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**Refrigerating systems and heat  
pumps — Safety and environmental  
requirements —**

**Part 2:  
Design, construction, testing, marking  
and documentation**

*Systèmes frigorifiques et pompes à chaleur — Exigences de sécurité et  
d'environnement —*

*Partie 2: Conception, construction, essais, marquage et  
documentation*





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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 on 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 the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 86, *Refrigeration and air conditioning*, Subcommittee SC 1, *Safety and environmental requirements for refrigerating systems*.

ISO 5149-2, together with ISO 5149-1, ISO 5149-3, and ISO 5149-4, cancels and replaces ISO 5149:1993, which has been technically revised.

ISO 5149 consists of the following parts, under the general title *Refrigerating systems and heat pumps — Safety and environmental requirements*:

- *Part 1: Definitions, classification and selection criteria*
- *Part 2: Design, construction, testing, marking and documentation*
- *Part 3: Installation site*
- *Part 4: Operation, maintenance, repair and recovery*

# Refrigerating systems and heat pumps — Safety and environmental requirements —

## Part 2:

## Design, construction, testing, marking and documentation

### 1 Scope

This part of ISO 5149 is applicable to the design, construction, and installation of refrigerating systems, including piping, components, materials, and ancillary equipment directly associated with such systems, which are not covered in ISO 5149-1, ISO 5149-3, or ISO 5149-4. It also specifies requirements for testing, commissioning, marking, and documentation. Requirements for secondary heat-transfer circuits are excluded except for any safety devices associated with the refrigerating system.

This part of ISO 5149 is applicable to new refrigerating systems, extensions or modifications of already existing systems, and for used systems, being transferred to and operated on another site.

This part of ISO 5149 applies to:

- a) refrigerating systems, stationary or mobile, of all sizes including heat pumps;
- b) secondary cooling or heating systems;
- c) the location of the refrigerating systems;
- d) replaced parts and added components after the adoption of this part of ISO 5149, if they are not identical in function and in capacity.

This part of ISO 5149 does not cover “motor vehicle air conditioners”. It does not apply to goods in storage, with respect to spoilage or contamination, but it also applies in the case of the conversion of a system for another refrigerant.

### 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 817 *Refrigerants — Designation system*

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

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

ISO 5149-1, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 1: Definitions, classification and selection criteria*

ISO 5149-4, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 4: Operation, maintenance, repair and recovery*

ISO 6708, *Pipework components — Definition and selection of DN (nominal size)*

ISO 7010:2011, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 14903, *Refrigerating systems and heat pumps — Qualification of tightness of components and joints*

IEC 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60335-2-24, *Household and similar electrical appliances — Safety — Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers*

IEC 60335-2-40, *Safety of household and similar electrical appliances — Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers*

IEC 60335-2-89, *Household and similar electrical appliances — Safety — Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant unit or compressor*

IEC 60730-2-6, *Automatic electrical controls for household and similar use — Part 2-6: Particular requirements for automatic electrical pressure sensing controls including mechanical requirements*

### 3 Terms and definitions

For the purposes of this document, the definitions given in ISO 5149-1 apply.

### 4 Requirements for components and piping

#### 4.1 General requirements

Refrigerating appliances or systems constructed according to product standards such as IEC 60335-2-24 or IEC 60335-2-89 are presumed to be in conformity with this part of ISO 5149.

IEC 60335-2-40 requires appliances to conform to the requirements of this International Standard with regard to mechanical strength. In all other respects, appliances constructed according to IEC 60335-2-40 are presumed to be in conformity with this part of ISO 5149.

Components and piping shall comply with the related standards or requirements as indicated in [Table 1](#). Components not included in [Table 1](#) shall conform to relevant national standards or codes. For components not listed in [Table 1](#) or not covered by national standards or codes, the requirements of [4.2](#) to [4.5](#) shall apply.

The same requirements as class 2 shall be applied to class 2L, unless specific provisions are given in this part of ISO 5149.

Table 1 — Components and piping requirements

Component and piping	Requirements
Fired heat exchangers	see <a href="#">Clause 4</a>
Heat exchangers: — pipe coil without air (tube in tube) — multi-tubular (shell and tubes)	see <a href="#">Clause 4</a>
Plate heat exchangers	see <a href="#">Clause 4</a>
Headers and coils with air as secondary fluid	see <a href="#">Clause 4</a>
Receiver/accumulator/economizer	see <a href="#">Clause 4</a>
Oil separator	see <a href="#">Clause 4</a>
Drier	see <a href="#">Clause 4</a>
Filter	see <a href="#">Clause 4</a>
Muffler	see <a href="#">Clause 4</a>
Hermetic positive displacement compressor	see IEC 60335-2-34 or IEC 60204-1
Semi-hermetic positive displacement compressor	see IEC 60335-2-34 or IEC 60204-1
Open positive displacement compressor	—
Non-positive displacement compressor	see IEC 60204-1
Pump	see IEC 60204-1 combined with <a href="#">4.4.3</a> and <a href="#">4.5.1</a>
General requirements	see <a href="#">Annex B</a>
Additional requirements for NH <sub>3</sub> plants	see <a href="#">Annex B</a>
Piping	see <a href="#">Clause 4</a>
Piping joints	
Permanent joints	see <a href="#">Clause 4</a>
Detachable joints	
Flexible piping	see ISO 13971
Valve	—
Safety valve	see ISO 4126-1 combined with <a href="#">4.4.3</a>
Safety switching devices for limiting the pressure	see <a href="#">Clause 4</a>
Control pressure switch	see <a href="#">Clause 4</a>
Isolating valves	see <a href="#">Clause 4</a>
Hand-operated valves	—
Capped valves	—
Bursting disc	see ISO 4126-2 combined with <a href="#">4.4.3</a>
Fusible plug	see <a href="#">4.5.3</a>
Liquid level indicators	see <a href="#">Clause 4</a>
Gauges	see <a href="#">Clause 4</a>
Soldering materials	see <a href="#">4.3.9</a>
Welding materials	see <a href="#">4.3</a>

If the component contains electrical components and if the component standard does not cover electrical safety, then the component shall fulfil the requirements of IEC 60335-2-40, IEC 60335-2-24, or IEC 60204-1.

## 4.2 Specific requirements for particular components

### 4.2.1 Piping joints

Joints shall be designed so that they will not be damaged because of freezing of water on the outside. They shall be suitable for the pipe, the piping material, and the pressure, temperature, and fluid.

Coated (e.g. galvanized) pipes shall not be welded unless all coating has been completely removed from the joint area. Welded joints shall be suitably protected.

### 4.2.2 Isolating valves

Valves which are used for isolation shall prevent flow in either direction when closed.

## 4.3 Materials

### 4.3.1 Cast iron and malleable iron

Cast iron and malleable iron shall only be used when suitable for the particular application, in accordance with the requirements of this part of ISO 5149.

NOTE 1 Since some grades of cast iron are brittle, their application is dependent on temperature/stress/design considerations.

NOTE 2 Malleable iron has two general classifications with several different grades in each. These can have very different mechanical properties.

### 4.3.2 Steel, cast steel, carbon steel, and low-alloy steel

Steel, cast steel, carbon steel, and low-alloy steel can be used for all parts carrying refrigerant and also for heat-transfer medium circuits. Where there is a combination of low temperatures and high pressure and/or where corrosion risks and/or thermal stresses are present, steel with adequate impact strength shall be used, paying regard to thickness, the lowest operating temperature, and its welding properties.

NOTE Guidance on stress corrosion cracking in carbon steel vessels is given in [G.3](#).

### 4.3.3 High-alloy steel

High-alloy steel can be required where there is a combination of low temperatures and high pressure and/or where corrosion risks and/or thermal stresses are present. The impact strength shall be adequate for the particular duty and the material suitable for welding, if required.

### 4.3.4 Stainless steel

When using stainless steel, care shall be taken to ensure that the grade of stainless steel is compatible with the process fluids and possible atmospheric impurities, e.g. sodium chloride (NaCl) and sulphuric acid (H<sub>2</sub>SO<sub>4</sub>).

### 4.3.5 Copper and copper alloys

Copper in contact with refrigerants shall be oxygen-free or de-oxidized.

Copper and alloys with a high percentage of copper shall not be used for parts carrying ammonia unless their compatibility has been previously established.

NOTE Guidance on stress corrosion cracking in copper pipes is given in [G.2](#).



#### 4.3.6 Aluminium and aluminium alloys

Aluminium used for gaskets for use with ammonia shall be of at least 99,5 % purity. Aluminium alloys containing more than 2 % magnesium shall not be used with halogenated refrigerants unless their compatibility has been previously established.

Aluminium and its alloys shall not be used in contact with methyl chloride (CH<sub>3</sub>Cl).

NOTE Aluminium and aluminium alloys can be used in any part of the refrigerant circuit provided that its strength is adequate and it is compatible with the refrigerants and the lubricants being used.

#### 4.3.7 Magnesium and magnesium alloys

Magnesium and magnesium alloys shall not be used unless their compatibility with refrigerants has been previously established.

#### 4.3.8 Zinc and zinc alloys

Zinc shall not be used in continuous contact with the refrigerants ammonia and methyl chloride (CH<sub>3</sub>Cl).

External zinc coating of components is permissible.

Electro-zinc plating of components is permissible.

#### 4.3.9 Soldering alloys

Soldering alloys shall not be used except for internal purposes.

#### 4.3.10 Brazing alloys

Brazing alloys shall not be used unless their compatibility with refrigerants and lubricants has been previously established.

#### 4.3.11 Tin and lead tin alloys

Tin and lead tin alloys can be corroded by halogenated refrigerants and shall not be used unless their compatibility has been previously established.

NOTE Copper-free lead antimony or lead tin alloys can be used for valve seats.

#### 4.3.12 Gasket and packing materials

Gasket and packing materials for sealing joints and for sealing stuffing boxes on valves shall be resistant to the refrigerants, oil, and lubricants used and shall be suitable for the expected range of pressures and temperatures.

#### 4.3.13 Glass

Glass can be used in refrigerant circuits and for terminal insulators, indicators, and sight glasses, but it shall be resistant to the pressures, temperatures, and chemical actions which can occur.

#### 4.3.14 Asbestos

Asbestos shall not be used.

#### 4.3.15 Plastics

When plastics are used, they shall be suitable for the mechanical, electrical, thermal, chemical, and long-term creep stresses to which they are subjected.

## 4.4 Testing

### 4.4.1 General

All components, except piping consisting of type-tested components, shall undergo the following tests:

- a) strength-pressure test (see [4.4.2](#));
- b) tightness test (see [4.4.3](#));
- c) functional test (see [5.3.1](#)).

The results of these tests shall be recorded. Tests according to the compatible component standard are considered to satisfy these testing requirements. When agreed by the manufacturer of the assembly, some or all tests can be executed on the assembly (see [5.3](#)).

### 4.4.2 Strength-pressure test for components

#### 4.4.2.1 General

Components of refrigerating systems shall be designed with a thickness according to nationally recognized standards or codes.

#### 4.4.2.2 Individual strength-pressure test

Each component shall be strength-pressure-tested individually at minimum  $1,43 \times PS$ . The individual strength-pressure test shall be carried out as a hydrostatic pressure test by means of water or some other liquid, except where a component cannot be pressure-tested with liquid for technical reasons. In that case, it shall be tested by means of air or some other non-hazardous gas. Adequate precautions shall be taken to prevent danger to people and to minimize risk to property.

#### 4.4.2.3 Type-approved strength-pressure test

As an alternative, the components can be type-approved by testing at  $3 \times PS$  or by testing according to the fatigue test as described below.

If the maximum continuous operating temperature exceeds  $125\text{ °C}$  for copper or aluminium, or  $200\text{ °C}$  for steel, then the type-approved strength test pressure shall be increased according to the ratio of allowable stress at the test temperature and that at the maximum continuous operating temperature based on a known pressure vessel code or a published national or international standard. For example, if the material of the component has an allowable stress of  $35\text{ N/mm}^2$  at test temperature and  $27\text{ N/mm}^2$  at maximum continuous operating temperature, then the type-approved test shall be conducted at  $3,9$  times ( $3 \times 35/27$ ) of maximum allowable pressure.

#### 4.4.2.4 Fatigue test

As an alternative to the pressure test as mentioned above, the components shall be subjected to a strength-pressure test at  $2 \times PS$  provided they comply with the fatigue test as described below.

Three test samples shall be filled with fluid and shall be connected to a pressure-driving source. The pressure shall be raised and lowered between the upper and lower cyclic values at a rate specified by the manufacturer for a total number of 250 000 cycles. The entire specified pressure excursion shall occur during each cycle.

NOTE For safety purposes, it is suggested to use a non-compressible fluid.

The following test pressures shall be applied.

- For the first cycle, the maximum PS for the low-pressure side components or the maximum PS for the high-pressure side components shall be applied.

- For the test cycles, the upper-pressure value shall not be less than  $0,7 \times PS$  and the lower-pressure value shall not be greater than  $0,2 \times PS$ . The pressure shall be  $0,9 \times PS$  for water heat exchangers in the heat pump.
- For the final test cycle, the test pressure shall be increased to  $1,4 \times PS$  (two times of  $0,7 \times PS$ ). The pressure shall be  $1,8 \times PS$  (two times of  $0,9 \times PS$ ) for water heat exchangers in the heat pump.

#### 4.4.2.5 Acceptance criteria

In the case of individual strength test at minimum  $1,43 \times PS$ , permanent deformation shall not result from these tests.

In the case of type approval, it is deemed that the components are designed to withstand a pressure not less than three times the component's maximum allowable pressure without rupture (or not less than two times the component's maximum allowable pressure without rupture after the fatigue test) and confirmation shall be provided by testing.

In the case of the fatigue test, the component shall not rupture, burst, or leak after completion of this test. The strength-pressure test at  $2 \times PS$  is to be performed on three samples, other than the samples used for the fatigue test. If the maximum continuous operating temperature exceeds  $125 \text{ }^\circ\text{C}$  for copper or aluminium, or  $200 \text{ }^\circ\text{C}$  for steel, the fatigue test shall be conducted at least  $10 \text{ }^\circ\text{C}$  above the maximum operating temperature.

#### 4.4.3 Tightness

The tightness test shall be performed according to the type approval procedure as specified in ISO 14903.

Unless otherwise agreed by the manufacturer of the assembly, components, not covered by the scope of ISO 14903, shall be tested with detection equipment with a sensitivity of  $3 \text{ g/yr}$  of refrigerant or better, under a pressure of at least  $0,25 \times PS$ . Acceptance criteria is that no leak shall be detected.

NOTE 1 This method can be specified in the component standard (see [Table 1](#)).

When agreed by the manufacturer of the assembly, some or all tests can be executed on the assembly (see [5.3](#)).

Tightness test shall be conducted only after the component has passed a strength-pressure test or has been verified by a type test.

For environmental and safety reasons, nitrogen, helium, and carbon dioxide are preferred test media. Radioactive tracers can be added to the test gases. Air and gas mixtures should be avoided as certain mixtures can be dangerous. Air can be used if the hazard of ignition is eliminated and the safety of the workers is ensured. Oxygen shall not be used for tightness tests.

After testing, care shall be taken to ensure that the test medium is relieved safely.

Where no tightness criteria are specified by the manufacturer, the components shall be tested with detection equipment with a capability of  $3 \text{ g/yr}$  of refrigerant or better, under a pressure of at least  $0,25 \times PS$ .

### 4.5 Marking and documentation

#### 4.5.1 General

Components shall be marked with the following items, unless the component standard is established and requires more specific marking items:

- a) the name or logo of manufacturer;
- b) the type designation;

- c) the serial number or batch number;
- d) the year of manufacture;
- e) the design pressure or maximum allowable pressure;
- f) the applicable refrigerant (where appropriate);
- g) the capacity of main function (where appropriate).

Components assembled in a factory could not be marked if agreed upon by the manufacturer and the purchaser. Small components on which such markings are impractical could not be marked, but the attached documentation shall indicate the information specified from a) to g).

#### **4.5.2 Documentation**

The documentation shall include the following information:

- a) the results of tests;
- b) the material test certificates;
- c) the inspection certificates.

Material test certificates shall be provided by the manufacturer as required by the purchaser to enable him to ensure that the material used conforms with the required specification and that it is traceable from the final test through production up to receipt, preferably at the time of delivery and not later than the time of commissioning. Any required inspection certificate shall be prepared on behalf of and signed by the competent person who carried out the inspection, test, or checking.

Documentation shall include the following specifications:

- the maximum allowable pressure;
- the maximum allowable temperature;
- the applicable refrigerant;
- the applicable oil.

**NOTE** Generic components which can be used for all types of refrigerant can be labelled with a more general indication of the refrigerant, for example, "suitable for halocarbons", "suitable for all refrigerants listed in ISO 817", or as appropriate.

#### **4.5.3 Fusible plugs**

The nominal melting temperature of the fusible material shall be stamped on the non-fusible portion of the plug.

## **5 Requirements for assemblies**

### **5.1 General**

The design, construction, testing, installing, documentation, and marking of the refrigerating system assembly shall comply with [Clause 5](#).

Refrigerating system assemblies using ammonia (NH<sub>3</sub>) as refrigerant shall also comply with the additional requirements specified in [Annex B](#).

Determination of the category of the assembly shall be done in accordance with [Annex C](#).

## 5.2 Design and construction

### 5.2.1 General

All components selected for the assembly of the refrigerant circuit shall comply with [Clause 4](#).

The supports and bases of refrigerating systems shall have sufficient strength to withstand the following external forces:

- a) the mass of the vessels;
- b) the mass of the contents and equipment, including the mass of hydrostatic test fluid and the mass of ice which can form under extreme operating circumstances;
- c) the snow load;
- d) the wind load;
- e) the mass of stays, braces, and interconnecting piping;
- f) the thermal movement of the piping and components;
- g) the forces arising from foreseeable misuse, e.g. the mass and force of the person for repairing and operation.

The supports and bases of refrigerating systems installed in areas with possible risk of earthquakes shall have sufficient strength to withstand the expected acceleration due to earthquakes.

### 5.2.2 Pressure requirements

#### 5.2.2.1 Maximum allowable pressure (PS)

PS shall be determined by taking into account factors such as:

- a) the maximum ambient temperature;
- b) the possible build-up of non-condensable gases;
- c) the setting of any pressure relief device;
- d) the method of defrosting;
- e) the application (e.g. cooling or heating application);
- f) the solar radiation (e.g. impact on icerinks during standstill);
- g) the fouling.

Based on the refrigerating system, the designer shall determine the maximum allowable pressures in the different parts of the system taking into account a maximum ambient temperature as appropriate for the installation site.

One of the following methods shall be used to determine the PS of the different parts of the refrigerating system.

- a) Method 1

The designer shall document the determination of the maximum allowable pressure by calculation or testing. Where the temperature difference between ambient temperature and condensing temperature is calculated, the method shall be verified by testing.

For refrigerants used in the low-temperature part (with or without compressor) of a cascade system, the PS shall be determined by the designer. The designer shall make provision for normal and emergency

standstill conditions, either through provision of a fade-out vessel or by means of safe, controlled venting of the secondary charge (if permissible) or by other means.

b) Method 2

Table 2 is an alternative to Method 1. The minimum value of the maximum allowable pressure shall be determined by the minimum specified temperatures given in Table 2 to determine the saturated refrigerant pressure. When the evaporators can be subject to high pressure, e.g. during hot gas defrosting or reverse cycle operation, the high-pressure side specified temperature shall be used.

**Table 2 — Specified design temperatures**

Ambient conditions	≤32 °C	≤38 °C	≤43 °C	≤55 °C
High-pressure side with air-cooled condenser	55 °C	59 °C	63 °C	67 °C
High-pressure side with water cooled condenser and water heat pump.	Maximum leaving temperature + 8 K			
High-pressure side with evaporative condenser	43 °C	43 °C	43 °C	55 °C
Low-pressure side with heat exchanger exposed to the outdoor ambient temperature	32 °C	38 °C	43 °C	55 °C
Low-pressure side with heat exchanger exposed to the indoor ambient temperature	27 °C	33 °C	38 °C	38 °C

NOTE 1 For the high-pressure side, the specified temperatures are considered the maximum that occur during operation. This temperature is higher than the temperature during compressor shutdown (standstill). For the low-pressure side and/or intermediate-pressure side, it is sufficient to base the calculation of pressure on the expected temperature during compressor standstill period. These temperatures are minimum temperatures and thus determine that the system is not designed for maximum allowable pressure lower than the saturated refrigerant pressure corresponding to these minimum temperatures.

NOTE 2 The use of specified temperatures does not always result in saturated refrigerant pressure within the system, e.g. a limited-charge system or a system working at or above critical temperature.

NOTE 3 For zeotropic blends, PS is the pressure at the bubble point.

NOTE 4 The system can be subdivided into several parts (e.g. low- and high-pressure sides) for each of which there could be a different maximum allowable pressure.

NOTE 5 The pressure at which the system (or part of the system) normally operates is lower than PS.

NOTE 6 Excessive stress can result from gas pulsations.

NOTE 7 For the determination of the ambient conditions, IEC 60721 can be used, as well as regional data.

**5.2.2.2 Component maximum allowable pressure**

The maximum allowable pressure (PS) for each component shall not be less than the maximum allowable pressure of the system or part of the system.

**5.2.2.3 Pressure relationships to maximum allowable pressure**

Systems and components shall be designed to meet the pressure relationship given in Table 3.

**Table 3 — Relationship between the various pressures and the maximum allowable pressure (PS) of components and assemblies**

Components/assemblies	Values	Additional information
Design pressure	$\geq PS$	Component related For systems, see <a href="#">5.2.2.2</a> .
Strength test pressure	according to <a href="#">5.3.2</a>	
Tightness test pressure for assemblies	according to <a href="#">5.3.3</a>	
Pressure limiter for systems with relief device, setting	$\leq 1,0 \times PS$	Related to part of the system. See <a href="#">5.2.9</a> .
Pressure limiter for systems without relief device, setting	$\leq 1,0 \times PS$	
Pressure relief device, setting	$1,0 \times PS$	Component related where it protects the component;
Pressure relief valve, required discharge at	$\leq 1,2 \times PS$	Related to part of the system where it protects a part of the system . See <a href="#">5.2.9</a> .

### 5.2.3 Piping and fitting

#### 5.2.3.1 General

For piping, where the misuse can be foreseen, e.g. climbing, storage, hanging of tools or similar misuses, adequate countermeasures shall be taken such as sufficient strength, protection, or warning labels.

Piping joints and fittings shall comply with the requirements of national standards and those of ISO 14903. If no equivalent national standard exists, an equivalent standard, e.g. EN 14276-2 or ASME B 31.5, shall be used.

Snap-on or push-on connections shall only be used for connection of the parts of self-contained systems.

Where mechanical joints are used on piping, damage caused by freezing or vibration shall be avoided.

Mechanical joints shall be so made and located to minimize tension, compression, bending, or torsion of pipe. Pipe support shall be provided as necessary, considering static and dynamic effects of the weight of the joint and joining components as well as possible displacement of the pipe due to flexible support of movable components. Operation, assembling, handling, transportation, and maintenance shall be taken into account.

NOTE 1 Permanent joints are preferred to detachable joints.

NOTE 2 It is recommended that in insulated piping, the positions of detachable joints are permanently marked.

#### 5.2.3.2 Flanged joints

Flanged joints shall be arranged so that the connected parts can be dismantled with minimum distortion stress of the piping.

It is preferable to use standardized flanges for steel piping according to national standards, e.g. EN 1092-1 for steel piping or ASME B 31.5. For copper piping, EN 1092-3, ASME B 31.5, or an equivalent national standard can be used.

The joints should be solid and resistant enough to avoid any danger of the gasket being blown out. Flanges with a groove and tongue or projection and recess are preferred. Dismantling should be possible without forcing the jointed components. Care should be taken not to overstress bolts due to cold operation by applying a defined prestress.



**5.2.3.3 Flared joints**

Flared joints shall be restricted to use with annealed pipe only and to pipe sizes not exceeding an outside diameter of 20 mm.

When copper piping is used, it shall comply with national standards, e.g. EN 12735-1, EN 12735-2, or ASME B 31.5.

For single-flare connections of copper tubes, the appropriate torque and conditions shall apply as indicated in [Table 4](#). The flares shall be tightened with the designated torque by means of a torque wrench and appropriate spanner.

**Table 4 — Standard tightening torque**

Metric series mm	Nominal outside diameter		Minimum wall thickness mm	Tightening torque Nm
	Millimeter/inch series			
	mm	in		
6			0,80	14 – 18
	6,35	1/4	0,80	14 – 18
	7,94	5/16	0,80	33 – 42
8			0,80	33 – 42
	9,52	3/8	0,80	33 – 42
10			0,80	33 – 42
12			0,80	50 – 62
	12,7	1/2	0,80	50 – 62
15			0,80	63 – 77
	15,88	5/8	0,95	63 – 77
18			1,00	90 – 110
	19,06	3/4	1,00	90 – 110

When making flared joints, care should be taken to ensure that the flare is of the correct size and that the torque used to tighten the nut is not excessive. Care should be taken not to flare piping that has been work hardened.

The pipe ends shall be cut with a right angle to the axis (perpendicular) and checked to be free of burrs.

A torque other than the value specified in [Table 4](#) can be applied, provided it is recommended by the manufacturer.

**5.2.3.4 Taper pipe threads**

Taper pipe threads that are part of the pressure-containing envelope shall be restricted to maximum DN 40 (1,5 in) and shall only be used for connecting control, safety, and indicating devices to components. Taper pipe fittings and sealing medium shall be type-approved by the manufacturer with regard to tightness.

**5.2.3.5 Compression joints**

Compression joints shall be restricted to piping with maximum DN 32 (1,38 in) in accordance with ISO 6708.



### 5.2.3.6 Requirements for piping installed at site

For proper arrangement of piping, the physical layout, particularly, the position of each pipe, the flow conditions (two-phase flow, oil supply operation on partial load), condensation processes, thermal expansion, vibration, and good accessibility shall be taken into account.

NOTE Routing and supporting of piping have an important effect on the operational reliability and serviceability of a refrigerating system.

As a general rule, piping shall be installed so as to avoid damage from any normal activity.

The following considerations shall apply to the installation of piping for safety and environmental protection.

- There shall be no hazard for persons and free passage in escape and access routes shall not be restricted.
- No valves and detachable joints shall be located in areas accessible to the general public where group A2, B1, B2, A3, or B3 refrigerants are used. For all refrigerants, the valves and detachable joints in areas accessible to the general public shall be protected against an unauthorized operation or disconnection.
- Flexible refrigerant connectors (such as connecting lines between the indoor and outdoor units) that can be displaced during normal operations shall be protected against mechanical damage.
- Connecting pipe joints (e.g. in the case of split systems) shall be made before opening the valves to permit refrigerant to flow between the refrigerating system parts. A valve shall be provided to evacuate the interconnecting pipe and/or any uncharged refrigerating system part.
- See [5.2.3.12](#) for requirements regarding the accessibility of piping and joints.

### 5.2.3.7 Specific requirements for the installation of piping for equipment intended to use A2, A3, B2, or B3 refrigerants, excluding A1, B1, A2L, and B2L refrigerants

Piping and joints of a split system shall be made with permanent joints when inside an occupied space, except joints directly connecting the piping to indoor units.

Components shall be shipped without refrigerant charge.

Refrigerant piping shall be protected to avoid damage.

### 5.2.3.8 Spacing for pipe supports

Piping shall be suitably supported according to its size and service weight. The recommended maximum spacing for pipe supports is shown in [Tables 5](#) and [Table 6](#).

**Table 5 — Recommended maximum spacing for supports for copper pipes**

Outside diameter mm	Spacing m
15 to 22 (soft)	2
22 to <54 (half hard)	3
54 to 67 (half hard)	4

NOTE Information on soft and half hard are given in EN 12735-1 and EN 12735-2.

**Table 6 — Recommended maximum spacing for supports for steel pipes**

Nominal bore DN (according to ISO 6708)	Spacing m
15 to 25	2
32 to 50	3
65 to 80	4,5
100 to 175	5
200 to 350	6
400 to 450	7

### 5.2.3.9 Protection of piping

Precautions shall be taken to avoid excessive vibration or pulsation. Particular attention shall be paid to preventing direct transmission of noise or vibration to or through the supporting structure.

NOTE 1 The assessment of vibrations or pulsations should be carried out on the system in service, at maximum condensing temperature and at start and stop conditions which give the worst effect on piping.

Protection devices, piping, and fittings shall be protected as far as possible against adverse environmental effects, for example, the danger of water collecting and freezing in relief pipes or the accumulation of dirt and debris.

Provision shall be made for expansion and contraction of long runs of piping.

Piping in refrigerating systems shall be so designed and installed to minimize the likelihood of liquid hammer (hydraulic shock) damaging the system.

Solenoid valves shall be correctly positioned in the piping to avoid liquid hammer.

Steel pipes and components shall be protected against corrosion with a rustproof coating before applying any insulation.

NOTE 2 Corrosion protection can comply with ISO 12944-1 (for steel piping).

Flexible pipe elements shall be protected against mechanical damage, excessive stress by torsion, or other forces. They should be checked for mechanical damage regularly.

### 5.2.3.10 Piping in ducts or shafts

Where refrigerant piping shares a duct with other services, provision shall be made to avoid damage due to interaction between them.

There shall be no refrigerant pipes in ventilation or air conditioning routes where these are also used as escape routes.

Piping shall not be located in lift shafts or other shafts containing moving objects.

### 5.2.3.11 Location

Sufficient space for insulation of the piping shall be provided where it is required.

Piping outside a machinery room or enclosure shall be protected against possible accidental damage.

Piping with detachable joints not protected against disconnection shall not be located in public hallways, lobbies, stairways, stairway landings, entrances, exits, or in any duct or shaft which has unprotected openings to these locations.

An exception to this is piping which has no detachable joints, valves, or controls therein and is protected against accidental damage. Piping which has no detachable joints, valves, or controls and which is protected against accidental damage can be installed in public hallways, stairways, or lobbies provided it is not less than 2,2 m above the floor.

Piping passing through fire-resistant walls and ceilings shall be sealed in such a way as to be consistent with the fire rating of the partition.

#### **5.2.3.12 Accessibility of piping and joints**

The clearance around the piping shall be sufficient to allow routine maintenance of insulation, vapour barrier, and components, checking of pipe joints, and repairing of leaks.

All detachable joints shall be readily accessible for inspection.

#### **5.2.3.13 Piping for accessories and measurements**

The piping, including flexible pipes, for connection of measuring, control, and safety devices shall be of sufficient strength in relation to the maximum allowable pressure and be installed in such a way that it minimizes vibration and corrosion.

Tubes for connection of measuring, control, and safety devices shall be connected and routed so that the collection of liquid, oil, or dirt is avoided as much as practically possible.

A minimum nominal internal diameter of 4 mm (0,157 in) is required for the connection pipes of safety switching devices. Exception: safety switching devices requiring a connection pipe with a smaller bore in order to damp pulsations. If this damping is required to ensure the function of the device, then the connection pipe shall be made as high as practical on the vessel or piping to avoid the entry of oil or liquid into the pipe.

#### **5.2.3.14 Drain and vent connections**

##### **5.2.3.14.1 General**

Shut-off devices in drain and vent lines which should not be actuated when the system is normally operating shall be safeguarded against unauthorized actuation. Installation in a special machinery room provides sufficient protection against unauthorized actuation.

##### **5.2.3.14.2 Special requirements**

Where service instructions require regular changes of the oil, the manufacturer or the installer shall provide instructions on how to drain off oil with minimum refrigerant emission to the environment.

When a self-closing valve is used in the oil drain line, a shut-off valve shall be installed on the inlet side of it or a valve combining these two functions shall be fitted.

**NOTE** The risk of dirt on the seat can be minimized by installing the valve with the spindle in horizontal position.

Refrigerating systems other than sealed systems shall have the necessary shut-off devices and/or connection facilities in order to enable the compressor of the system or external evacuation devices to transfer refrigerant and oil from the system to internal or external liquid receivers.

Drain-off valves shall be provided to facilitate removal of the refrigerant from the system with minimum refrigerant emission.

Piping which is not used during normal operation shall be fitted with a permanent or removable cap or equivalent.

## 5.2.4 Shut-off devices

### 5.2.4.1 Isolating valves

Refrigerating systems shall be provided with sufficient isolating valves to minimize danger and loss of refrigerant, particularly, during repair and/or maintenance.

### 5.2.4.2 Hand-operated valves

Hand-operated valves which can require instantaneous operation, e.g. emergency shut-down, shall be fitted with a hand wheel or operating handle.

### 5.2.4.3 Change of gland packing/seal

If it is not possible to tighten or change the gland packing/seal(s) while the valve is exposed to system pressure, it shall be possible to isolate the valve from the system or provisions shall be made to evacuate refrigerant from the part of the system where the valve is located.

### 5.2.4.4 High-risk release areas

Self-closing or quick-closing valves shall be installed wherever there is an increased risk of release of refrigerant to the atmosphere, e.g. at oil draining points.

Where service instructions require regular draining of oil, written instructions for draining oil to minimize the risk for emission of refrigerant to the atmosphere shall be developed and followed.

### 5.2.4.5 Arrangement of shut-off devices

Hand-operated shut-off devices shall not be mounted in crawl spaces.

## 5.2.5 Setting of protection devices

### 5.2.5.1 General

The setting pressure of a pressure-limiting device shall be equal or less than high-side design pressure if no pressure relief device is provided. If a pressure relief device is provided, the setting pressure of the pressure-limiting device shall be 90 % or lower than that of the setting of the pressure relief device.

### 5.2.5.2 Pressure relief to atmosphere from the low-pressure side

A high-pressure relief device can relieve to the low-pressure side if the following conditions are satisfied.

- The relief path between high side and low side of the system cannot be shut off except as specified in [5.2.9.4](#).
- A pressure relief device relieving to atmosphere is fitted on the low-pressure side.
- The pressure setting of the low-pressure relief device is less than or equal to low-side design pressure.

## 5.2.6 Safety switching devices for limiting the pressure

### 5.2.6.1 Electro-mechanical safety switching devices for limiting the pressure

Electro-mechanical safety switching devices shall be in accordance with IEC 60730-2-6. If used to protect the refrigerating system against excessive pressure, they shall not be used for other purposes.

### 5.2.6.2 Electronic safety switching for limiting the pressure

Electronic devices shall not be used as safety switching devices for limiting the pressure unless they meet the requirements of ISO 13849-1.

### 5.2.6.3 Arrangement of safety switching devices

No shut-off valve shall be positioned between the pressure limiter and the pressure-imposing element unless either a second pressure limiter of equal type is fitted and the shut-off valve is a changeover valve or a pressure relief valve or bursting disc is fitted to the system.

Examples of practical arrangement of safety devices can be found in [Annex E](#).

Safety switching devices for limiting the pressure and type-approved pressure limiters mounted on the high-pressure side shall be protected against the pulsations that can occur. This can be obtained by applying the appropriate construction methods, by applying a damping device, or by using reduced connection tubes. See [5.2.3.6](#) for installation of piping.

NOTE 1 Type-approved safety pressure cutout, type-approved pressure cutout, and type-approved pressure limiters are considered as safety switching devices for limiting the pressure, as defined ISO 5149-1.

NOTE 2 One safety switching device for limiting the pressure can be used to stop more than one pressure-imposing element if the safety switching device complies with the above-mentioned requirements.

Safety switching devices for limiting the pressure shall be so arranged that the change of setting can only be carried out by the use of a tool.

In case of an automatic restart after failure of the power supply, means shall be provided to prevent hazardous situations. Failure of electrical power to the safety switching devices for limiting the pressure or to the micro-processor/computer, if it is used in the safety circuit, shall stop the compressor.

## 5.2.7 Size calculations for pressure relief devices

### 5.2.7.1 Calculations

The minimum required discharge capacity of the pressure relief device or fusible plug for each pressure vessel shall be determined by Formulae (1) and (2):

— for a cylindrical vessel:

$$C = f \times D \times L \quad (1)$$

— for a non-cylindrical vessel:

$$C = f \times \frac{S}{3} \quad (2)$$

where

- C* is the minimum required discharge capacity of the relief device, in kilograms of air per second (kg/s);
- D* is the outside diameter of the vessel, in metres;
- L* is the length of the vessel, in metres;
- f* is the factor dependent upon the type of refrigerant, in kilogram second per square metre;
- S* is the external surface of the non-cylindrical pressure vessel, in square metres (plate-type heat exchanger).

NOTE 1 When combustible materials are used within 6,1 m of a pressure vessel, multiply the value of *f* by 2,5.

NOTE 2 The formula is based on fire conditions at specific relief valve settings. More general calculations for other circumstances, e.g. internal heat sources or different relief valve settings, are detailed in EN 13136.

Some values of factor *f*, which is dependent upon the type of refrigerant, are given in [Table 7](#) when used on the low side of a limited-charge cascade system and in [Table 8](#) for the other applications.

**Table 7 — Value of *f* dependent upon the type of refrigerant (when used on the low side of a limited-charge cascade system)**

Refrigerant	Value of <i>f</i> <sup>a</sup> kg s <sup>-1</sup> m <sup>-2</sup>
R-23, R-170, R-744, R-1150, R-508A, R-508B	0,082
R-13, R-13B1, R-503	0,163
R-14	0,203

<sup>a</sup> Values derived from ASHRAE 15:2010.

**Table 8 — Value of *f* dependent upon type of refrigerant (for other applications)**

Refrigerant	Value of <i>f</i> <sup>a</sup> kg s <sup>-1</sup> m <sup>-2</sup>
R-717	0,041
R-11, R-32, R-113, R-123, R-142b, R-152a, R-290, R-600, R-600a,	0,082
R-12, R-22, R-114, R-124, R-134a, R-401A, R-401B, R-401C, R-405A, R-406A, R-407C, R-407D, R-407E, R-409A, R-409B, R-411A, R-411B, R-411C, R-412A, R-414A, R-414B, R-500, R-1270,	0,131
R-143a, R-402B, R-403A, R-407A, R-408A, R-413A	0,163
R-115, R-402A, R-403B, R-404A, R-407B, R-410A, R-410B, R-502, R-507A, R-509A	0,203

<sup>a</sup> Values derived from ASHRAE 15:2010.

When one pressure relief device or fusible plug is used to protect more than one pressure vessel, the required capacity shall be the sum of the capacities required for each pressure vessel.

### 5.2.7.2 Fusible plugs

A fusible plug is used to protect the refrigerating system against overpressure in case of an excessive external heat source such as fire. If a fusible plug is mounted on the pressure vessel or any other part which it protects, it shall be placed in a section where superheated refrigerant would not affect its correct function. Fusible plugs shall not be covered by thermal insulation.

Discharge from fusible plugs shall take place so that persons and property are not endangered by the released refrigerant.

Fusible plugs can only be used when A1 and A2L refrigerants are used.

Fusible plugs shall not be used as the sole pressure relief device between a refrigerant-containing component and the atmosphere for systems with a refrigerant charge larger than 2,5 kg of group A1 and A2L refrigerants.

### 5.2.7.3 Bursting disc

A bursting disc relieving to the atmosphere can only be used in series with a pressure relief valve and located on the inlet side of the pressure relief valve. Provision shall be made to indicate pressure build up between the bursting disc and the relief valve due to leakage through the upstream device. The bursting disc installed ahead of a pressure relief valve shall not be smaller than the inlet of the pressure relief valve. The bursting disc shall be so constructed that no piece of the broken disc obstructs the pressure relief valve or hinders the flow of refrigerant.

In the case of a low-pressure centrifugal compressor (maximum allowable pressure less than 0,2 MPa), a bursting disc as a relief device is permitted without a pressure relief valve.

### 5.2.7.4 Discharge capacity

The rated discharge capacity of a bursting disc or fusible plug discharging to the atmosphere under critical flow conditions, in kilograms of air per second (kg/s), shall be determined by Formulae (3) and (4):

$$C = 1,09 \times 10^{-6} P_1 d^2 \quad (3)$$

$$d = 958,7(C / P_1)^{0,5} \quad (4)$$

where

$C$  is the rated discharge capacity, in kilograms per second;

$d$  is the smallest of the internal diameter of the inlet pipe, retaining flanges, fusible plug, and bursting disc, in millimetres.

For bursting discs,  $P_1$  is the rated gauge pressure  $\times 1,1 + 101,33$  (kPa).

For fusible plugs,  $P_1$  is the absolute saturation pressure corresponding to the stamped temperature melting point of the fusible plug or the critical pressure of the refrigerant used, whichever is the smaller, in kilopascals.

Discharge capacity of bursting disc shall be calculated according to ISO 4126-2.

Discharge capacity of safety valves shall be determined according to the tests in ISO 4126-1.



## 5.2.8 Discharge piping from pressure relief devices

### 5.2.8.1 General

Discharge from pressure relief devices shall take place so that persons and property are not endangered by the released refrigerant.

The size of the discharge pipe from a pressure relief device shall not be less than the outlet size of the pressure relief device. The size and maximum equivalent length of common discharge piping downstream from each of two or more relief devices shall be governed by the sum of the discharge capacities of all the relief devices that are expected to discharge simultaneously, at the lowest pressure setting of any relief device that is discharging into the piping, with due allowance for the pressure drop in all downstream sections.

**NOTE** The refrigerant can be diffused into the air by adequate means but away from any air intake to the building or discharged into an adequate quantity of a suitable absorbing substance.

Adverse effects shall be considered, e.g. the danger of water collecting and freezing in relief discharge pipes or the accumulation of dirt or debris, or in the case of CO<sub>2</sub> systems, blockage of the discharge by solid CO<sub>2</sub>.

Internal diameter of discharge piping shall be larger than the required diameter of the pressure relief device (see [Annex F](#)).

The connection of discharge lines to discharge devices shall be so arranged that individual tightness testing (e.g. access for leak refrigerant detection) of the discharge devices is possible.

### 5.2.8.2 Indication device for pressure relief devices

For systems with a minimum charge of 300 kg of refrigerant, an indicating device shall be provided to check whether the relief valve has discharged to atmosphere.

**EXAMPLE 1** Upstream installation of bursting discs with interspace monitoring and pressure alarm device (pressure limiter). The actual relieving pressure of the type-tested pressure limiter monitoring the inter-space should be set to a pressure of less than or equal to 50 kPa (0,5 bar).

**EXAMPLE 2** Gas sensor in the discharge line.

**EXAMPLE 3** Use of safety valves with a soft seal, with pressure monitoring of the protected section and alarming of the permanently attended station when a level of 200 kPa (2 bar) below the actual relieving pressure of the safety valve is reached.

## 5.2.9 Application of the protection devices

### 5.2.9.1 General

Protection devices shall be provided for both the refrigerating system and the secondary heat-transfer circuit.

If pressure relief devices are used to prevent excessive pressure at the high-pressure sides of one- and two-stage systems during operation, a safety switching device for limiting the pressure shall be used (see [5.2.9.2](#)) to stop the pressure-imposing element before any pressure relief device operates. For relieving excessive pressure, a pressure relief valve relieving to the low-pressure side of the system should be used in preference to a safety valve relieving to the atmosphere.

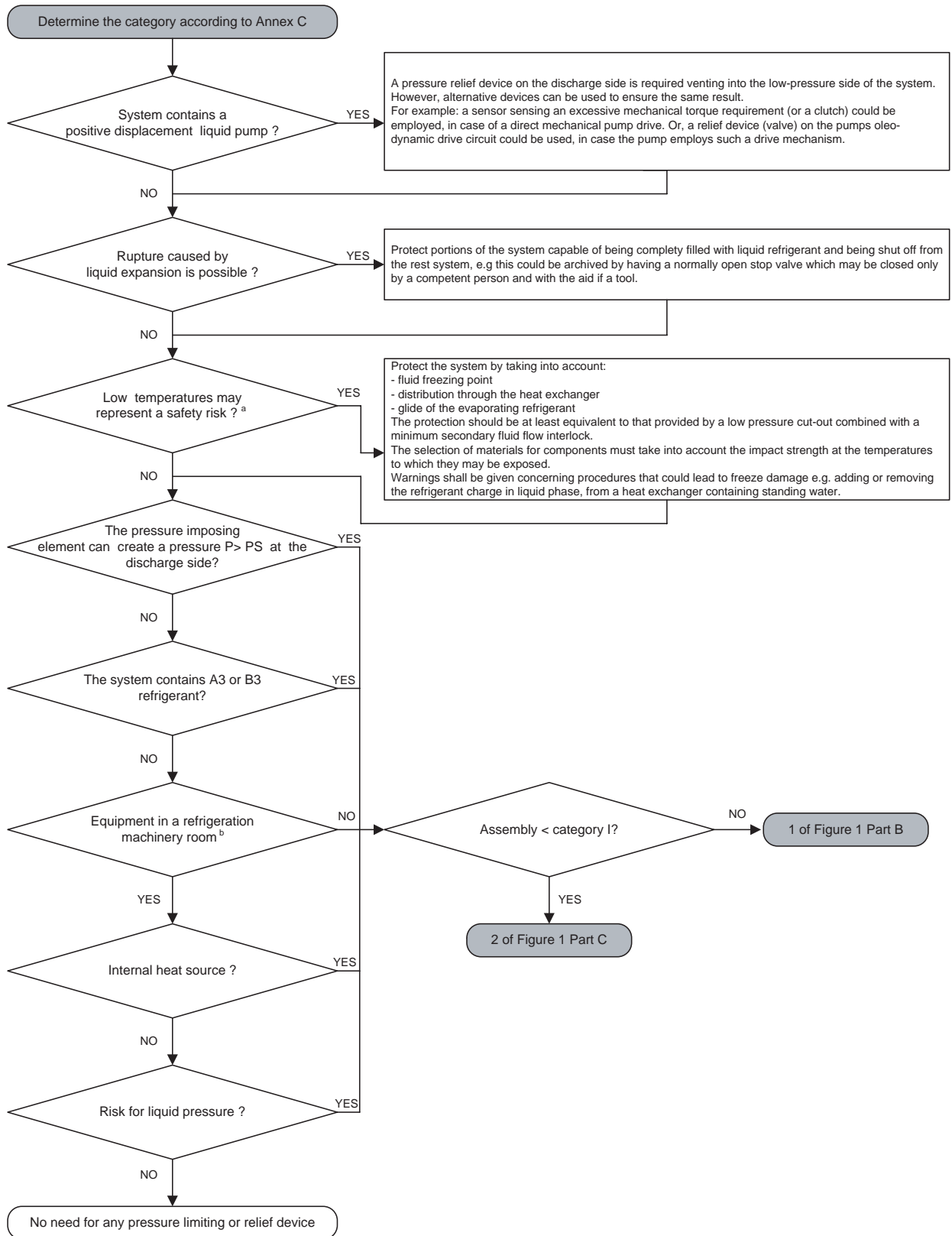
### 5.2.9.2 Protection of the refrigerating system against excessive pressure

For each refrigerating system, protection devices shall be provided according to the flowcharts as indicated in [Figures 1a](#)), [1b](#)), [1c](#)), and [1d](#)).

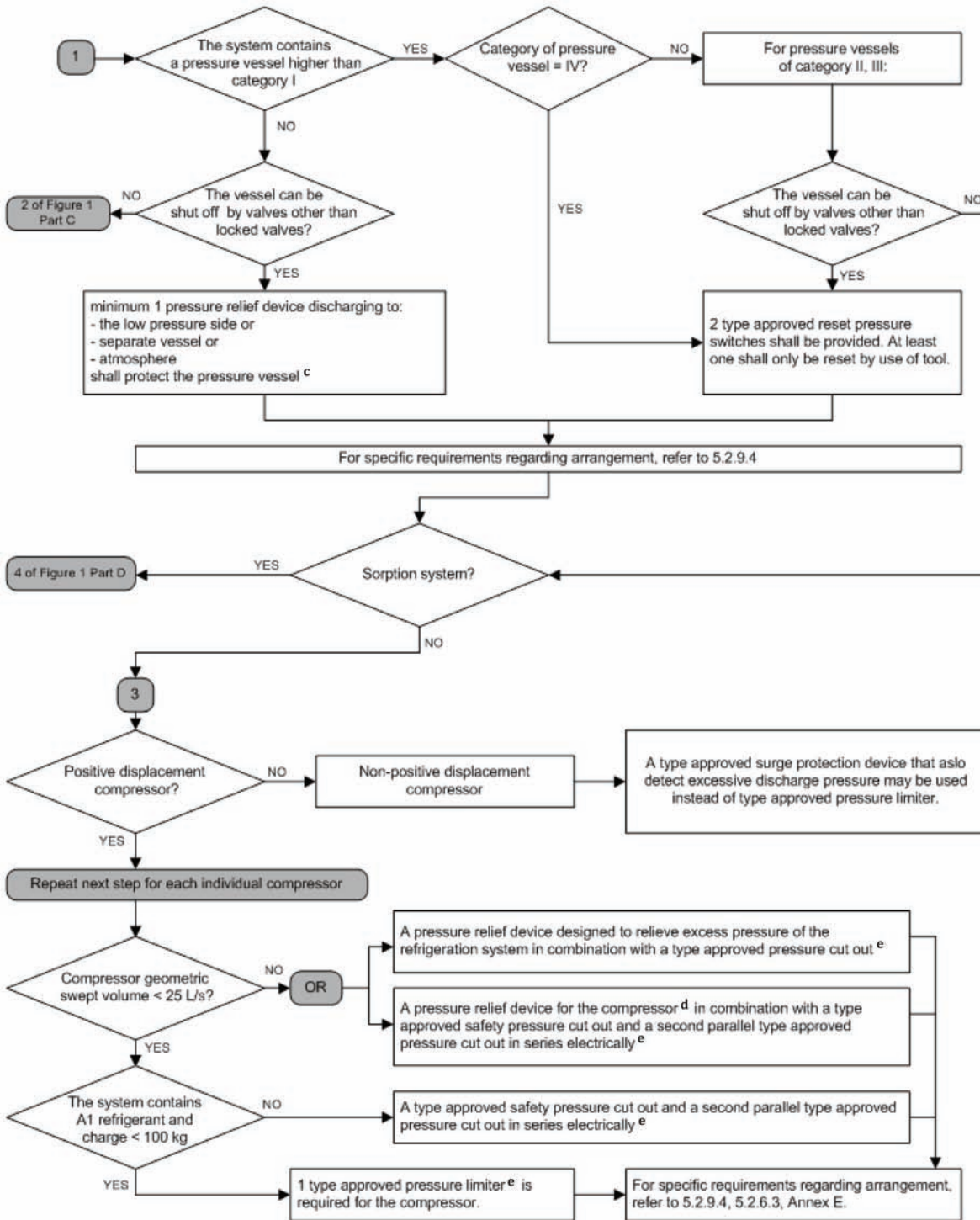


Figures 1a), 1b), 1c), and 1d) shall be considered in relation to one another in order to determine the protective devices.

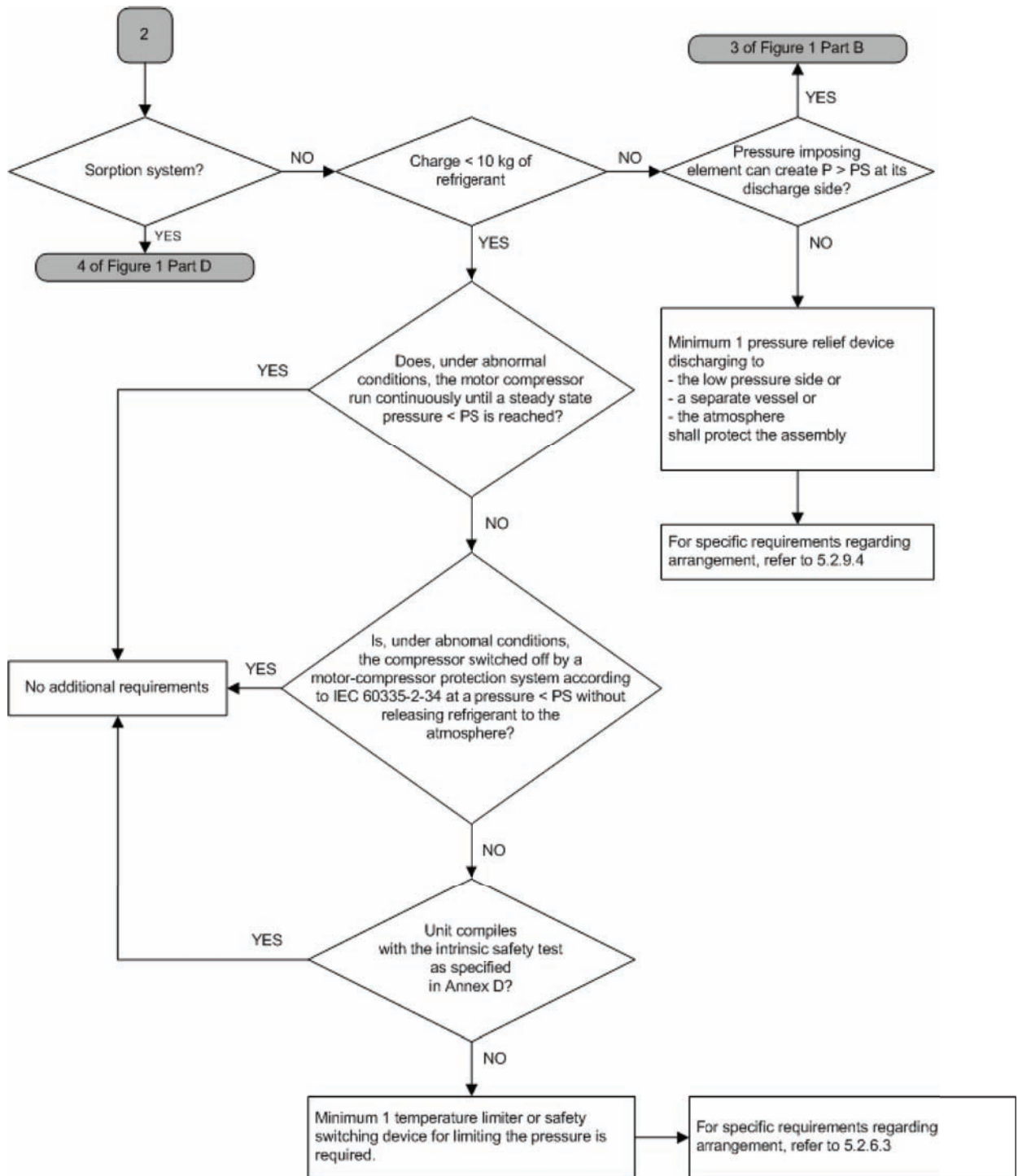
Examples of the arrangement of pressure relief devices in refrigerating systems are given in Annex E.



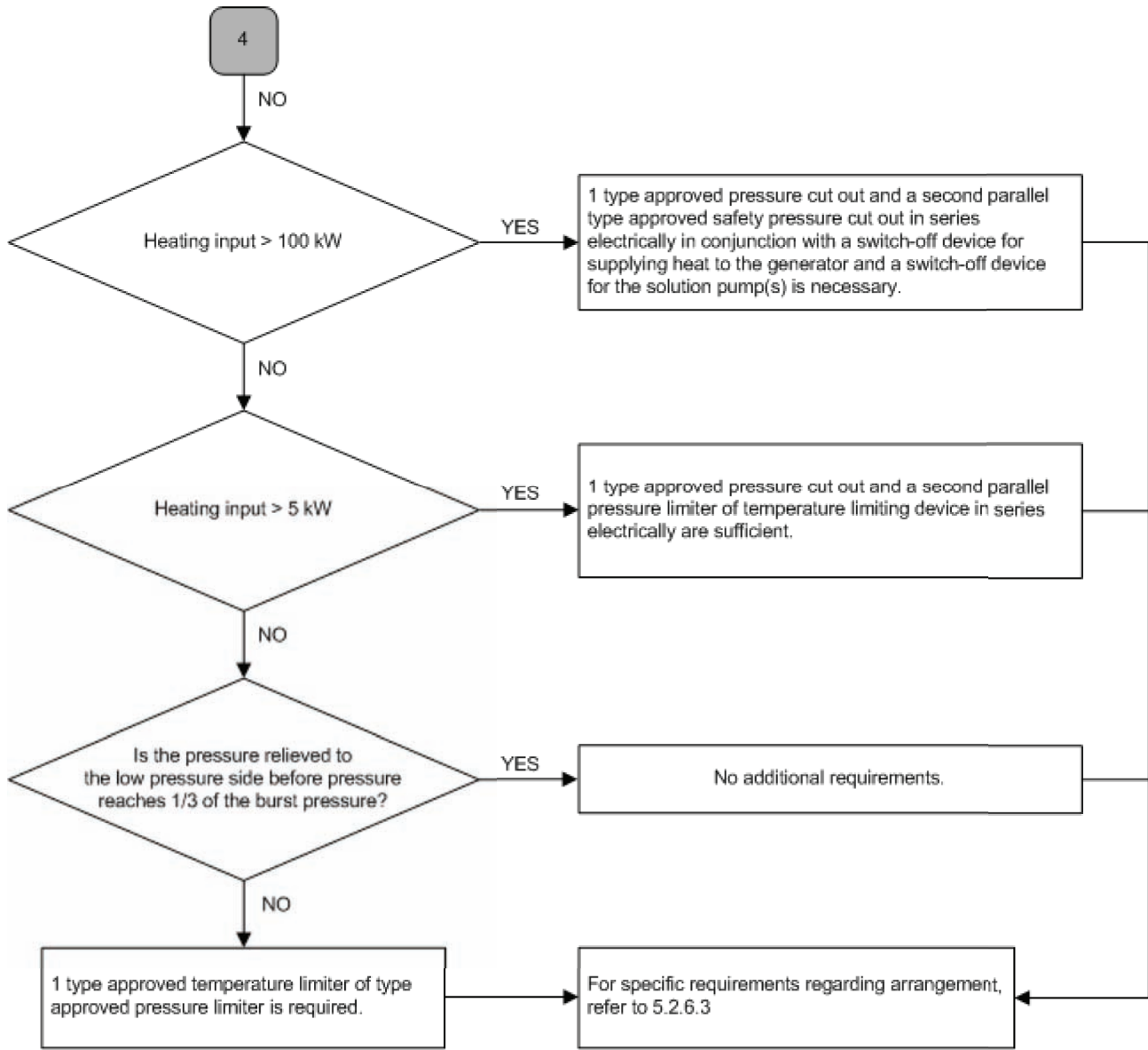
a) Part A



b) Part B



c) Part C



**d) Part D**

**Key**

- a For example, reduced impact structure or damage due to liquid freezing.
- b Refer to ISO 5149-3.
- c In cases where the pressure relief device protects a particular vessel or part of the system, the setpoint of the pressure relief device shall be set at the pressure of that vessel or part of the system.
- d In cases where discharge shut-off valves other than non-capped valves are not fitted, a high-pressure relief device will be sufficient, providing there are no intermediate shut-off valves other than capped valves. Relieving to the low-pressure side can cause compressor overheating. The setting of a compressor relief device shall normally be above the maximum allowable pressure of the system and shall therefore not serve as a protection of the system or other components unless its setting is at the maximum allowable pressure.
- e A pressure limiter fulfilling the required function and deemed to be more safe than the prescribed one can be used, e.g. a type-approved safety pressure cutout can be used instead of a type-approved pressure cutout.

**Figure 1 — Protection of the refrigerating system against excessive pressure**

### 5.2.9.3 Overflow valves

When a pressure relief device, except a compressor relief device, discharges from a higher to a lower pressure stage of the system, the design and capacity of such a pressure relief device shall take into account the allowance for backpressure.

The characteristics of the overflow valve shall be such that the pressure during relief is not higher than the pressure that occurs with a pressure relief device relieving to the atmosphere.

The relieving capacity of the pressure relief devices on the low-pressure side of the system shall protect all connected vessels, compressors, and pumps subjected to excess pressure simultaneously.

### 5.2.9.4 Isolation and arrangement of protection devices for refrigerating systems

Pressure relief devices shall be mounted on or in proximity to the parts of the refrigerating system which they protect. Pressure relief devices shall be easily accessible and shall be connected, except for devices to protect against the effect of liquid expansion, above the level of liquid refrigerant.

There shall be no isolating valves in the inlet or outlet line of a pressure relief device except as specified below.

When an external-mounted single pressure relief device is used to release to the low-pressure side of the system, means shall be provided by which the device can be removed without losing a significant quantity of refrigerant. Shut-off devices shall be provided in front of and behind the overflow valve. Shut-off devices shall be secured when open against unauthorized use by means of a lead seal or an equivalent. This seal shall be clearly marked with the identification of a competent person. The overflow lines of overflow valves should preferably lead into the gas phase and shall lead into the low-pressure side of the system (e.g. the return line to the separator) via the shortest path (see [Figures E.5](#) and [E.6](#)).

NOTE Pressure relief devices discharging into the atmosphere can be installed in parallel to the overflow pressure relief devices to protect the system against excessive pressure arising from external heat sources.

### 5.2.9.5 Protection of the secondary cooling and heating system

If the heat exchanger between the refrigerating system and the secondary cooling and heating system can be shut off so that an increase in pressure could occur, then the heat exchanger shall be protected on the secondary side by means of a pressure relief device set at a pressure not higher than the PS of the secondary side.

When the system contains a secondary heat exchanger, the heat exchanger shall not allow the release of the refrigerant into the areas served by the secondary heat-transfer fluid due to a breakdown of the evaporator or the condenser wall. The following comply with this requirement.

- An automatic air/refrigerant separator is mounted on the secondary circuit on the outlet pipe from the evaporator or the condenser and at a high level relative to the heat exchanger. The air/refrigerant separator shall have sufficient flow rating to discharge the refrigerant that can be released through the heat exchanger. The air separator shall discharge the refrigerant into the vented unit housing or the outside. The vent shall be arranged to minimize the risks of hazard.
- A double wall heat exchanger is mounted between the primary and the secondary circuits in order to avoid, in case of leakage, having refrigerant leaks into the secondary circuit.
- The pressure of the secondary circuit is always greater than the pressure of the primary circuit in the area of contact.

Where the primary refrigerant is soluble in the secondary fluid, an automatic detector shall be fitted and connected to an alarm system.

## 5.2.10 Indicating and measuring instruments (monitoring)

### 5.2.10.1 General

Refrigerating systems shall be equipped with the indicating and measuring instruments necessary for testing, operating, and servicing as specified in this part of ISO 5149.

“Monitoring devices” as described in this part of ISO 5149 are not considered to be protection devices.

### 5.2.10.2 Arrangement of refrigerant pressure indicators

For systems containing more than 10,0 kg of refrigerant, pressure-indicator connections for each pressure side or distinct pressure stage shall be provided (the fitting of permanent pressure indicators being optional).

When a pressure gauge is permanently installed on the high side of a refrigerating system, its dial shall be graduated to at least 1,2 times the design pressure.

If a replaceable oil strainer is provided in the lubricating system of the open-type compressor, an oil-pressure gauge shall be provided to detect insufficient lubrication pressure.

Pressure vessels with an internal net volume of 100 l or larger which are provided with shut-off devices on the inlet and outlet and which can contain liquid refrigerant shall be provided with a pressure-indicator connection.

Refrigerant-containing components which are cleaned or defrosted in the warm or hot state and under manual control shall be equipped with a pressure indicator(s). When a pressure gauge is used, its dial shall be graduated to at least 1,2 times the saturation pressure of the refrigerant at the temperature achieved during the cleaning or defrosting process.

### 5.2.10.3 Liquid level indicators

Refrigerant receivers in systems containing more than

- 100 kg of group A1 refrigerant, according to ISO 817,
- 25 kg of group A2, B1, or B2 refrigerant, according to ISO 817, and
- 2,5 kg of group A3 or B3 refrigerant, according to ISO 817

and which can be isolated shall be provided with a liquid level indicator to show at least the maximum refrigerant level.

Liquid level indicators constructed of glass tubes shall not be used.

Exception: Liquid level-gauge glass tubes having automatic shut-off valves can be used only if protected against external damage and properly supported.

Bull’s-eye-type liquid level-gauge glasses are not considered to be tubes.

### 5.2.11 Electrical requirements

The design of the electrical equipment shall comply with the IEC 60335 series or IEC 60204-1.

### 5.2.12 Protection against hot surfaces

The equipment shall comply with the IEC 60335 series or IEC 60204-1 so that persons shall not be endangered by hot surfaces in combination with the following requirements.

Temperatures on surfaces that can be exposed to leakage of refrigerants shall not exceed the auto-ignition temperature except for A1, B1, A2L, and B2L refrigerants.



For A1, B1, A2L, and B2L refrigerants, hot surfaces shall not exceed a temperature of 700 °C or the auto-ignition temperature, whichever is higher.

### 5.2.13 Protection against moving parts

The equipment shall comply with the IEC 60335 series or IEC 60204-1 and ISO 12100 so that persons are not endangered by the moving parts. Unless otherwise specified, all moving parts (e.g. fan blades, blower wheels, pulleys, and belts) that if accidentally contacted, could cause bodily injury shall be guarded against accidental contact by an enclosure or a screen requiring the use of tools for removal or permanently attached.

### 5.2.14 Safe handling of equipment

Refrigerating equipment shall be designed to allow safe handling.

### 5.2.15 Standstill conditions during transportation

The pressure in parts protected by a pressure relief device shall not exceed 0,9 times the setting of that device during transport.

The pressure shall be calculated or tested assuming that the system could be subjected to the highest transport temperature for a period of 12 h.

### 5.2.16 Protection against explosion hazards

Refrigerating systems using A2, A3, B2, or B3 refrigerants shall be constructed so that any leaked refrigerant will not flow or stagnate and cause a fire or explosion hazard in areas in the vicinity of the system where electrical components, which could be a source of ignition and could function under normal conditions or in the event of a leak, are fitted.

Separate components such as thermostats, which are charged with less than 0,5 g of flammable gas, are not considered to cause a fire or explosion hazard in the event of leakage of the gas within the component itself.

All electrical components that could be a source of ignition and which could function in normal conditions or in the event of a leak shall be located in an enclosure which satisfies the following:

- compliance with IEC 60079-15 regarding the supplementary requirements for restricted breathing enclosures protecting the equipment producing arcs, sparks, or hot surfaces;
- demonstration of compliance with IEC 60079-15 regarding the general supplementary requirements for equipments producing arcs, sparks, or hot surfaces.

NOTE 1 IEC 60079-15:2010, 22.5.3.1 is for sealed or encapsulated apparatus, but here the test can also be used for enclosures bigger than 100 cm<sup>3</sup>.

Components and apparatus complying with Clauses 16 to 22 of IEC 60079-15:2010 or the refrigerant used or an applicable standard that makes electrical components suitable for use in zones 2, 1, or 0, as defined in IEC 60079-14, are not considered as a source of ignition.

NOTE 2 The test current for a switching component is a rated current of the component or the actual load to be switched, whichever is greater.

### 5.2.17 Requirements for ventilated enclosures

When flammable refrigerant is used, ventilated enclosure can be employed to avoid explosion hazard.

The manufacturer shall specify the ventilation duct by the size and number of bends. The appliance enclosure shall provide airflow between the space and the interior of the appliance enclosure. The negative pressure measurement in the interior of the appliance enclosure shall be 20 Pa or more and

the flow rate to the exterior shall be at least  $Q_{\min}$  with a minimum ventilation flow of 2 m<sup>3</sup>/h. The ventilation duct flow area shall not be restricted by any components.

$Q_{\min}$  shall be calculated as follows:

$$Q_{\min} = 15 \times s \times \left( \frac{m}{\rho} \right) \geq 2 \text{ m}^3 / \text{h} \quad (5)$$

where

$Q_{\min}$  is the volume flow of the ventilation, in cubic metres per hour (m<sup>3</sup>/h);

15 is the constant converting the 4 min leak rate to a heavy leak rate (h<sup>-1</sup>);

$s$  is 4 (safety factor);

$m$  is refrigerant charge mass, in kilograms (kg);

$\rho$  is the density of the refrigerant at atmospheric pressure at 25 °C, in kilograms per cubic metre (kg/m<sup>3</sup>).

Compliance shall be determined by test.

The ventilation system shall operate as follows.

- It shall run at all times; the airflow shall be monitored continuously, and the appliance or the motor compressor is switched off within 10 s in the event that the airflow is reduced below  $Q_{\min}$ .
- It shall be switched on by a refrigerant gas sensor before 25 % of the Low Flammability Limit (LFL) is reached. The sensor shall be suitably located, considering the density of the refrigerant, and periodically tested in accordance with the manufacturer's instructions. The airflow is periodically checked and detected in the event that the airflow is reduced below  $Q_{\min}$ .

### 5.3 Testing

#### 5.3.1 Tests

Before putting into service any refrigerating system, all the components or the whole refrigerating system shall undergo the following tests:

- a) strength-pressure test;
- b) tightness test;
- c) functional test of safety switching devices for limiting the pressure;
- d) conformity test of the complete installation.

Joints shall be accessible for inspection while the strength-pressure testing and tightness testing are in progress.

After strength-pressure testing and tightness testing and before the system is started up for the first time, functional testing of all the electrical safety circuits shall be carried out.

The results of these tests shall be recorded.

#### 5.3.2 Strength-pressure test

If piping and piping joints are not tested beforehand, then following requirements apply for the remaining piping and piping joints not tested on beforehand.



For the remaining piping and piping joints of category II or higher, as defined in [Annex C](#), one of the following tests shall be applied.

- Individual strength-pressure test at minimum  $1,43 \times PS$ .
- The remaining piping and piping joints have to be strength-pressure-tested at minimum  $1,1 \times PS$ . In addition, 10 % of the permanent joints of category II or higher have to be submitted to a non-destructive test.

NOTE 1 Strength-pressure tests at  $1,1 \times PS$  are considered, where strength-pressure tests at  $1,43 \times PS$  can be harmful to the system. This procedure is only applied in case the other procedures are harmful for the system.

If the category of the remaining piping and piping joints is less than or equal to category I, as defined in [Annex C](#), then one of the following tests shall be applied.

- Carry out one of the tests required for piping and piping joints of category II or higher.
- Test the remaining piping and piping joints at minimum  $1,1 \times PS$ .
- Type-approved the remaining piping and piping joints as described in [4.4](#) in combination with the tightness test as described in [5.3.3](#).

If the category of the remaining piping and piping joints is less than or equal to category I (as defined in [Annex C](#)) and the unit fulfils the requirements of [Annex D](#), then a tightness test as described in [5.3.3](#) is sufficient.

For the strength-pressure test, the pressure relief devices and control devices can be removed if necessary.

For the connection of these parts, a tightness test is necessary if the parts are connected again to the equipment after the strength-pressure test.

The maximum allowable pressure can be separately specified for each section in the system. In this case, the test pressure can be different for each section.

During this test, the low-pressure side of the compressors should not be subjected to test pressures in excess of PS on the low-pressure side as defined by the manufacturer.

The test on the assembly shall be carried out by means of a non-hazardous gas. Oxygen shall not be used. Air shall not be used for site-erected systems.

NOTE 2 Oxygen-free nitrogen is preferred for this test.

### 5.3.3 Tightness test

#### 5.3.3.1 General

The system shall be leak-tested as a whole or in parts in accordance with this clause either before leaving the factory if it is factory-assembled or on site if it is assembled or charged on site, if necessary in stages as the system is completed.

Several techniques are used for testing for leaks depending on the production conditions, e. g. pressure with inert gas and radioactive gas traces. In order to avoid the emission of any hazardous substance, testing should be done using inert gas such as nitrogen, helium, or carbon dioxide. Air, oxygen, acetylene, or hydrocarbons should not be used for reasons of safety. Air and gas mixture should be avoided as certain mixtures can be dangerous.

NOTE A vacuum procedure can be used to get a rough indication of tightness.

The constructor shall apply a test method to reach the results equivalent to the requirements of [5.3.3.1](#) or [5.3.3.2](#).

**5.3.3.2 For self-contained systems with refrigerant charge less than 5 kg which are tested with refrigerant in the system**

No leaks shall be detected in the following cases.

a) For factory-made joints:

- joints in sealed systems shall be tested with detection equipment with a capability of 3 grams per year of refrigerant or better, under a pressure of at least  $0,25 \times PS$ ;
- joints in other systems shall be tested with detection equipment with a capability of 5 grams per year of refrigerant or better, under a pressure of at least  $0,25 \times PS$ .

b) For joints made at the installation site:

- Joints shall be tested with detection equipment with a capability of 5 grams per year of refrigerant or better, with the equipment in standstill and under operation or under a pressure of at least these standstill or operation conditions.

The leak-detection procedure shall take into account the response time of the equipment and the maximum distance between the leak and the leak-testing equipment.

The corresponding instructions have to be given by the manufacturer of the leak-testing equipment.

Where the system is not tested at the above required pressures or not tested with pure refrigerant, the constructor shall demonstrate the applied test method to be equivalent to the above requirements.

The detection equipment shall be regularly calibrated according to the instructions of its manufacturer.

Every detected leak shall be repaired and retested for tightness.

**5.3.3.3 For systems not covered by [5.3.3.2](#)**

Tests shall not be conducted using refrigerant as the test medium.

**5.3.3.3.1 Factory test**

All refrigerant-containing parts or unit systems shall be tested and proved tight by the manufacturer at not less than the design pressure for which they are rated. Tests shall be performed with dry nitrogen or another non-flammable, non-reactive, dried gas. Oxygen, air, or mixtures containing them shall not be used. The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device and a gauge on the outlet side. The pressure-limiting device shall be set above the test pressure but low enough to prevent permanent deformation of the system's components.

There are two exceptions to test fluids mentioned in the above requirement.

- Mixtures of dry nitrogen and inert gases in combination with flammable gas in concentrations not exceeding the lesser of a weight fraction (mass fraction) of 5 % or 25 % of the LFL are allowed for factory tests.
- Compressed air without added refrigerant is allowed for factory tests provided the system is subsequently evacuated to less than 132 Pa absolute pressure before charging with refrigerant.

**5.3.3.3.2 Acceptance criteria**

For refrigerants with Global Warning Potential (GWP) > 150, the acceptance criterion for this test is that no leaks shall be detected when using detection equipment with a capability of  $10^{-6}$  Pa·m<sup>3</sup>/s or better, for example, a helium sniffer.

For refrigerants with GWP < 150, the acceptance criterion for this test is that no leaks shall be detected when using detection equipment with a capability of  $10^{-3}$  Pa·m<sup>3</sup>/s or better, for example, application of a surfactant to the outer surface.

Any leak detected at this level of sensitivity shall be repaired and retested.

#### 5.3.3.3.3 Site tests

All sections of the system constructed on the installation site shall be tightness-tested before the plant is charged with refrigerant. The site test procedure and acceptance criteria shall conform to the requirements of [5.3.3.3.1](#) and [5.3.3.3.2](#). Elements that have already been tightness-tested and that can be safely isolated from the site test need not be retested.

### 5.3.4 Test of the complete installation before putting it into operation

#### 5.3.4.1 General

Before the refrigerating system is put into operation, the complete installation, including the complete refrigerating system, shall be checked against appropriate installation drawings, flow diagrams, and pipe and instrumentation diagrams of the system and electrical diagrams.

For assemblies or subassemblies having the appropriate declaration of conformity, this requirement is considered to be fulfilled.

National legislation should be obeyed when testing the installation. Where national legislation does not exist, the following can be taken as a guide.

#### 5.3.4.2 Inspection of refrigerating system

The inspection of a refrigerating system shall include the following items:

- a) checking of documentation relating to pressure equipment;
- b) checking of safety devices;
- c) checking that permanent joints on piping are in accordance with the design documentation;
- d) checking of piping against the design;
- e) checking and documenting the alignment of the drive couplings of open compressors, pumps, fans, etc. with their propulsions (electro-motor or engine);
- f) checking the record of the tightness test of the refrigerating system;
- g) visual inspection of the refrigerating system.

This inspection shall be documented (see [5.4.3](#)).

NOTE Where applicable, the competent person complies with EN 13313.

#### 5.3.4.3 Verification of safety devices

##### 5.3.4.3.1 Fitting

A check shall be made to ensure that the required safety devices for the refrigerating system are fitted and in working order and that the pressure at which those devices operate has been chosen so that the safety of the system is ensured.

#### 5.3.4.3.2 Compliance with appropriate standards

A check shall be made that safety devices comply with appropriate standards and have been tested and certified by the manufacturer.

NOTE This does not imply that every device is accompanied by a certificate.

#### 5.3.4.3.3 Safety switching devices for limiting the pressure

A check shall be made, where appropriate, that the safety switching devices for limiting the pressure function and are fitted correctly.

#### 5.3.4.3.4 External pressure relief valves

External pressure relief valves shall be checked to ensure that the correct set pressure is as stamped on the valve or is specified on a data plate.

#### 5.3.4.3.5 Bursting discs

The marking of the correct nominal bursting pressure of bursting discs (excluding internal discs) shall be checked.

#### 5.3.4.3.6 Fusible plugs

The marking of the correct fusing temperature of fusible plugs shall be checked.

#### 5.3.4.4 Refrigerant piping

A check shall be made, where appropriate, that the refrigerating system piping has been installed in accordance with the drawings, specifications, and appropriate standards.

#### 5.3.4.5 Visual inspection of the complete installation

Visual inspection of the complete installation should be carried out in accordance with [Annex A](#).

### 5.4 Marking and documentation

#### 5.4.1 General

Equipment shall comply with the requirements for marking in [5.4.2](#) and documentation in [5.4.3](#).

Equipment which is under the scope of and complies with IEC 60335-2-24, IEC 60335-2-40, or IEC 60335-2-89 is considered to comply with the requirements for marking given in [5.4.2](#) and documentation in [5.4.3](#).

#### 5.4.2 Marking

##### 5.4.2.1 General

Every refrigerating system and its main components shall be identifiable by marking. This marking shall always be visible. For sealed refrigerating systems with limited charge, the condenser and the evaporator do not need to be marked.

Shut-off devices and main control devices shall be clearly labelled.

Service access points to equipment operating with flammable refrigerants shall be marked with the flame symbol according to ISO 7010:2011, W021.

### 5.4.2.2 Refrigerating systems

A clearly readable identification plate shall be located near or on the refrigerating system.

The identification plate shall contain at least the following data:

- a) the name or identification of the installer or manufacturer;
- b) the model, serial number, or reference number;
- c) the year of manufacture;

NOTE The year of manufacture can be part of the serial number, and all information can be part of the identification plate of the equipment and can be coded.

- d) the number designation of the refrigerant in accordance with ISO 817 (see also Annex B of ISO 5149-1);
- e) the refrigerant charge;
- f) the maximum allowable pressure, high- and low-pressure sides;
- g) when flammable refrigerants are used, the flame symbol according to W021 of ISO 7010:2011, shall be displayed with a minimum height of 10 mm, and the symbol need not be in colour.

### 5.4.2.3 Piping and valves

Piping assembled and installed on site shall be marked by colour coding. This is not required if the piping flow is obvious by appearance.

Colour coding should be according to national codes.

When the safety of persons or property can be affected by the release of the piping contents, labels identifying the contents and hazard identification labels in accordance with national regulations shall be attached to the pipe near valves and where walls are penetrated.

The discharge piping from pressure relief valves shall be marked. Collecting lines for overflow valves shall be marked if the piping flow is not obvious from appearance.

Valves which permit parts of the refrigerating system to be isolated shall be marked.

Shut-off devices and main control devices shall be clearly labelled, if it is not obvious what they control.

Main shut-off devices and controls for refrigerant and services (gas, air, water, and electricity) shall be clearly marked as to function.

NOTE 1 Codes can be used to identify the devices provided a key to the codes is located near the devices.

NOTE 2 Devices to be operated by the authorized persons only should be marked.

## 5.4.3 Documentation

### 5.4.3.1 Certificates

The results of tests shall be recorded.

Any required certificate shall be prepared on behalf of and signed by the responsible person who carried out the inspection, test, or checking.

The installer shall provide a certificate confirming that the system has been installed in accordance with the design requirements and stating the setting of safety and control devices, if adjustable, as left after commissioning.

#### 5.4.3.2 Documentation at operating site

The installer shall also provide adequately protected documentation that shall be situated near the operating site of the refrigerating system and be clearly readable.

NOTE In the case of split or multisplit systems, the operating site can be considered as the outdoor unit.

The documentation at operating site shall at least contain the following information:

- a) the name, address, and telephone number of the installer, the installer's service department, the service department of the party concerned or, at any rate, of the person responsible for the refrigerating system, and the addresses and telephone numbers of fire department, police, hospitals, and burn centres;
- b) the nature of the refrigerant by indicating its chemical formula and its number designation (see Annex B of ISO 5149-1:—);
- c) the instructions for shutting down the refrigerating system in case of emergency;
- d) the maximum allowable pressures;
- e) the details of the flammability if a flammable refrigerant is used (group A2, A3, B2, B3 refrigerant);
- f) the details of the toxicity if a toxic refrigerant is used (group B1, B2, B3 refrigerant).

#### 5.4.3.3 Instruction manual

The manufacturer or installer shall supply an adequate number of instruction manuals or leaflets and shall also provide safety instructions.

Instruction manuals for the equipment shall be provided in the language (or languages) of the country where the equipment is to be used.

The instruction manual shall at least contain the following information, if relevant:

- a) the purpose of the system;
- b) the description of the machinery and equipment;
- c) the refrigerating system schematic diagram and electrical circuit diagram;
- d) the instructions concerning the starting, stopping, and standstill of the system and parts thereof;
- e) the instructions concerning the disposal of operating fluid and equipment;
- f) the causes of the most common defects and measures to be taken, e.g. instructions concerning leakage detecting by authorized personnel and the need to contact competent maintenance technicians in the event of leakage or breakdown;
- g) the precautions to be taken to prevent the freezing of water in condensers, coolers, etc. at low ambient temperatures or by normal reduction in the system pressure/temperature;
- h) the precautions to be taken when lifting or transporting the systems or parts of the systems;
- i) the information displayed on the documentation at the operating site, if necessary, in its entirety;
- j) a reference to protective measures, first aid provisions, and procedures to be followed in the event of emergencies, e.g. leakage, fire, explosion;
- k) the maintenance instructions for the entire system with a time schedule for preventive maintenance with respect to leakage (see ISO 5149-4);
- l) the instructions concerning the charging and discharging of refrigerant;

- m) the instructions concerning the handling of refrigerant and the hazards associated with it;
- n) the instructions concerning the function and maintenance of safety, protective, and first aid equipment, alarm devices, and pilot lamps;
- o) a guidance for the drafting of the logbook, according to [5.4.3.5](#);
- p) the certificates required.

The party concerned shall outline emergency procedures to be taken in the event of disturbances and accidents of other kinds.

#### 5.4.3.4 Drawings

For complex systems for which it is difficult to see the function of each component, a piping and instrument diagram of the refrigerating system shall be displayed on or near the machine card identifying the shut-off and control devices.

#### 5.4.3.5 Logbook

When the refrigerant charge exceeds 3 kg, a logbook shall be prepared upon installation of the system by the installer according to national or regional requirements. This logbook is to be regularly updated as specified in ISO 5149-4.

In the logbook, at least the following information shall be recorded:

- a) the details of the maintenance and repair works;
- b) the quantities and kind of (new, reused, recycled) refrigerant which have been charged on each occasion, and the quantities of refrigerant which have been transferred from the system on each occasion (see also ISO 5149-4);
- c) the results of any analysis of a reused refrigerant;
- d) the source of the reused refrigerant;
- e) the changes and replacements of components of the system;
- f) the result of all periodic routine tests;
- g) the significant periods of non-use.

The log book shall either be kept in the machinery room or the data shall be stored in a computer of the party concerned with a printout in the machinery room in which case the information shall be accessible to the competent person when serving or testing.



## Annex A (informative)

### Checklist for external visual inspection of the refrigerating system

For external visual inspection of the refrigerating system, the checklist covers the following items:

- a) check for transit or storage damage to the equipment;
- b) check that all components are as specified;
- c) check that all safety devices, documents, and equipment required by this part of ISO 5149 are present;
- d) check that all devices and arrangements for safety and environmental protection are present and in compliance with this International Standard;
- e) check that pressure vessel documents, certificates, identification plates, instruction manual, and documentation required in this International Standard are present;
- f) check that volume of receivers is sufficient;
- g) check instructions and directions to prevent deliberate discharge of refrigerants to the environment;
- h) check that, where piping is accessible to the general public, the surface temperatures shall not endanger the general public;
- i) compare the complete installation with the refrigerating and electrical system drawings; check whether electrical supply is adequate for the power to be drawn;
- j) verification of documentation relating to pressure vessels if vessels are changed, modified, or used for another refrigerant;
- k) check vibrations and movements caused by temperature and pressure under operation conditions;
- l) check installation of fittings;
- m) check supports and fixing (materials, routing, connection);
- n) check quality of welding and other joints;
- o) check protection against mechanical damage;
- p) check protection against heat;
- q) check protection of moving parts;
- r) check accessibility for maintenance or repair and for inspection of piping;
- s) check valve arrangement;
- t) check quality of thermal insulation and vapour barriers;
- u) check fouling of heat exchange surfaces.



## Annex B (normative)

### Additional requirements for refrigerating systems and heat pumps with ammonia (NH<sub>3</sub>)

#### B.1 Systems with a refrigerant charge above 50 kg

Refrigerating systems with a refrigerant charge above 50 kg shall have shut-off devices in order to isolate components of the system where liquid refrigerant exists normally such as receivers, accumulators, and flooded-type heat exchangers. When a system is charged with less than 100 kg of ammonia and is confined in a casing where leak alarm and emergency refrigerant absorber or venting system are provided, then it does not require a shut-off device.

**NOTE** For an installation where earthquakes are anticipated, a seismoscope that triggers the emergency stop system can be required. This system resets manually.

When safety valves are used as protection devices against excessive pressure, [5.2.9](#) shall apply.

#### B.2 Systems with a refrigerant charge above 4 500 kg

Groups of components with a maximum possible total refrigerant charge above 4 500 kg of ammonia shall be equipped with a functionally remote-controlled shut-off device in the liquid line. This device shall close in the case of control power failure, detection of a leak, or emergency stop. It shall be integrated into the emergency stop system with a manual override. If the shut-off device (e.g. solenoid valve) only operates in one direction, back-flow shall be prevented in any case, e.g. by means of a pump-down circuit. Automatic operated shut-off valves have to be fail-safe.

Pumps shall be mounted between valves, of which the valve on the suction side of the pump shall be a remote-controlled valve. To be able to carry out repairs on remote-controlled valves, it is recommended that a shut-off valve, which cannot be actuated during operation, be installed upstream.

#### B.3 Emergency stop system for refrigerating systems with a refrigerant charge above 4 500 kg

An emergency stop system that acts on the relevant drives and actuators shall be installed for the refrigerating system.

Consideration shall be given to hydrostatic expansion due to temperature rise of liquid refrigerant trapped in or between closed valves. A hydrostatic relief device or other means shall be provided to prevent over-pressurization; this relief shall be into a lower pressure portion of the system. When the emergency stop system is triggered, it shall be possible to shut off the pipes between components such that no additional risks, such as the inclusion of liquid, can occur due to the emergency stop system.

An emergency power supply unit for the process control technology is not necessary if the system is monitored regularly (once every 24 h) or a competent personnel can arrive on site within 60 min.

**NOTE** An emergency stop system consists of operations that are triggered by a manual switch and by leak-detection devices and that put the refrigerating system in a safe operating mode.

## Annex C (informative)

### Determination of category for assemblies

#### C.1 General

For the determination of category of the assembly, the steps described in [C.2](#) to [C.5](#) should be followed.

#### C.2 Safety classification of the refrigerant

Fluids are classified in two groups according to their flammability and/or toxicity as follows.

a) Group 1 comprises fluid defined as:

- explosive;
- extremely flammable;
- highly flammable;
- flammable (where the maximum allowable temperature is above flashpoint);
- very toxic;
- toxic;
- oxidizing.

b) Group 2 comprises all other fluids not referred to group 1.

NOTE Classification is given in Globally Harmonization System of Classification and Labelling of Chemicals (GHS).

#### C.3 Determination of the maximum allowable pressure of the assembly

See [5.2.2.1](#).

#### C.4 Determination of the state (liquid or gas) of the refrigerant

If the vapour pressure at the maximum allowable temperature is greater than 0,5 bar (50 kPa) above normal atmospheric pressure, then this fluid is considered to be a gas; otherwise, the fluid is to be considered a liquid.

#### C.5 Determination of category of components

##### C.5.1 General

Before the determination of the category of the assembly, the categories of the different components within the refrigerating systems should be determined

It is possible that the maximum allowable pressure (PS) of the component is larger than the PS of the assembly that it has to fit into. Normally, for the determination of the category, the PS value of the assembly

shall be used. In this case, the safety accessory to be used for the protection of this component should be set at this PS value. In case protection for the component is provided at the PS of this component, then the PS value of the component should be used for the determination of the category.

**C.5.2 Pressure vessels**

Parameters of pressure vessels are indicated in [Table C.1](#).

**Table C.1 — Parameters of pressure vessels**

Fluid group if	Nature and	PS bar <sup>a</sup> and	V l and	PS × V bar l and	Category then
Group 1	Gas	≤0,5	—	—	—
		>0,5 and ≤200	≤1	—	—
			>1	≤25	—
				>25 and ≤50	I
		>50 and ≤200	II		
		>200 and ≤1 000	≤1	—	III
		≤1 000	>1	>200 and ≤1 000	III
	>1 000	—	>1 000	IV	
	Liquid	≤0,5	—	—	—
		>0,5 and ≤500	≤1	—	—
			>1	≤200	—
		>200		I	
		>10 and ≤500		II	
		>500	≤1	—	II
>500		>1	—	III	

<sup>a</sup> 1 bar = 0,1 MPa.

**Table C.1 (continued)**

Fluid group if	Nature and	PS bar <sup>a</sup> and	V l and	PS × V bar l and	Category then
Group 2	Gas	≤0,5	—	—	—
		>0,5 and ≤1 000	≤1	—	—
			>1	≤50	—
				>50 and ≤200	I
				>200 and ≤1 000	II
		>1 000 and ≤3 000	≤1	—	III
			>1	>1 000 and ≤3 000	III
				>1 000	III
	>4	—	IV		
	>3 000	—	IV		
	Liquid	≤10	—	—	
		>10 and ≤1 000	≤10	—	
			>10	≤10 000	—
		>10 and ≤500	—	>10 000	I
		>1 000	<10	—	I
>500	>10	>10 000	II		

<sup>a</sup> 1 bar = 0,1 MPa.

### C.5.3 Piping

The parameters of piping are given in [Table C.2](#).

**Table C.2 — Parameters of piping**

Fluid group If	Nature and	PS bar <sup>a</sup> and	DN and	PS × DN and	Category then
Group 1	Gas	≤0,5	—	—	—
		>0,5	≤25	—	—
			>25 and ≤100	≤1 000	I
			>100 and ≤350	>1 000 and ≤3 500	II
	>350		>3 500	III	
	Liquid	≤0,5	—	—	—
		>0,5	≤25	—	—
			—	≤2 000	—
		>0,5 and ≤10	—	>2 000	I
		>10 and ≤500	>25		II
>500		—		III	

<sup>a</sup> 1 bar = 0,1 MPa.

Table C.2 (continued)

Fluid group	Nature	PS bara <sup>a</sup>	DN	PS × DN	Category
If	and	and	and	and	then
Group 2	Gas	≤0,5	—	—	—
		>0,5	≤32	—	—
			—	≤1 000	—
			>32 and ≤100	>1 000 and ≤3 500	I
			>100 and ≤250	>3 500 and ≤5 000	II
			>250	>5 000	III
	Liquid	≤0,5	—	—	—
		>0,5 and ≤10	—	—	—
		—	—	≤5 000	—
		—	≤200	—	—
		>10 and ≤500	>200	>5 000	I
		>500		—	II

<sup>a</sup> 1 bar = 0,1 MPa.

#### C.5.4 Safety accessories

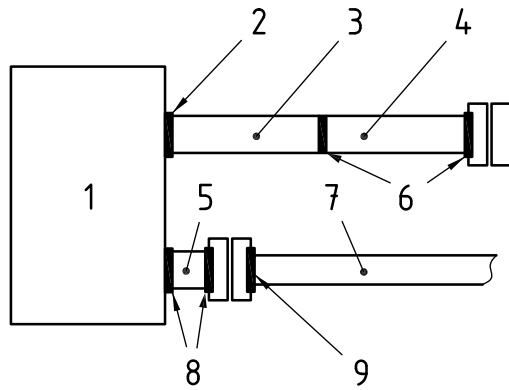
The category of the safety accessories should be determined based upon the category of the component, subassembly, or assembly they have to protect. This category should be as a minimum equal to the category of the protected component, subassembly, or assembly.

#### C.5.5 Joining of pressure equipment

For the practical determination of category, some examples are the following.

- Permanent connections between two parts should comply with the highest category of the two parts.
- Assemblies can be considered as an assembly of subassemblies in a sequence so that the permanent joint falls in the lowest possible category.

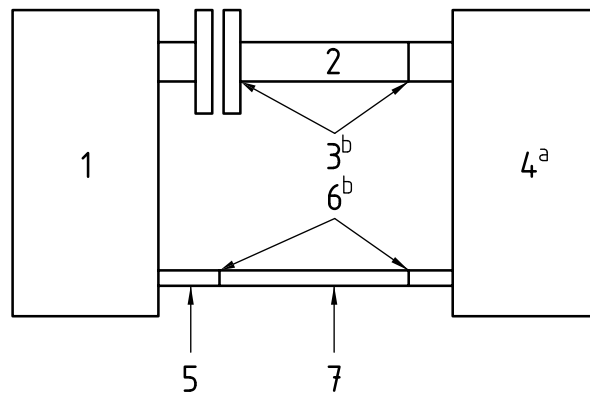
For parts equipped with extension pipes, the category of the extension pipe should determine the category of the connection. The connections to an extension pipe should not have any influence on the strength of a higher category vessel.



**Key**

- 1 vessel category III
- 2 permanent connection category III
- 3 extension pipe category I
- 4 pipe category I
- 5 pipe category II
- 6 permanent connection category I
- 7 pipe category I
- 8 permanent connection category III
- 9 permanent connection category I

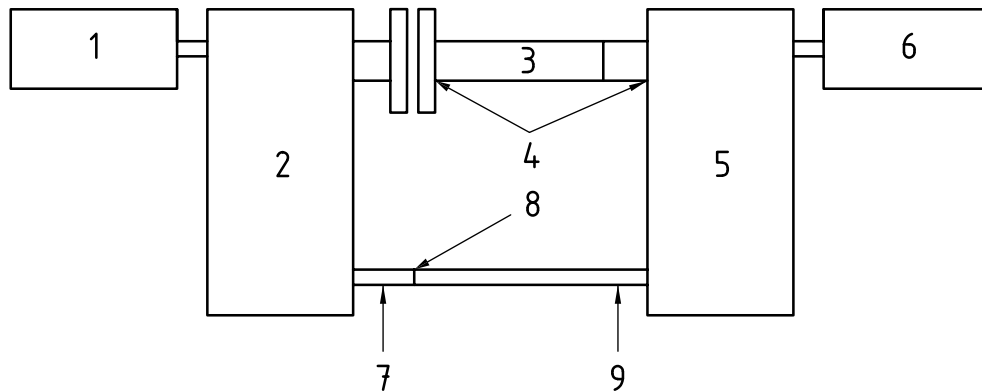
**Figure C.1 — Joining of pressure equipment**



**Key**

- 1 condensing unit category II
- 2 pipe category I
- 3 permanent joint category I
- 4 evaporator category I with electric fan included
- 5 extension pipe uncategorized
- 6 permanent connection uncategorized
- 7 pipe uncategorized

**Figure C.2 — Example 1: Category II assembly**

**Key**

- 1 safety accessory (category III or higher)
- 2 condensing unit category III
- 3 pipe category II
- 4 permanent joint category II
- 5 vessel category II
- 6 safety accessory (category II or higher)
- 7 extension pipe category I
- 8 permanent joint category I
- 9 pipe category I

**Figure C.3 — Example 2: Category III assembly**

### C.5.6 Determination of category of the assembly

The category of the assembly should be determined based on the highest category of the components it consists of (as determined in previous point) without taking into account the category of the safety accessories.

## Annex D (normative)

### Requirements for intrinsic safety test

#### D.1 General

Requirements for intrinsic safety test are only applicable for equipment which, according to the flow chart in [5.2.9.2](#), results in the option which requires the intrinsic safety test to be performed.

#### D.2 Determination of the maximum pressure during abnormal operation

##### D.2.1 Determination of the pressure at the high-pressure side ( $P_{\text{HIS}}$ )

The heat exchanger at the high-pressure side of the refrigerating system shall be subjected to the following test in order to determine  $P_{\text{HIS}}$ .

The refrigerating system shall be installed, taking into account the clearances to adjacent surfaces as specified by the manufacturer.

The refrigerating system shall be operated at rated voltage or at the upper limit of the rated voltage range, at an ambient temperature of  $23\text{ °C} \pm 5\text{ °C}$ .

When steady-state conditions are attained, the heat-transfer medium flow of the heat exchanger at the high-pressure side shall be restricted or shut off, whichever is the most unfavourable with the refrigerating system operating.

Where the refrigerating system is equipped with external heaters, they shall be operated. The highest pressure that occurred during this test is considered to be  $P_{\text{HIS}}$ .

##### D.2.2 Determination of the pressure at the low-pressure side ( $P_{\text{LIS}}$ )

The heat exchanger at the low-pressure side of the refrigerating system shall be subjected to following test in order to determine  $P_{\text{LIS}}$ .

The refrigerating system shall be installed, taking into account the clearances to adjacent surfaces as specified by the manufacturer.

The refrigerating system shall not be operated in order to simulate standstill conditions.

The temperature of the heat-transfer medium at the low-pressure side heat exchanger shall be maintained at the maximum temperature specified by the manufacturer.

If the heat-transfer medium is water, then this condition shall be maintained during 30 min. If the heat-transfer medium is air, this condition shall be maintained for 1 h.

For refrigerating systems or parts carrying the liquid refrigerant during transport under tropical climate, the refrigerating system or the charged part of it shall be maintained at a temperature of  $70\text{ °C}$  for 1 h.

The highest pressure that occurred at the low-pressure side is considered to be  $P_{\text{LIS}}$ .

NOTE The temperature of  $70\text{ °C}$  is the maximum temperature expected during transport in a container under tropical climate conditions.



### D.2.3 Determination of $P_{\text{HIS}}$ and $P_{\text{LIS}}$ for reversible heat pumps

For reversible heat pumps, the test shall be executed in both cooling and heating modes as described in [D.2.1](#) and [D.2.2](#). The highest values obtained in each section shall be taken into account to decide  $P_{\text{HIS}}$  and  $P_{\text{LIS}}$  for that section.

## D.3 Strength-pressure test

A pressure test shall be carried out on three samples of each component and joints or on the assembly as a total.

One of the following test methods shall be applied.

a) Method 1

The test shall be conducted at three times  $P_{\text{HIS}}$  on the high-pressure side and at three times  $P_{\text{LIS}}$  on the low-pressure side.

b) Method 2

Test according to [4.4.2](#) where for the burst test and the first cycle PS is considered to be  $P_{\text{HIS}}$  when the test is performed on the high-pressure side and  $P_{\text{LIS}}$  when the test is performed on the low-pressure side.

For both methods, the strength-pressure test shall be carried out as a hydrostatic pressure test by means of water or some other liquid. Adequate precautions shall be taken to prevent danger to people and to minimize risk to property.

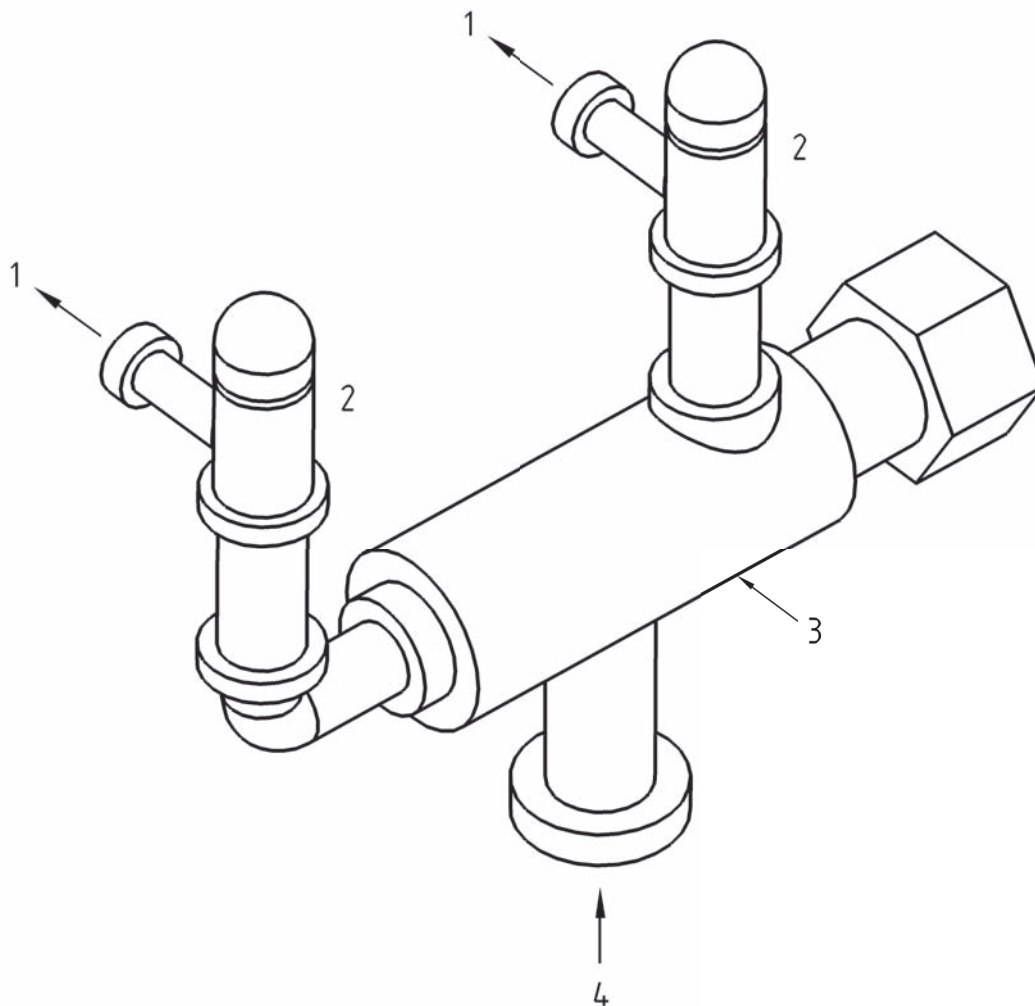
Acceptance criteria: the part under test shall not rupture.

## Annex E (informative)

### Examples for arrangement of pressure relief devices in refrigerating systems

Certain systems containing large amount of refrigerant can require specific arrangements for pressure relief valves to allow adequate tightness and monitoring of the correct setup of the pressure relief device and their periodic maintenance.

[Figure E.1](#) illustrates a three-way valve equipped with dual pressure relief valves for continuous pressure vessel protection while servicing the relief devices one at a time.

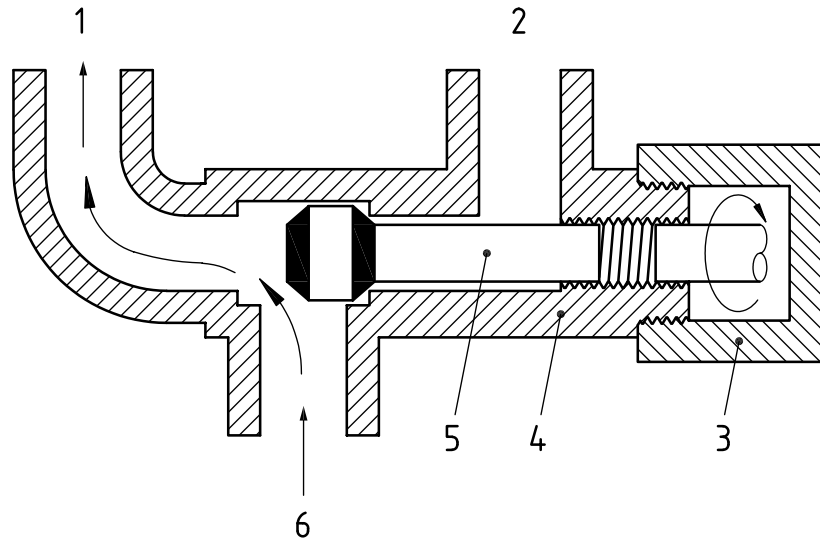


**Key**

- 1 Vent
- 2 relief valve
- 3 three-way valve assembly
- 4 from vessel

**Figure E.1 — A three-way valve equipped with dual pressure relief valves**

[Figure E.2](#) is a schematic illustrating the internal components of a three-way valve. During normal operation, the three-way valve stem should be in its back-seated position as shown to minimize the risk of refrigerant loss through the stem seal/packing. During periods where servicing or testing is required, the stem can be re-positioned to isolate the left or right valve by moving the stem plug to the left or to the right, respectively.



#### Key

- 1 outlet open
- 2 outlet closed
- 3 valve stem protector (remove and rotate stem with handle to change position)
- 4 threads
- 5 valves stem
- 6 from vessel

**Figure E.2 — Schematic diagram of a three-way valve for dual relief devices**

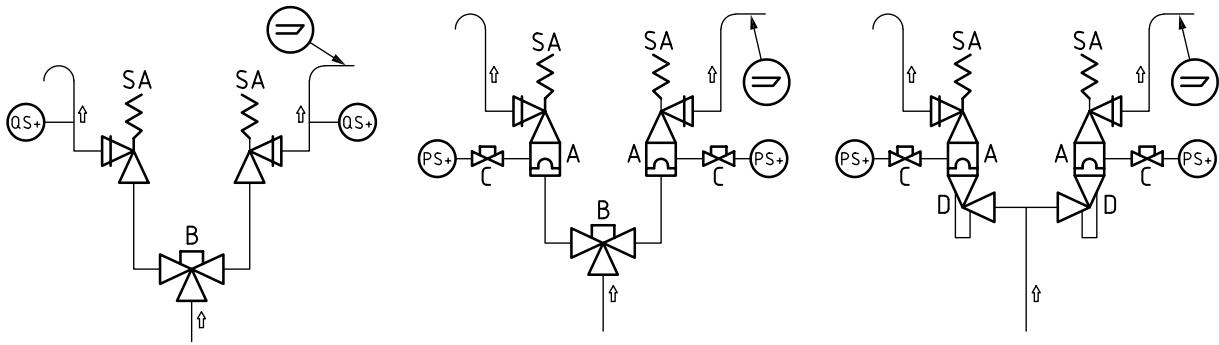
These three-way valve and pressure relief devices need to be connected above the liquid refrigerant level and installed so that they are accessible for inspection and repair. Stop valves should not be located between a pressure relief device and parts of the system protected. A three-way valve used in conjunction with the dual relief valves is not considered a stop valve.

When relief valves are connected to discharge to a common discharge header, a full area stop valve can be used in the discharge branch line at each relief valve outlet. When such a stop valve is installed, a locking device shall be installed to ensure that the stop valve is locked in the open position. This discharge stop valve shall not be shut unless one of the following conditions exists.

- a) Parallel relief valves are installed and the second relief valve is protecting the system or vessels.
- b) System or vessels have been depressurized and are vented to the atmosphere.

The purpose of the stop valve at the discharge outlet of a relief device is to isolate the valve for service without the risk of refrigerant vapour being released to the atmosphere should another relief device on the common header lift.

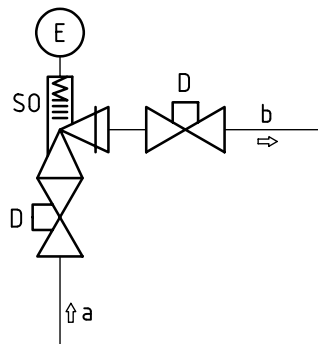
Examples of such specific arrangements are given in [Figures E.3](#) to [E.6](#).



**Key**

- SA pressure relief valve relieving to the atmosphere
- QS+ detection of refrigerant concentration
- PS+ pressure limiter (adjusted to 0,5 bar resp. 0,05 MPa)
- A bursting disc with monitoring device
- B change-over device secured with a cap
- C shut-off valve with vent and cap
- D shut-off valve as in 5.2.9.4

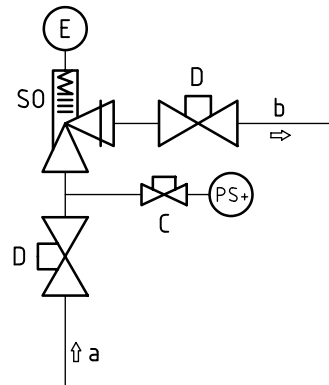
**Figure E.3 — Arrangements of pressure relief valves equipped with monitoring devices for their tightness**



**Key**

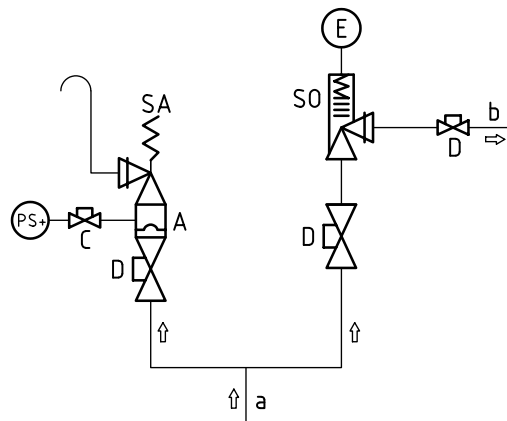
- SO pressure relief valve in the form of a backpressure compensating overflow valve with bellows vent relieving to LPS
- D shut-off valve as in 5.2.9.4
- E bellows monitoring device, e.g. PS+, PS-, QS+
- a From vessel of high-pressure side or piping section.
- b To low-pressure side of system.

**Figure E.4 — Backpressure compensating overflow valve for protection of a pressure vessel of the high-pressure side or piping section against liquid expansion**

**Key**

- SO pressure relief valve in the form of a backpressure compensating overflow valve with bellows vent relieving to LPS
- PS+ pressure limiter (adjusted 2 bar resp. 0,2 MPa lower than PS)
- C shut-off valve with vent and cap (recommended)
- D shut-off valve as in [5.2.9.4](#)
- E bellows monitoring device, e.g. PS+, PS-, QS+
- a From externally heated components of low-pressure side.
- b To low-pressure side of system.

**Figure E.5 — Backpressure compensating overflow valve for protection of a pressure vessel of the low-pressure side against liquid expansion and/or external heat**



**Key**

- SA pressure relief valve relieving to the atmosphere
- SO pressure relief valve in the form of a backpressure compensating overflow valve with bellows vent relieving to LPS
- PS+ pressure limiter (adjusted 0,5 bar resp. 0,05 MPa lower than PS)
- A bursting disc with monitoring device
- C shut-off valve with vent and cap (recommended)
- D shut-off valve as in [5.2.9.4](#)
- E bellows monitor, e.g. PS+, PS-, QS+
- a Common piping from pressure vessel.
- b To low-pressure side of system.

**Figure E.6 — Pressure relief device consisting of a backpressure compensating overflow valve relieving to the low-pressure side of the system and a pressure relief valve discharging to the atmosphere for protection against liquid expansion and/or external heat**

## Annex F (normative)

### Allowable equivalent length of discharge piping

The design backpressure due to flow in the discharge piping at the outlet of pressure relief devices and fusible plugs, discharging to atmosphere, shall be limited by the allowable equivalent length of piping determined by Formulae (F.1) or (F.2). See [Table 3](#) for the flow capacity of various equivalent lengths of discharge piping for conventional relief valves.

$$L = 0,214\ 6 d^5 (P_0^2 - P_2^2) - d \times \ln(P_0 / P_2) \quad (\text{F.1})$$

$$f C_r^2 = 0,214\ 6 d^5 (P_0^2 - P_2^2) \quad (\text{F.2})$$

$$6f = d \times \ln(P_0 / P_2) \quad (\text{F.3})$$

$$L = 7,438\ 1 \times 10^{-15} d^5 (P_0^2 - P_2^2) - d \times \ln(P_0 / P_2) \quad (\text{F.4})$$

$$f C_r^2 = 7,438\ 1 \times 10^{-15} d^5 (P_0^2 - P_2^2) \quad (\text{F.5})$$

$$500f = d \times \ln(P_0 / P_2) \quad (\text{F.6})$$

where

$L$  is the equivalent length of discharge piping, in metres (m);

$C_r$  is the rated capacity as stamped on the relief device, in kilograms per second (kg/s) or in SCFM, multiplied by 0,076 4 or as adjusted for reduced capacity due to piping as specified by the manufacturer of the device or as adjusted for reduced capacity due to piping as estimated by an approved method;

$f$  is the Moody friction factor in fully turbulent flow (see typical values below);

$d$  is the inside diameter of the pipe or tube, in millimetres;

$\ln$  is the natural logarithm;

$P_2$  is the absolute pressure at the outlet of the discharge piping, in kilopascal;

$P_0$  is the allowed backpressure (absolute) at the outlet of the pressure relief device, in kilopascal.

For the allowed backpressure ( $P_0$ ), use the percentage of set pressure specified by the manufacturer, or when the allowed backpressure is not specified, use the following values, where  $P$  is the set pressure.

For conventional relief valves, 15 % of set pressure,

$$P_0 = (0,15 \times P) + \text{atmospheric pressure} \quad (\text{F.7})$$

or balanced relief valves, 25 % of set pressure,

$$P_0 = (0,25 \times P) + \text{atmospheric pressure} \quad (\text{F.8})$$

for bursting disc, fusible plugs, and pilot-operated relief valves, 50 % of set pressure,

$$P_0 = (0,50 \times P) + \text{atmospheric pressure} \quad (\text{F.9})$$

NOTE For fusible plugs,  $P$  is the saturated absolute pressure for the stamped temperature melting point of the fusible plug or the critical pressure of the refrigerant used, whichever is smaller, kPa (psi); atmospheric pressure is at the elevation of the installation above sea level. A default value is the atmospheric pressure at sea level, 101,325 kPa (14,7 psi).

Typical Moody friction factors ( $f$ ) for fully turbulent flow are given in [Tables F.1](#) and [F.2](#).

**Table F.1 — Typical Moody friction factors for tubing**

Tubing OD in	DN	ID in	$f$
3/8	8	0,315	0,013 6
1/2	10	0,430	0,012 8
5/8	13	0,545	0,012 2
3/4	16	0,666	0,011 7
7/8	20	0,785	0,011 4
1 1/8	25	1,025	0,010 8
1 3/8	32	1,265	0,010 4
1 5/8	40	1,505	0,010 1

**Table F.2 — Typical Moody friction factors for piping**

Piping NPS	DN	ID in	$f$
1/2	15	0,622	0,025 9
3/4	20	0,824	0,024 0
1	25	1,049	0,022 5
1 1/4	32	1,380	0,020 9
1 1/2	40	1,610	0,020 2
2	50	2,067	0,019 0
2 1/2	65	2,469	0,018 2
3	80	3,068	0,017 3
4	100	4,026	0,016 3
5	125	5,047	0,015 5
6	150	6,065	0,014 9



## **Annex G** (informative)

### **Stress corrosion cracking**

#### **G.1 General**

Stress corrosion is a chemo-physical phenomenon which affects a range of metals including copper, titanium, carbon steel, and stainless steel. It is most likely to occur when certain metallic components are subjected to moderate stresses while exposed to a specific environment, and it is characterized by the appearance of microcracks which run perpendicular to the major stress axis and can be intergranular or transgranular (i.e. can run between grains in the metal structure or through them). The crack tip is typically feathered (contains many fine branches) indicating that this is not a simple yield or fatigue fracture.

Stress corrosion failures have been reported in the copper pipework of fluorocarbon refrigerating systems and in steel pressure vessels and pipework in ammonia systems. The majority of stress corrosion failure cases in ammonia equipment are in high-pressure receivers, although stress corrosion is known to have affected the shell of water chiller evaporators, oil recovery pots, and suction header pipework. There are no reported cases of stress corrosion failures of steel vessels in fluorocarbon plants, although it is possible that conditions conducive to the formation of stress corrosion cracks could arise in the event of acidification of the refrigerant. There are no known cases of stress corrosion cracking of stainless steel or titanium in refrigerating systems.

#### **G.2 Stress corrosion in copper**

Stress corrosion has been reported in copper pipes for fluorocarbon refrigerant systems, typically progressing from the outside of the pipe inward and usually triggered by chemicals in insulation adhesive compounds when exposed to a wet environment, for example, where insulated pipes have been submerged during installation. The stress arises from the pressure loading of the pipe and so the resultant cracks are longitudinal. After stress corrosion failure, the inside of the pipe will show a characteristic copper-blue pattern. Once the stress corrosion has been established, it often results in multiple pinhole leaks necessitating replacement of the affected pipework. The stress corrosion will not spread to sections of the pipe that were not subjected to the corrosive environmental conditions.

#### **G.3 Stress corrosion in steel**

Stress corrosion has also been associated with non-catastrophic failure of carbon steel pressure vessels in ammonia systems. It has been established that microcracks in the inner surface of the pressure vessel are not uncommon. Provided these cracks do not progress beyond the vessel's corrosion allowance and do not affect the mechanical strength of the pressure envelope, they should not pose a problem. Usually, the microcracks penetrate to a depth of about 1 mm but do not progress beyond. Occasionally, however, a stress corrosion crack continues to propagate.

#### **G.4 Factors that influence stress corrosion cracking**

##### **G.4.1 General**

The subclauses that follow are focused on ammonia refrigerating systems using carbon steel pressure-containing equipment. Recommendations for preventing stress corrosion cracking are given.

## G.4.2 Yield strength

Stress corrosion cracking is more likely in steels with a high-yield strength because the surface is more brittle. It has been established that cracking is unlikely if the parent material has a yield strength less than 350 MN/m<sup>2</sup>. It is recommended that a material with a minimum yield strength of 265 MN/m<sup>2</sup> be specified for pressure vessel shell and end caps, but the actual material yield strength can be higher than the specified minimum.

NOTE "Minimum yield strength" is a term commonly used in the steel industry referring to the lowest allowable yield strength for material. The yield strength of the actual materials used in the fabrication of a vessel could exceed the minimum by as much as 50 %.

## G.4.3 Temperature

Stress corrosion cracking is more likely to occur at elevated temperatures. If the normal operating temperature of the vessel is above -5 °C or if the vessel temperature during system shutdown is expected to be above -5 °C, then the vessel should be post-weld stress-relieved. Traditionally, this has been applied to high-pressure receivers, but economizers and intercoolers can operate in this temperature range, as do evaporators for water chillers. Oil recovery pots can also be subject to higher temperatures for long periods and should be stress-relieved.

## G.4.4 Oxygen content

Stress corrosion cracking is more likely to occur where there are increased oxygen levels within the system. High-pressure receivers, where non-condensable gases, including oxygen, can accumulate, are particularly at risk. The majority of reported cases of stress corrosion cracking are in high-pressure receivers, although instances in intermediate-pressure and low-pressure vessels are not unknown.

NOTE Stress corrosion cracking can be initiated if the oxygen level exceeds  $5 \times 10^{-7}$  (0,5 ppm). Maintaining the oxygen content below 0,5 ppm in a system on a continuous basis is not feasible, but care should be taken to ensure that the system is purged of non-condensable gases at commissioning and routinely during operation.

## G.4.5 Water content

It is reported that stress corrosion cracking is less likely to occur if there are moderate levels of water in the ammonia. As the water content in the ammonia increases, the amount of oxygen required to initiate stress corrosion also increases, up to a limit of  $2 \times 10^{-3}$  (2 000 ppm) water which inhibits the onset of stress corrosion cracking provided the oxygen levels are below  $1 \times 10^{-4}$  (100 ppm).

NOTE This finding was the result of research into failures of ammonia holding tanks in the fertilizer industry and has been widely reported as a preventative measure for ammonia vessels including refrigeration receivers. However, it is less useful in a refrigerating system, where oxygen accumulates as a non-condensable gas upstream of the expansion valve at the vapour/liquid interface (usually in the high-pressure receiver) but water accumulates as a non-volatile liquid (or ice) downstream of the expansion valve (usually in the surge drum or accumulator).

## G.4.6 Age of equipment

Leakage due to stress corrosion cracking is most likely to occur in the first few months of operation, suggesting that the microcracks form almost immediately when all the prerequisite conditions are present and it is only the time taken for the crack to propagate through the material that is variable. This is a function of the thickness of the material, the stress applied to the material, and the material properties.

## G.4.7 Avoiding stress corrosion cracking

Ensuring that the parent metal yield strength is sufficiently low is the most effective measure for avoiding SCC, as the initial surface cracking is associated with high-yield strength material. All fittings such as end caps should be hot-formed or stress-relieved after cold forming. The shell material should be specified with a minimum yield strength of 265 MN/m<sup>2</sup>. Vessels should be stress-relieved after

manufacture if possible. If the vessel contains delicate internal components such as rubber bushes, then post-weld heat treatment cannot be possible.

**NOTE** For low-temperature vessels (for example, accumulators, surge drums, and suction traps) post-weld heat treatment is less critical but is recommended if possible. For high-temperature vessels such as high-pressure receivers, water chillers, intercoolers, and economizers, post-weld heat treatment is strongly recommended.

The literature based on the ammonia production and fertilizer industries recommends a minimum water content of  $2 \times 10^{-3}$  (2 000 ppm) in ammonia systems in order to prevent stress corrosion with oxygen content up to  $1 \times 10^{-4}$  (100 ppm). In refrigerating systems, this could be beneficial for evaporators, for example, water chillers, but it is unlikely to have much effect on high-pressure receivers and intercoolers.

#### **G.4.8 Conclusions**

Attention to detail in the material specification, production, testing, and installation of the system ensures that stress corrosion is avoided. Where stress corrosion cracking has caused a leak, the damaged component shall be replaced whether it is copper pipe in a fluorocarbon system or a steel pressure vessel in an ammonia system. Where stress corrosion cracks are identified, but are not propagating, then the vessel should be monitored as the basis for determining when its replacement could be warranted.

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1) In course of revision.



