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BSI Standards Publication

Refrigeration systems and heat pumps — Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes — Requirements and classification

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Refrigeration systems and heat pumps — Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes — Requirements and classification

Systèmes de réfrigération et pompes à chaleur — Éléments flexibles de tuyauterie, isolateurs de vibration, joints de dilatation et tubes non métalliques — Exigences et classification

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ISO 13971 was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning,* Subcommittee SC 1, *Safety and environmental requirements for refrigerating systems*.

Introduction

Flexible pipe elements are used to eliminate impermissible stresses from refrigerating circuits and absorb pipe expansion or relative movements of components.

Flexible pipe elements are often the weakest part of a refrigerating system and the part most likely to suffer from fatigue or stress corrosion cracking.

INTERNATIONAL STANDARD ISO 13971:2012(E)

Refrigeration systems and heat pumps — Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes — Requirements and classification

1 Scope

This International standard describes requirements, design and installation of flexible pipe elements (e.g., metallic flexible pipe, metallic flexible tube, vibration isolator, expansion joint) and non-metallic tube used in the refrigerant circuits of refrigerating systems and heat pumps.

It also describes the requirements to qualify the tightness and permeability of non-metallic tubes (e.g., plastic) used in evaporating and/or condensing sides of refrigerating systems and heat pumps.

This International standard does not apply to flexible pipes that are only occasionally stressed beyond the elastic limit (e.g., during repair work), or to joints that are free to rotate or hinge.

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 175, *Plastics — Methods of test for the determination of the effects of immersion in liquid chemicals*

ISO 5149-2, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 2: Design, construction, testing, marking and documentation*

ISO 6605:2002, *Hydraulic fluid power — Hoses and hose assemblies — Test methods*

3 Terms and definitions

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

3.1
expansion joint
tubular pipe element shaped in such a way that it provides limited movement to accommodate thermal expansion without reaching its elastic limit

3.2
flexible pipe element
pipe or tube of non-permanent shape linking two parts that are moveable with respect to each other

See Figure 1.

NOTE 1 This generic term includes all types, as defined in 3.1, 3.3 to 3.5, and 3.8 to 3.11.

NOTE 2 Flexible pipe elements may include a plastic barrier in the construction, either as a liner on the inner surface or as a sandwich in the pipe wall. The main purpose of such a barrier is to reduce the permeation of refrigerant gas.

NOTE 3 This type of pipe is flexible by virtue of the shape into which the tube is bent (e. g., coiled capillary tube).

3.3
flexible pipe element, fixed installed
element used to minimize assembly difficulty by accommodating slight misalignments or relative movement between components of the refrigerating system

3.4
flexible pipe element, for intermittent movement
element moving intermittently to take up relative movement between components of the refrigerating system

3.5
flexible pipe element, for significant movement
element moving regularly through significant distance to allow the operation of refrigerating equipment

EXAMPLE Plate freezers.

3.6
maximum allowable pressure
P_S
maximum pressure for which the equipment is designed, as specified by the manufacturer

3.7
maximum/minimum allowable temperature
T_S
maximum/minimum temperature for which the equipment is designed, as specified by the manufacturer

3.8
metallic flexible pipe
readily flexible, small bore pipe, that is capable of movement within its elastic limit during operation of the refrigerating system or within reasonable plastic deformation range during installation or maintenance

3.9
metallic flexible tube
tubular flexible element designed to bend within defined limits and containing a corrugated metal bellows, the corrugations of which may be annular or spiral

See Figure 1.

NOTE 1 Metallic flexible tubes can be reinforced by metallic braiding covered either by rubber or plastic but the whole element should be designed so that, when bent within pre-determined limits, it is not stressed beyond the elastic limit.

NOTE 2 This type of pipe is flexible by virtue of its design and construction, e. g. bellows.

3.10
non-metallic flexible tube
tubular flexible element designed to bend within defined limits

See Figure 1.

NOTE 1 Non-metallic flexible tubes can have smooth bore or corrugated bore and be reinforced to withstand pressure, vacuum or external impact.

NOTE 2 This type of pipe is flexible by virtue of its material (e. g., elastomer).

NOTE 3 Non-metallic flexible tube is intended to include all pipes made of plastic or rubber, mono-layer or multi-layer, reinforced or non-reinforced.

3.11
vibration isolator
short, flexible tube usually of metallic construction, that is intended to reduce the effects of vibration from the compressor to other parts of the refrigerating system or vice versa

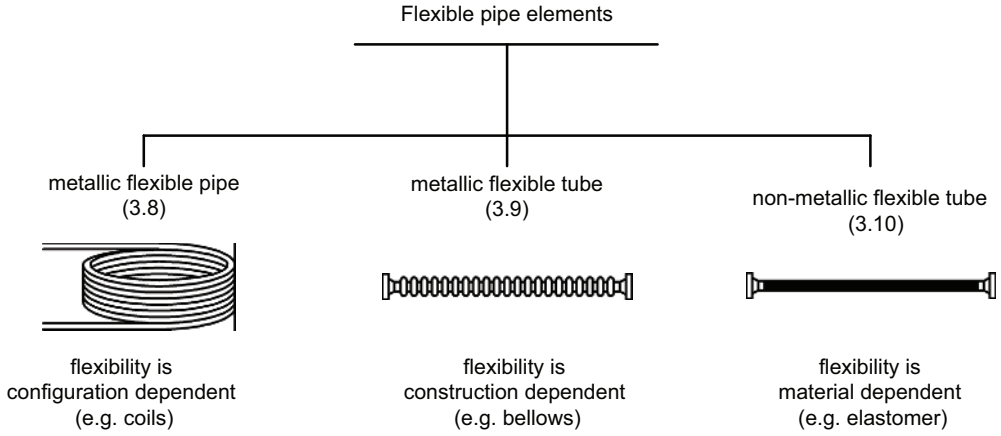


Figure 1 — Types of flexible pipe elements

4 Applications

4.1 General

4.1.1 The refrigerating system shall be so designed and constructed that the components being connected by the flexible pipe elements and non-metallic tubes cannot move in such a way as to stress the pipe element beyond its fatigue limit during operation, including start and stop.

4.1.2 Flexible pipe elements and non-metallic tubes shall be installed in accordance with the manufacturer's instructions.

4.1.3 Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes shall be used only if necessary.

4.2 Flexible pipe elements for significant movements, flexible pipe elements for intermittent movement and fixed installed flexible pipe elements

Flexible pipe elements for significant movements, flexible pipe elements for intermittent movement and fixed installed flexible pipe elements shall

— be supported and connected in such a way that they are not bent to radii less than those specified by the manufacturer;

— not allow the generation of static electricity when non-conducting refrigerants pass through them at high velocity;

NOTE This can be achieved by the use of antistatic plastic as lining.

— be so constructed and connected that they are not liable to damage by the freezing of water or by corrosion by humidity at the surface or at joints.

Flexible pipe elements for significant movement and flexible pipe elements for intermittent movement shall be so installed that there is no danger of the outer covering being abraded on stationary objects during movement of the flexible pipe.

The manufacturer of non-metallic flexible tubes for significant movements shall specify the permeability of the pipe element to water vapour and to the refrigerants for which it is suitable (see Clauses 7 and 8).

4.3 Vibration isolators

4.3.1 Vibration isolators shall be so installed that they are not subjected to combined bending and twisting.

4.3.2 Vibration isolators shall be so installed that they can accommodate not only the vibration emanating from a running compressor but also the movement of a spring-mounted compressor at starting and stopping.

4.3.3 Where the vibration being isolated has components in more than one plane, care shall be taken to ensure that the axis of the vibration isolator enables accommodation of all these components. If necessary, two vibration isolators connected at right angles to each other shall be installed.

4.3.4 Vibration isolators shall be firmly anchored at the point where they join the fixed piping of the refrigerating system.

4.3.5 Vibration isolators shall be so constructed and connected that they are not liable to damage by freezing of water at the surface or at joints. In particular, they shall not be installed vertically, unless a waterproof sleeve has been tightly fitted over the isolator where the freezing of water is expected.

4.3.6 Vibration isolators shall be installed in accordance with the manufacturer's instructions.

NOTE 1 Vibration isolators are commonly used as suction and discharge connections for compressors and are also sometimes used as connections to evaporators and condensers.

NOTE 2 Vibration isolators are not suitable for preventing the transmission of gas pulsation.

4.4 Expansion joints

4.4.1 Expansion joints or equivalent means shall be used to protect the system if the effects of thermal expansion are significant

NOTE Expansion joints are designed to take up strain produced by thermal expansion of the piping without stressing the piping system beyond its elastic limit. Expansion joints can be of the bellows type. Alternatively, flexibility can be produced by using a suitable configuration of the piping system (angular, lateral or axial compensating movements).

4.4.2 In every case the unrestrained expansion of the piping system shall be calculated to indicate the degree of flexibility which is required.

4.4.3 Where expansion joints are used, piping systems shall be designed with fixed anchor points and guide points.

NOTE Anchor points, which can be a compressor or a pressure vessel or can be additional rigid fixings to a building structure, are the fixed points between which expansion and contraction occurs. Guide points are necessary to prevent uncontrolled movement of the pipe in a transverse direction.

4.4.4 For insulated piping systems, the anchor points shall be fixed to the pipe but the guide points shall be on the outside of the insulation.

4.4.5 Bellows type expansion joints shall be so installed that they do not suffer from longitudinal movement produced by internal pressure.

4.4.6 Bellows-type expansion joints shall not be subjected to excessive shear forces due to transverse movement of pipes.

4.4.7 Care shall be taken to prevent damage to bellows by freezing of condensed water within the convolutions of the bellows. This may be achieved by packing the convolutions with low temperature grease or paste. Insulation and vapour seal should be applied over the paste.

4.4.8 Expansion joints shall be installed in accordance with the manufacturer's instructions.

4.5 Metallic flexible pipes

4.5.1 Metallic flexible pipes shall be of material that is resistant to work-hardening, or shall be arranged so that work-hardening does not take place.

4.5.2 Metallic flexible pipe coils shall not resonate under any foreseeable conditions of continuous operation. Design or choice of metallic flexible pipe shall take fatigue due to stress during starting and stopping into account.

NOTE Metallic flexible pipes, which are usually of small bore, are used to prevent the transmission of vibration from the piping system to, for example, controls and safety devices. Such pipes are often bent into a spiral to minimize the stress.

5 Materials

The materials used shall be subjected to ISO 175 for the refrigerants used and for the environment to which they will be exposed. Materials used at low temperature shall have adequate flexibility and shall not become brittle within the operating temperature range of the refrigerating system.

6 Pressure, pulsation and distortion requirements

6.1 Flexible pipe elements shall be designed according to a known or established standard and shall be capable of withstanding a pressure of −99 kPa (−0,99 bar) without damage. They shall either be strength pressure tested individually at minimum 1,43 P_S of the element or shall be type-approved by testing at 3 P_S of the element or 1 000 kPa (10 bar), whichever is the greater.

Users should be aware that under operating conditions pressure requirements, vibration stresses, stress due to misalignment, combined bending and twisting, and temperature effects can exist in combination.

6.2 Flexible pipe elements for heat transfer media (secondary refrigerants) where vacuum is not required shall conform to 6.1 but shall not be required to withstand the specified vacuum conditions.

6.3 For burst test pressure requirements for non-metallic flexible tubes, the test methodology shall be in accordance with ISO 6605:2002, 5.4 and the test pressure shall be minimum equal to 3 P_S.

6.4 Fatigue resistance for non-metallic flexible tubes shall be verified according to the test methodology for cyclic (impulse) tests, in accordance with ISO 6605:2002, 5.6, and with the following conditions:

— cycles number: 250 000;

— pressure: 1,1 P_S;

— temperature: 1 T_S.

6.5 Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes shall be confirmed with appropriate tests maintaining tightness against stresses, distortion and/or vibration caused by expected uses and duration of them.

7 Permeability of non-metallic flexible tubes

7.1 General

7.1.1 The permeability, expressed in grams per square metre, shall be calculated considering the internal hose surface.

7.1.2 The allowable permeability shall be established according to the following conditions:

— at a temperature of 32 °C and the saturated vapour pressure of the refrigerant;

— at a temperature of 100 °C and P_S.

7.1.3 For each of these conditions, the leakage rate class shall be determined according to Table 1 and the leakage rate class of the flexible pipe element is the higher class of the two conditions.

Table 1 — Allowable permeability for non-metallic flexible tubes

Leakage rate class	Permeability at 32 °C g/m^2 per year	Permeability at 100 °C g/m^2 per year
1	10	200
2	100	1 000
3	1 000	5 000

Unless otherwise specified in the relevant product standards, for example, ISO 5149 (all parts), leakage rate class 1 shall be applied.

7.1.4 The permeability of non-metallic flexible tubes for a specific refrigerant shall be as low as reasonably practicable.

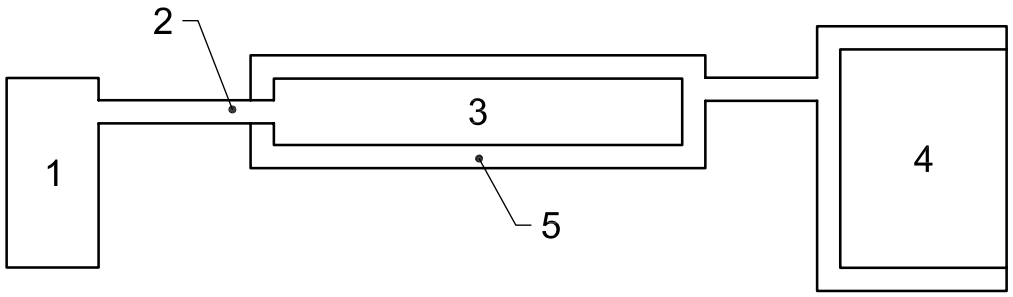
The allowable permeabilities shall not create local hazards from a specific refrigerant (e.g. toxicity, flammability, asphyxiation).

The contribution to the environmental impact (global warming, ozone depletion) due to the permeation of a refrigerant through flexible tubes shall be as low as reasonably practicable.

7.2 Test procedure

7.2.1 The leakage indicator shall have a minimum sensitivity of 3 g per year (at 32 °C and saturated vapour pressure).

7.2.2 For the permeability test three tube assemblies having at least 1 000 mm length of exposed tube between couplings are required for each nominal diameter.



Key

1 gas
2 external connection for P_S control
3 tube assemblies
4 leak detector mass spectrometer for the measurement by global vacuum method
5 control room

Figure 2 — Permeability test

7.2.3 Put the tube, plugged on one end, in a climatic room capable to detect the temperature directly on the tube to be tested.

7.2.4 Apply to the tube under test the required test temperature (100 °C ± 2 °C to 32 °C ± 2 °C).

7.2.5 Once the required temperature is reached, disconnect the heat source and execute the vacuum [95 kPa (<0,95 bar)] both in the tube to be tested and in the climatic room.

7.2.6 Charge, within 5 s from the vacuum, the tube with helium to the required pressure.

7.2.7 Maintain a constant pressure inside the tube under test, expressed in grams per square metre per year, [20 kPa (±0,2 bar)], check the leak rate for at least 1 h.

7.2.8 Use the highest value of the obtained curve leak rate/time.

7.2.9 Repeat the test on the other samples and calculate the average of all the obtained values to get the definitive leak rate. Table 2 gives conversion leak rate from helium into refrigerant.

Table 2 — Conversion leak rate from helium into refrigerant through molecular flow

Refrigerant leak	**Refrigerant designation**					
g/yr	R-12	R-134a	R-404A	R-407C	R-410A	R-600a
	Helium leak rate equivalent, 0,1 kPa·l/s (mbar·l/s)					
1	$3{,}5\ 10^{-5}$	$3{,}8\ 10^{-5}$	$3{,}9\ 10^{-5}$	$4{,}2\ 10^{-5}$	$4{,}5\ 10^{-5}$	$5{,}1\ 10^{-5}$

8 Internal cleanliness, internal humidity and permeability of water vapour

8.1 All the internal surfaces shall be free from any foreign matter, such as rust, scale, dirt, chips and the like. After completion of manufacturing and testing, the flexible pipe element shall contain no liquid except that required for protection. Any such liquid for protection shall have no adverse effect on the refrigerating system.

8.2 Flexible pipe elements shall be protected against contamination during transport and storage, e. g. by means of protective covers, by sealing in protective sheets or similar methods.

8.3 The residual water content inside the assemblies of metallic pipes at the time of supply shall not exceed 30 g/m^3 of inner volume of the tube assembly.

8.4 The volume of water in non-metallic tube assemblies at the time of supply shall not exceed 500 mg of water per metre of the tube and the permeability rate shall not exceed 10 mg of water per square decimetreper year at (23 ± 2) °C and a relative humidity of 50 %± 5%.

NOTE Suitable test methods for the assessment of water permeability include, e.g. Karl-Fischer titration, weighing, capacitive moisture sensor, mirror hygrometer, phosphorpentoxide [P_2O_5] method.

9 End connections

9.1 Non-metallic flexible tubes shall have end fittings fastened according the manufacturer's instructions. A suitable fitting with a high clamping force shall be used to reliably transmit all possible loads and prevent the tube pulling out.

Where applicable, a suitable coating or surface treatment should be applied to end connections to prevent corrosion in the presence of condensation.

9.2 Metallic flexible tubes, expansion joints and metallic flexible pipes shall be welded or brazed either into suitable connecting fittings or directly into the refrigerant piping.

Care should be taken to cool the flexible pipe element while such welding or brazing is taking place.

9.3 Flexible pipe elements shall be connected to the refrigerant piping in accordance with the requirements of ISO 5149-2.

10 Pre-charged flexible pipe elements

Pre-charged flexible pipe elements shall be fitted with self-sealing couplings arranged so that, when the elements are connected or disconnected, refrigerant is not lost and air and moisture cannot enter.

11 Marking

Flexible pipe elements and fittings shall be durably marked in an easily legible manner so that the manufacturer, the type reference and the size can be identified.

In addition, non-metallic flexible tubes (capillary included) shall be marked with

— 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 may be coded.

— minimum/maximum allowable temperature T_S;

— maximum allowable pressure P_S;

— leak rate class and reference to this International standard.

This does not apply to copper capillary tubes.

12 Documentation

For each type and size of factory made flexible pipe element and fitting the following documentation shall be available to the users:

— name and address of the manufacturer;

— manufacturer's type reference;

— type of element;

— allowable pressure;

— suitable refrigerants;

— permeability to suitable refrigerants;

— permeability of water vapour in accordance with Clause 8;

— reference to this International standard.

Bibliography

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

[2] ISO 5149-3, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 3: Installation site*

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

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