate maintenance schedule. Factors that may influence the frequency of maintenance are the following:

- chemical aggressiveness of the cargoes and tendency of cargo vapour to crystallize;
- valve design features allowing condensate to accumulate;
- valve designs sensitive to seizing if free passage is hindered at certain narrow passages;
- valve designs where the proper function depends on the free through-passage of ingress water (rain or sea water) and vapour condensate through drains or drain valves;
- valve designs where the condition of the gas passage way cannot be examined visually without dismantling;
- valve designs where the gas passage way cannot be cleaned without dismantling.

## E.9 General inspections of in-service equipment

The lasting effectiveness of the corrosion protection system and the function of the valves in general shall be monitored throughout the service life of the valves.

Assessment of the condition of the valves should be carried out regularly reflecting the items and conditions listed in [8.2](#).

Hard coatings shall be assessed by monitoring any localized breakdown that should indicate accelerated corrosion.

## Annex F (informative)

### Specification information

In order for the manufacturer to provide the end-user with a suitable pressure-vacuum valve, the end-user shall provide the manufacturer with sufficient information. This annex contains typical elements of such information. Specifications for devices should include the following information:

- a) nominal pipe size, configuration of piping and pipe length;
- b) maximum gas density;
- c) maximum gas growth rate factor;
- d) lowest maximum experimental safe gap (MESG);
- e) set opening points for pressure and vacuum;
- f) maximum pressure drop allowed over the device at any flow rate;
- g) reseating pressure;
- h) maximum and minimum ambient air temperature;
- i) materials of construction, in particular the wearing parts mentioned in [Annex D](#), and information on the anticipated pH-value of the environment anticipated and the desired service lifetime of the wearing parts;
- j) surface treatment and coating considerations (from [Annex E](#));
- k) maximum gas flow converted into standard conditions, the design pressure drop of the piping system and the maximum allowed operating tank pressure range;
- l) maximum allowed contribution of pressure drop generated over the valve at the larger of either full flow or the maximum pressure drop;
- m) maximum outer ice-layer thickness permitted for proper operation;
- n) whether heating is required to prevent crystallization of certain cargoes;
- o) for high velocity vents, the minimum average velocity required for a cross section of the valve's outlet to atmosphere.

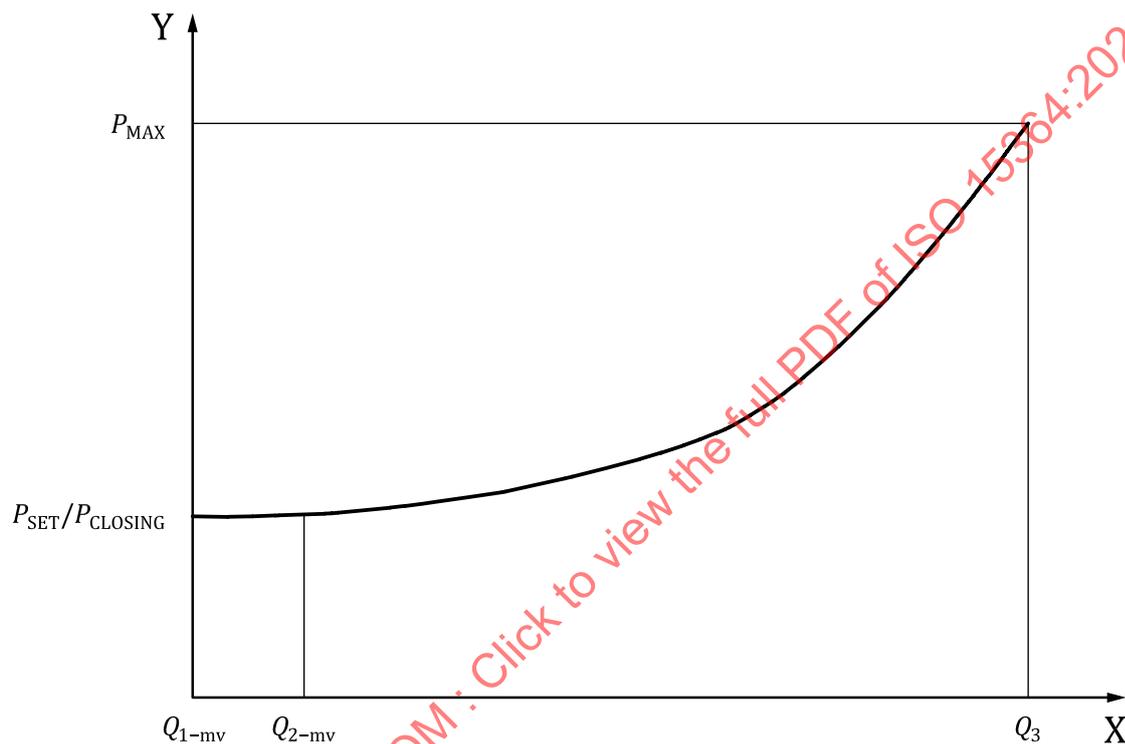
The information provided shall include the specifications by reference to a recognized national standard or International Standard on materials of construction for the following components (see [Clause 5](#) for additional details):

- housing and bolting;
- discs, spindles, seats, springs, gaskets, seals, flame arresting components.

## Annex G (informative)

### Flow graph examples

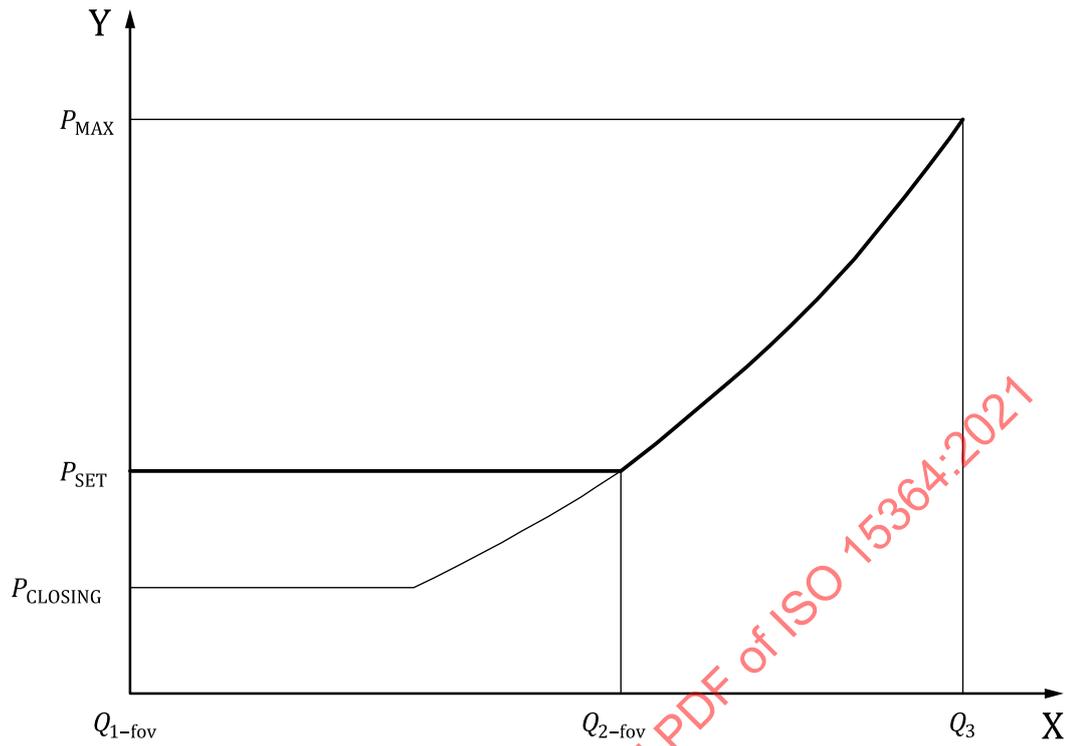
Flow graphs issued in accordance with [Clause 9](#) should appear as shown in [Figures G.1](#) to [G.5](#), indicated for each type.



**Key**

- X volume flow
- Y pressure

**Figure G.1 — Flow for modulating valves**

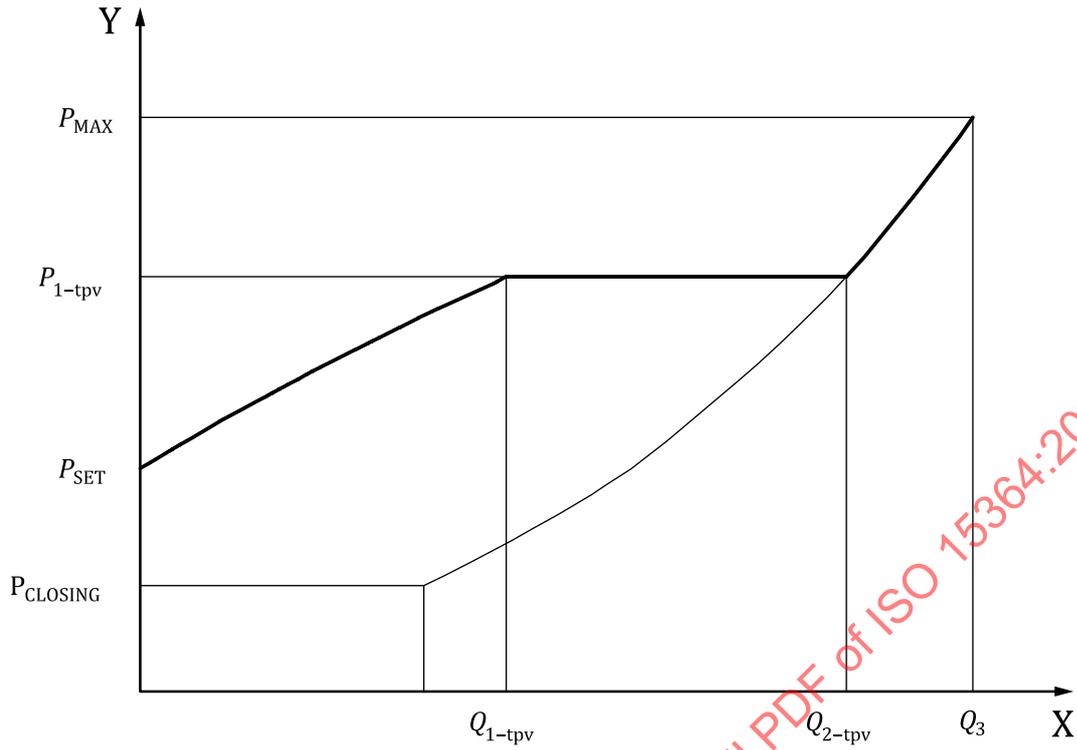


**Key**

- X volume flow
- Y pressure

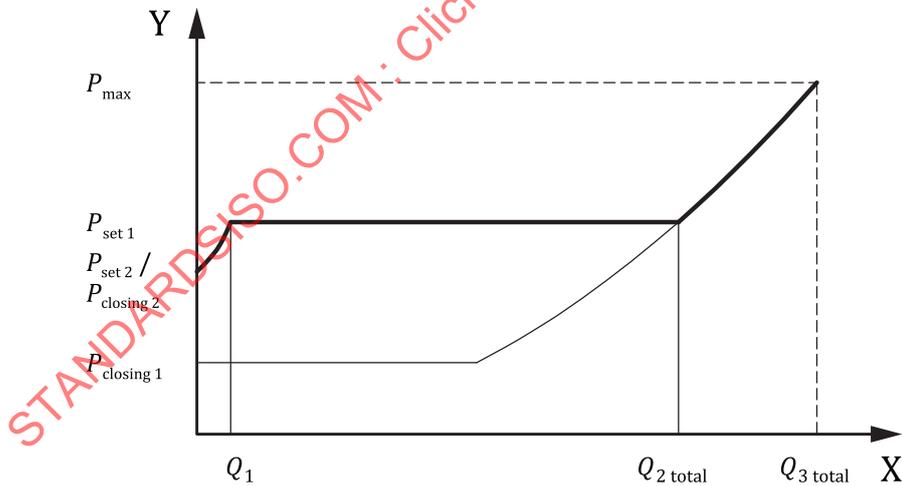
**Figure G.2 — Flow for full opening valves**

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**Key**  
 X volume flow  
 Y pressure

Figure G.3 — Flow for transition point valves



**Key**  
 X volume flow  
 Y pressure

NOTE This figure represents a combination where the main valve is a type full opening valve and the extra valve is a type modulating valve.

Figure G.4 — Flow for dual nozzle valves