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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation 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 Clause 4
Heat exchangers: — pipe coil without air (tube in tube) — multi-tubular (shell and tubes)	see Clause 4
Plate heat exchangers	see Clause 4
Headers and coils with air as secondary fluid	see Clause 4
Receiver/accumulator/economizer	see Clause 4
Oil separator	see Clause 4
Drier	see Clause 4
Filter	see Clause 4
Muffler	see Clause 4
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 4.4.3 and 4.5.1
General requirements Additional requirements for NH_3 plants	see Annex B
Piping	see Clause 4
Piping joints Permanent joints Detachable joints	see Clause 4
Flexible piping	see ISO 13971
Valve	—
Safety valve	see ISO 4126-1 combined with 4.4.3
Safety switching devices for limiting the pressure	see Clause 4
Control pressure switch	see Clause 4
Isolating valves	see Clause 4
Hand-operated valves	—
Capped valves	—
Bursting disc	see ISO 4126-2 combined with 4.4.3
Fusible plug	see 4.5.3
Liquid level indicators	see Clause 4
Gauges	see Clause 4
Soldering materials	see 4.3.9
Welding materials	see 4.3

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_2SO_4).

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_3Cl).

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_3Cl).

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 × 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 × PS or by testing according to the fatigue test as described below.

If the maximum continuous operating temperature exceeds 125 °C for copper or aluminium, or 200 °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 N/mm^2 at test temperature and 27 N/mm^2 at maximum continuous operating temperature, then the type-approved test shall be conducted at 3,9 times (3 × 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 × 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 × PS and the lower-pressure value shall not be greater than 0,2 × PS. The pressure shall be 0,9 × PS for water heat exchangers in the heat pump.

— For the final test cycle, the test pressure shall be increased to 1,4 × PS (two times of 0,7 × PS). The pressure shall be 1,8 × PS (two times of 0,9 × 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 × 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 × 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 °C for copper or aluminium, or 200 °C for steel, the fatigue test shall be conducted at least 10 °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 g/yr of refrigerant or better, under a pressure of at least 0,25 × 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 g/yr of refrigerant or better, under a pressure of at least 0,25 × 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_3) 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	≥PS	Component related For systems, see 5.2.2.2.
Strength test pressure	according to 5.3.2	
Tightness test pressure for assemblies	according to 5.3.3	
Pressure limiter for systems with relief device, setting	≤1,0 × PS	Related to part of the system. See 5.2.9.
Pressure limiter for systems without relief device, setting	≤1,0 × PS	
Pressure relief device, setting	1,0 × PS	Component related where it protects the component; Related to part of the system where it protects a part of the system . See 5.2.9.
Pressure relief valve, required discharge at	≤1,2 × PS	

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.