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Refrigerating systems and heat pumps — Safety and environmental requirements —

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

Systèmes de réfrigération 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 5149-2 was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 1, *Safety and environmental requirements for refrigerating systems*.

This first edition of 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 and materials and including 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. Deviations are permissible only if equivalent protection is ensured.

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; and

d) parts replaced and components added after adoption of this standard if they are not identical in function and in capacity.

This part of ISO 5149 does not cover "motor vehicle air conditioners".

This part of ISO 5149 does not apply to goods in storage, with respect to spoilage or contamination.

This part of ISO 5149 also applies in the case of the conversion of a system for another refrigerant.

2 Normative references

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

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

ISO 5149-4:—[2], *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 4: Operation, maintenance, repair and recovery*

1) To be published.

2) To be published.

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

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

ISO 13971[3)], *Refrigeration systems and heat pumps — Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes — Requirements and classification*

ISO 14903[4)], *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 60335-2-34, *Household and similar electrical appliances — Safety — Part 2-34: Particular requirements for motor-compressors*

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

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 terms and 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 ISO 5149 with regard to mechanical strength. In all other respects appliances constructed according to IEC 60335-2-40 are presumed to be in conformity with ISO 5149-2.

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.

Refrigerants classified as 2L shall be considered as a subgroup of class 2 (see ISO 817). 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

3) To be published.

4) To be published.

Table 1 *(continued)*

Component and piping	Requirements
Headers and Coils with air as secondary fluid	see Clause 4
Receiver/accumulator/economiser	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 General requirements Additional requirements for NH_3 plants	see IEC 60204-1, and combined with 4.5.1 and 4.4.3 see Annex B
Piping	see Clause 4
Piping joints Permanent joints Detachable joints	 see Clause 4
Flexible piping	see ISO 13971
Valve	
Safety valve	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	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 standard.

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 may 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 Annex G.

4.3.3 High alloy steel

High alloy steel may 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), 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 pipe is given in Annex G.

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 may 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 may 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 may 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, etc. 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 may 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 may 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 may 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 may 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 approval 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 component has allowable stress of 35 N/mm^2 at test temperature and 27 N/mm^2 at maximum continuous operating temperature, then the type approval test shall be conducted at 3,9 times (3 × 35/27) the 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 heat pump.

— For the final test cycle, the test pressure shall be increased to 1,4 × PS (two times 0,7 × PS). The pressure shall be 1,8 × PS (two times 0,9 × PS) for water heat exchangers in 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 ISO 14903.

Unless otherwise agreed with 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/year of refrigerant or better, under a pressure of at least 0,25 × PS.

NOTE 1 This method may be specified in the component standard (see Table 1).

When agreed by the manufacturer of the assembly, some or all tests may 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 may 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/year 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) name or logo of manufacturer;

b) type designation;

c) serial number or batch number;

d) year of manufacture;

e) design pressure or maximum allowable pressure;

f) applicable refrigerant (where appropriate);

g) capacity of main function (where appropriate).

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

4.5.2 Documentation

The component manufacturer shall maintain 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 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 refrigeration system assembly shall comply with this clause.

Refrigeration 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 refrigeration 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 may 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. mass and force of person for repairing and operation.

The supports and bases of refrigeration 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) solar radiation (e.g. impact on iceriinks during standstill);

g) 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 PS of the different parts of the refrigeration system.

Method 1

The designer shall document the determination of the maximum allowable pressure by calculation or testing. Where temperature difference between ambient temperature and condensing temperature are 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 maximum allowable pressure 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.

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