BS ISO 14903:2012

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Refrigerating systems and heat pumps — Qualification of tightness of components and joints

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee RHE/18, Refrigeration safety.

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

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INTERNATIONAL STANDARD

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Refrigerating systems and heat pumps — Qualification of tightness of components and joints

Systèmes de réfrigération et pompes à chaleur — Qualification de l'étanchéité des composants et des joints

Reference number
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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.

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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 14903 was prepared by Technical Committee ISO/TC 86, *Refrigeration and air conditioning*, Subcommittee SC 1, *Safety and environmental requirements for refrigerating systems*.

Introduction

This International Standard is intended to describe the qualification procedure for type approval of the tightness of hermetically sealed and closed components, joints and parts used in refrigerating systems and heat pumps as described in ISO 5149. The sealed and closed components, joints and parts concerned are, in particular, fittings, bursting discs, flanged or fitted assemblies.

Refrigerating systems and heat pumps — Qualification of tightness of components and joints

1 Scope

The requirements contained in this International Standard are applicable to joints of maximum DN 50 and components of maximum 5 l and maximum mass of 50 kg.

This International Standard is intended to describe the qualification procedure for type approval of the tightness of components, joints and parts used in refrigerating systems and heat pumps as described in ISO 5149. It characterizes the joint tightness and stresses met when operating, following the fitting procedure specified by the manufacturer, and to specify the minimal list of necessary information to be provided by the supplier of a component to the person in charge of carrying out this procedure.

This International Standard specifies the level of tightness of the component, as a whole, and its assembly as specified by the manufacturer.

This International Standard applies to the hermetically sealed and closed components, joints and parts used in refrigerating installations, including those with seals, whatever their material and their design are.

This International Standard specifies additional requirements for mechanical joints that can be recognized as hermetically sealed joints.

2 Normative references

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

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

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

EN 13134, *Brazing — Procedure approval*

ISO 13971:2012, *Refrigerating systems and heat pumps — Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes — Requirements, design and installation*

EN 12693, *Refrigerating systems and heat pumps — Safety and environmental requirements — Positive displacement refrigerant compressors*

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

IEC 60068-2-64:1993, *Environmental testing — Part 2: Test methods — Test Fh: Vibration, broad-band random (digital control) and guidance*

IEC 60335-2-34, *Household and similar electrical appliances — Safety — Part 2-34: Particular requirements for motor-compressors*

1) To be published.

2) To be published.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5149-1:— and the following apply.

3.1
mass flow per year
q_m
value of the leak mass flow rate

NOTE It is expressed in grams per year.

3.2
volume flow rate
Q
value of the leak volume flow rate

NOTE It is expressed in pascal cubic metres per second.

3.3
hermetically sealed system
system in which all refrigerant containing parts are made tight by welding, brazing or a similar permanent connection which may include capped valves and capped service ports that allow proper repair or disposal and which have a tested tightness control level of less than 3 grams per year under a pressure of at least a quarter of the maximum allowable pressure

NOTE Sealed systems as defined in ISO 5149-1:— are equal to hermetically sealed systems.

3.4
product family
group of products that have the same function, same technology, and same material for each functional part and sealing materials, produced according to the same specification but of a different size

3.5
permanent joints
means joints which cannot be disconnected except by destructive methods

3.6
reusable joint
joint other than permanent joint that can be disconnected without destructive manner

NOTE In some cases the tube is used as sealing material (e.g. flared joint). Sealing component may be replaced.

3.7
same base material
material belonging to the same group as follows:

— steel group

— aluminium and aluminium alloy group, and

— copper group

NOTE Subgroups of these material groups are considered to be same base materials (see EN 14276-2).

4 Symbols and units

The symbols and units used in this International Standard are given in Table 1.

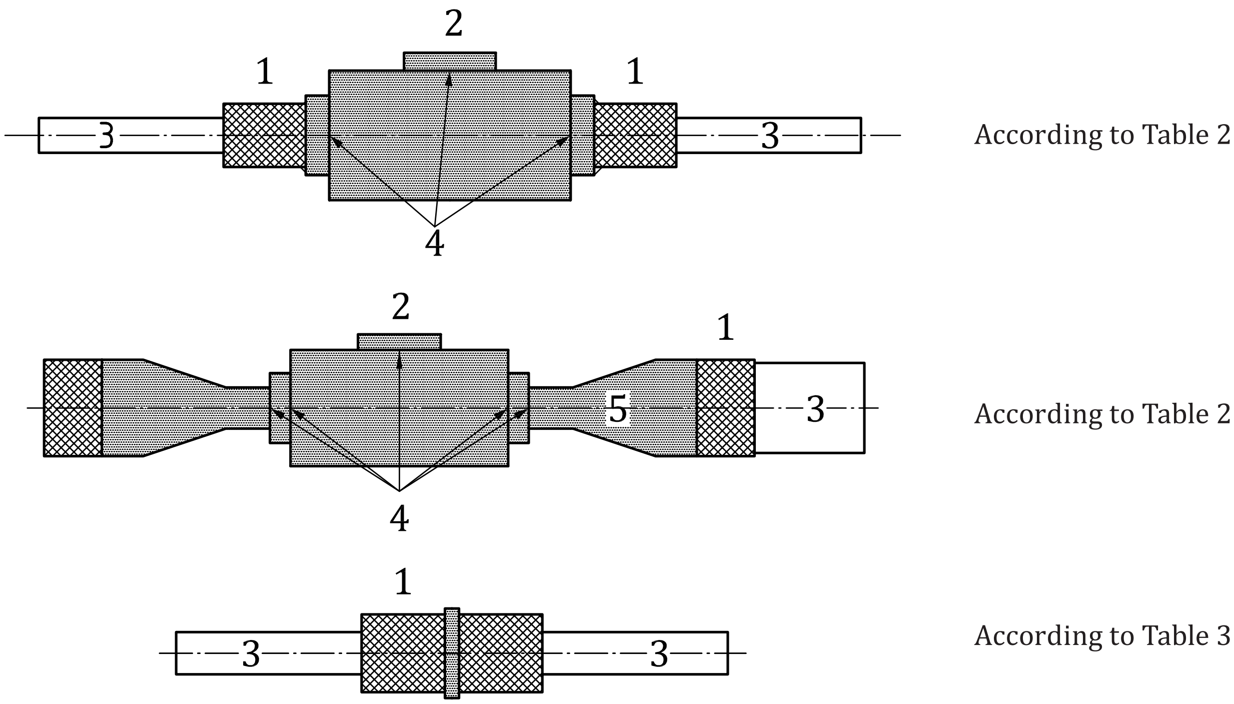
Table 1 — Symbols and units

Symbol	Description	Unit
DK_{rel}	Percentage deviation of the minimum and maximum torque from the average of the minimum and maximum torque, $(K_{o,max} - K_{o,min})/(K_{o,min} + K_{o,max})$	
f	Frequency of vibrations	Hz
$K_{o,ave}$	Average torques of the respective joint standard	
$K_{o,max}$	Required maximum torques of the respective joint standard, if specified. Otherwise, the maximum torque values supplied by the manufacturer	
$K_{o,min}$	Required minimum torques of the respective joint standard, if specified. Otherwise, the minimum torque values supplied by the manufacturer	
L	Length of tube	mm
n	Number of cycles in temperature and in pressure (method 1)	
n_1	Number of cycles in temperature and in pressure(method 2)	
n_2	Number of cycles in pressure	
n_3	Number of cycles in vibration	
n_{total}	Total number of cycles in temperature and in pressure	
N	Number of samples	
P	Tightness test pressure	bar
P_{max}	Maximal pressure of cycle	bar
P_{min}	Minimal pressure of cycle	bar
PS	Maximal allowable pressure	bar
P_{set}	Nominal set pressure of the device	bar
Q	volume flow rate	Pa m^3/s
q_m	mass flow per year	g/year
s	Vibration displacement (peak to peak value)	mm
T_{max}	Maximal temperature of cycle	°C
T_{min}	Minimal temperature of cycle	°C
Θ	Mass flow rate	kg/s

5 Test requirements

The required tests to be applied to the body of the component and to the joint used in refrigerating systems and heat pumps are given in Tables 2 and 3.

Figure 1 illustrates the principle of a component and a joint and the corresponding requirements shall conform to Table 2 or Table 3.



Key

1 joint

2 component body

3 pipe

4 component body joint

5 extension pipe

Figure 1 — Principle: component body-joint

All component types and joints types shall be tested.

When a component is connected with different types of joints, one of these joints shall be tested with the component according to Table 2. The other possible types of joints shall be tested independently according to Table 3.

Table 2 — Requirements for the body of the component

Description of the components (including valves)	Tests to be carried out							
	Tightness test 7.4	PTV test (pressure temperature vibration) 7.6	Operation simulation 7.7	Freezing test 7.8	Chemical compatibility with materials 7.11	Vacuum test 7.10	Additional test for hermetically sealed joints	
							Pressure test 7.9	Fatigue test 7.12
Component bodies having only permanent body joints: brazing and welding Identical base materials	YES	NO	NO	NO	NO	NO	NO	NO
Components having permanent body joints : brazing and welding Different base materials	YES	YES [a]	NO	NO	NO	NO	NO	NO
Component bodies having other permanent body joints: e.g. glue, permanent compression fittings, expansion joints	YES	YES	NO	YES if operating temperature below 0 °C	YES if non-metallic parts	YES	YES	YES
Component bodies with non-permanent body joints	YES	YES	YES if any external stems, shaft seals or removable or replaceable parts	YES if operating temperature below 0 °C	YES if non-metallic parts	YES	Not applicable	Not applicable
Capped valves and capped service ports for hermetically sealed systems	YES	YES	YES	YES if operating temperature below 0 °C	YES if non-metallic parts	YES	YES	YES
Safety valves	YES	YES	NO	NO	YES if non-metallic parts	Not applicable	Not applicable	Not applicable
Flexible piping	Test according to ISO 13971:2012							

As an exception compressors that comply with the requirements of EN 12693 or IEC 60335-2-34 only need to be subjected to the following test:

— joints connecting to other parts of the refrigerating systems;

— chemical compatibility test for all gaskets (sight glass,etc.).

NOTE Another qualification for this chemical compatibility done according to another standard is equivalent.

[a] PTV tests are not required if the destructive and non-destructive tests in EN 13134 are carried out.

Table 3 — Requirements for the joining of components

Description of the joints and parts	Requirements							
	Tightness test 7.4	PTV test (pressure temperature vibration) 7.6	Operation simulation 7.7	Freezing test 7.8	Chemical compatibility with materials 7.11	Vacuum test 7.10	Additional test for hermetically sealed joints	
							Pressure test 7.9	Fatigue test 7.12
Permanent piping joints: brazing and welding Identical base materials	YES	NO	NO	NO	NO	NO	NO	NO
Permanent piping joints: brazing and welding Different base materials	YES	YES	NO	NO	NO	NO	NO	NO
Other permanent piping joints: e.g. glue, permanent compression fittings, expansion joints	YES	YES	NO	YES	YES	YES	YES	YES
Non-permanent piping joints	YES	YES	YES	YES	YES, if sealing material	YES	Not applicable	Not applicable
Gaskets and sealing	NO	NO	NO	NO	YES	NO	Not applicable	Not applicable

6 Requirements for hermetically sealed systems

Hermetically sealed systems shall be constructed with components that have a tightness control level qualified according to A.1 or A.2, or that comply with Table 3. These components and joints shall be submitted to the relevant tests as specified in Tables 2 and 3.

7 Test procedures

7.1 General

The test characteristics to be applied to the components, joints and parts shall pass the qualification test for type approval of the tightness. The test procedures are shown in Figure 2.

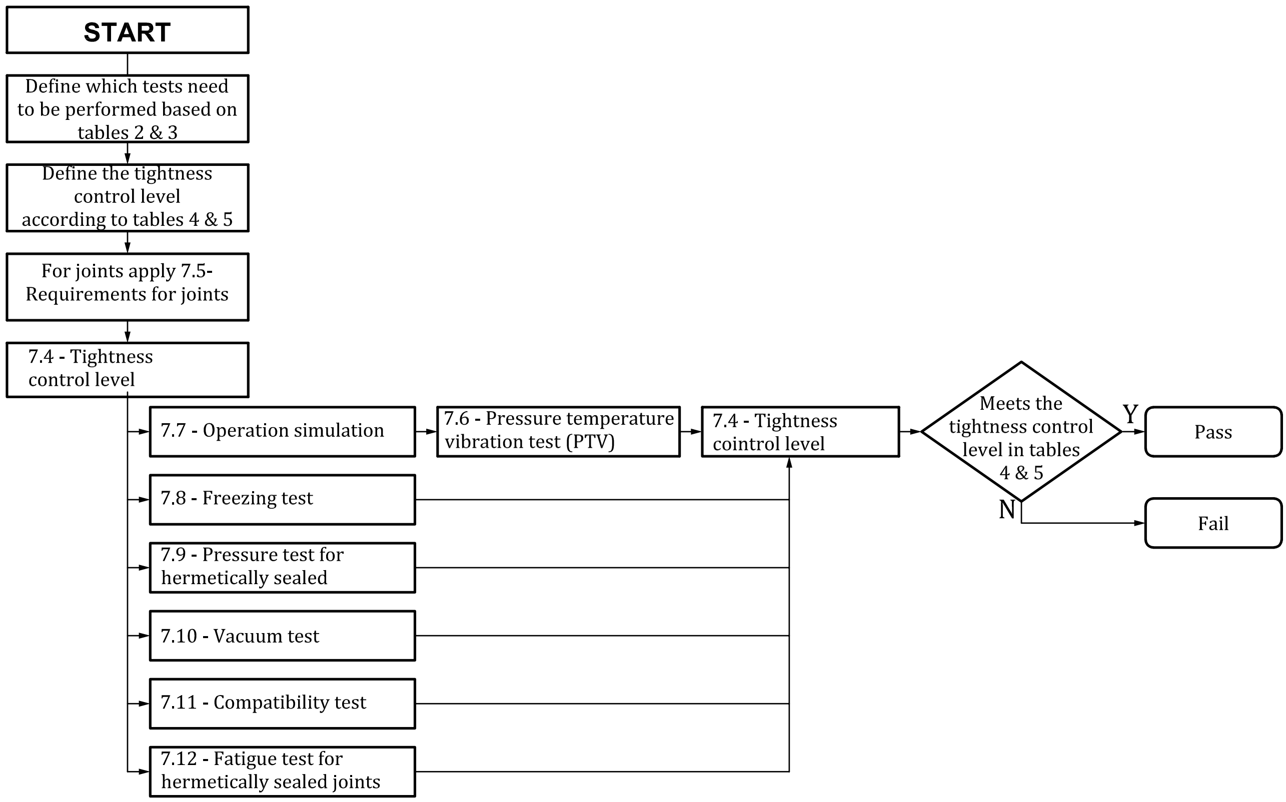


Figure 2 — Test procedure

7.2 Sampling

The largest, the smallest and any random samples in between of the product family shall be submitted to the test as required in Table 2 or Table 3. The samples used for pressure temperature vibration test (7.6) and for operation simulation (7.7) shall be the same. For each of the tests described in 7.8, 7.9, 7.10, 7.11, 712, different samples may be used.

7.3 Test temperature

The test temperature (ambient and gas) shall be between 15 °C and 35 °C, unless otherwise specified as the test conditions.

7.4 Tightness test

7.4.1 General

The tightness of components and joints shall be tested.

For pressure relief devices, P = 0,9 × P_{set} +0/-2%

For all other components and joints P = PS +0/-2% (PS = maximum allowable pressure)

Q ≤ requirements for actual tightness control level A1 – A2 (hermetically sealed components) or B1 – B2 for all other components

The maximum required tightness control levels are specified for Helium at 10 bar and + 20 °C as a reference.

The actual tightness control levels can be calculated (e.g. other test fluids or pressures) by using the stated calculation formulas (see Annex A).

The maximum tightness control depends on the size of the tested component or joint. Tightness control levels are specified in accordance with the joints used in Table 4. These are levels for each individual joint.

Table 4 — Tightness control level according to joints nominal diameter

Joints	Nominal diameter (DN)	Tightness control levels
Hermetically sealed joints	≤ 50	A1
Closed joints	≤ 50	B1

Tightness control levels are specified in accordance with the components used in Table 5. These levels are for each individual component.

Table 5 — Tightness control level according to components volume

Components	Component volume *l*	Tightness control levels
Hermetically sealed components	0 up to 1,0	A1
	> 1,0	A2
Closed components	0 up to 2,0	B1
	> 2,0 up to 5,0	B2

The required tightness control level is stated in Table 6. The manufacturer can choose a more stringent tightness control level if adequate.

Table 6 — Equivalence of test gas flow according to tightness control levels

Component type	Tightness control level	Helium reference leak ($Q_{he\text{-}ref}$) +20 °C, 10 bar	Equivalent air leak ($Q_{air\text{-}ref}$) +20 °C, 10 bar	Equivalent iso-butane leak (q_{mR600a}) +20 °C, 10 bar
		Pa.m^3/s	Pa.m^3/s	g/yr
Hermetically sealed	A1	≤ 7,5 × 10^{-7}	≤ 8 × 10^{-7}	≤ 1,5
	A2	≤ 1 × 10^{-6}	≤ 11 × 10^{-7}	≤ 2,0
Closed	B1	≤ 1 × 10^{-6}	≤ 11 ×v10^{-7}	≤ 2,0
	B2	≤ 2 × 10^{-6}	≤ 2,1 × 10^{-6}	≤ 4,0

NOTE The equivalent iso-butane leak is calculated as gas. At +20 °C and 10 bar iso-butane is in the liquid phase. See R600a in Table A.1.

7.4.2 Tightness control level

NOTE EN 1779 gives guidance on the criteria for method and technique selection.

7.4.2.1 Test method

The tightness control level of joints and components shown in Figure 3 shall be measured by an integration measure method, i.e. the sum of all leaks.

It is preferable to use tracer gas method.

NOTE 1 For further details on tracer gas method, see EN 13185:2001, Clause 10.

Tracer gas is admitted to the internal volume of the object and it is collected and tested in a vacuum chamber.

The following procedure shall be carried out to measure the tightness control level:

— connect the vacuum chamber to the detector;

— connect the component to the trace gas pressure generator (in the vacuum chamber); see Figure 3 below;

— close the vacuum box and start the leak detector (and if it is needed add a vacuum pump);

— calibrate and adjust the leak detector in accordance with the manufacturer's instructions using a calibration leak (if required the leak shall be "standard");

— measure the background signal in the vacuum box and the component without helium pressure;

— adjust the test pressure in the component;

— measure the leak signal of the component;

— evacuate air from inside the component with a vacuum pump;

— fill the component with tracer gas and adjust test pressure;

NOTE 2 This signal is the total flow of the tracer gas from the component measured by the leak detector.

— calculate the total leakage rate, such as:

$$q_G = \frac{q_{CL} \times (S_L - R_L)}{S_{CL} - R_{CL}} \times \frac{1}{c} \times \frac{101\,325}{p}$$

where

q_G is the total leakage rate, in pascals cubic metres per second;

q_{CL} is the leakage rate of the calibration leak in pascals cubic metres per second (pure tracer gas);

S_L is the leak signal;

S_{CL} is the signal generated by the calibration leak;

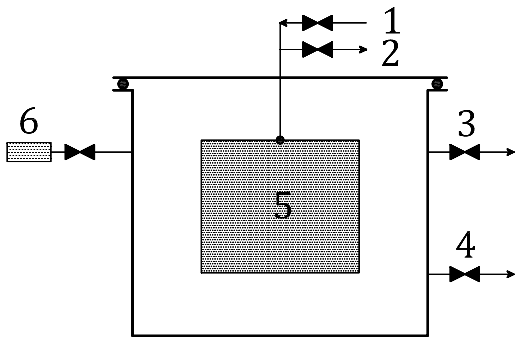
R_L, R_{CL} are the background signal associated with signal S_L and S_{CL}, respectively;

c is the volume fraction of the tracer gas in the gas mixture;

p is the total pressure in the auxiliary enclosure, in pascals.

NOTE 3 The calculation is detailed in EN 13185:2001, 9.2.6

If joints and/or components are tested together, the total level shall fulfil the most stringent tightness control level of the individual joint or component.



Key

1 tracer gas (*PS*)
2 vacuum
3 vacuum
4 mass spectrometric leak detector
5 test object
6 calibrated leak

Figure 3 — Principle of tightness control — Tracer gas

7.4.2.2 Alternative test methods

Two alternative methods may be applied.

— Alternative method 1:

The control by pressure technique by accumulation can be a method to measure the leak rate of the component.

NOTE 1 For details on the pressure technique by accumulation, see EN 13185:2001, 10.4.1.

— Alternative method 2:

Bubble test methods shown in Figure 4 can be acceptable for tightness control level B only, provided that the method is capable of measuring the actual leakage rate.

NOTE 2 The bubble test method is detailed in EN 1593.

The accuracy of the selected method shall be verified and be in compliance with the requirements for actual tightness control level. If this method is used, the following requirements shall be applied:

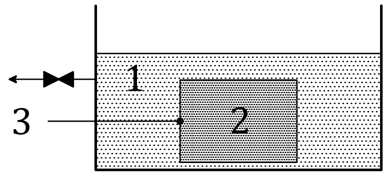
— the test object shall be subjected to an internal air pressure = *PS* (maximum allowable pressure); reduced pressure is not acceptable,

— the test object shall be totally immersed in water at a temperature of at least 35 °C,

— the test object shall be exposed to atmospheric pressure,

— the test shall be performed at normal ambient temperature,

— the period of time between bubbles leaving the test object shall be more than 60 s.



Key

1 water
2 test object
3 air pressure (*PS*)

Figure 4 — Principle of tightness control — Bubble method

7.5 Requirements for joints

7.5.1 General conditions

7.5.1.1 Test samples

All joints tested shall be tested in the same form as the final part received by the customer.

All joints shall to be submitted to the tests as indicated in Table 3.

7.5.1.2 Torque

Tube joints shall be tested both at the minimum torque K_{min} and the maximum torque K_{max} defined in Table 7.

Table 7 — Torque for the test, K_{min} and K_{max}

Torque deviation	K_{min}	K_{max}
$DK_{rel} \geq 20$ %	$K_{o,min}$	$K_{o,max}$
$DK_{rel} < 20$ %	$0,8 \times K_{o,ave}$	$1,2 \times K_{o,ave}$

7.5.1.3 Reusable joint

If the joints to be tested are reusable, the following steps shall be taken before the test:

a) fit the joints to tubes to be connected and tighten the joints to the maximum torque K_{max} specified in Table 7,

b) loosen the joints and take the tubes completely apart,

c) repeat a) and b) four more times.

7.5.1.4 Requirements for hermetically sealed joints

The joint shall not be opened without the use of special tools.

NOTE Special tools are those other than screwdrivers, parallel wrenches, simple gripping tools, etc.

The joint shall not be reusable without replacing the sealing material in normal use. In case the sealing material is the tube and the tube is deformed during the sealing process, the deformed part of the tube shall not be reusable for sealing purposes.

7.6 Pressure temperature vibration tests (PTV)

7.6.1 General

For pressure temperature vibration tests, 7.6.4 or 7.6.5 shall be applied.

The components or joints shall comply with one of the two methods described in 7.6.4 and 7.6.5 for combined cycle testing in order to qualify the tightness control level.

7.6.2 Samples

For the combined cycle test, the number of samples is determined based on tightness control level according to Table 8.

Table 8 — Test parameters

Tightness control level	Number of samples
A1, B1	3
A2, B2	2

7.6.3 Test method

7.6.3.1 Equipment

Test equipment shall be composed of:

a) a regulated enclosure for environment tests, able to maintain temperatures varying regularly between T_{min} and T_{max};

b) a pressure device, connected to the joints, capable of producing pressures that vary between P_{min} and P_{max};

c) a vibration generator, to make the specified frequency and amplitude;

d) a pressure control system capable of controlling the pressure with an accuracy of ± 5%;

e) a temperature control system capable of controlling the temperature inside of the test enclosure with an accuracy of ± 5 K;

f) a thermocouple capable of monitoring the temperature (T_{max}, T_{min}) of the component or joint submitted to the test.

   The temperature sensor shall be adhered to the surface of the sample on the item with the biggest mass concentration of the pressure bearing part in order to ensure that the sample has reached the defined temperature values. Where the pressure bearing part is made from metallic and non-metallic materials, the sensor shall be fixed on the non-metallic material.

   The sensor can be fixed to the sample by soldering or with adhesives, whichever is more appropriate, depending on the material of the sample.

Another method proven to have the same performance as the thermocouple can be applied;

g) a cycle counter of temperature and pressure;

h) test equipment to perform tightness test according to 7.4.

7.6.3.2 Test arrangements

The test samples shall be mounted as shown in Annex B in accordance with the number of joints to be tested and with the dimension of the climatic enclosure in which the tests are carried out.

The tube section shall have a diameter and dimensional tolerances such as specified by the manufacturer of the joint.

The assembly of the joints on the tube shall be carried out following the fitting instructions of the manufacturer.

For pressure tests, one end of a tube shall be connected to the pressure generator, the other end shall be tightly closed.

7.6.4 Method 1 — Combined pressure temperature cycle test with integrated vibration test

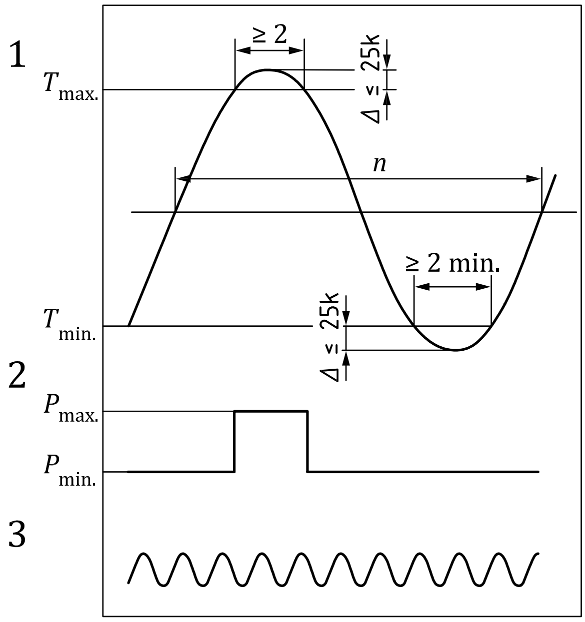
7.6.4.1 General

The samples (joints fitted on a tube) shall be submitted to a defined number n of cycles of temperature and pressure, between maximal values (T_{max}, P_{max}) and minimal values (T_{min}, P_{min}).

The test characteristics shall be applied to the components according to Table 9.

A typical temperature-pressure cycle is given in Figure 5.

Principle PTV test method 1



Key

1 temperature
2 pressure
3 vibration

Figure 5 — Temperature pressure cycle test

Table 9 — Test parameters

Parameters	Value
n	160
n_{total}	$5 \times n$
T_{min}	Minimum temperature as specified by the manufacturer or -40 °C if this is not specified
T_{max}	Maximum temperature as specified by the manufacturer +10 °C or 140 °C if this is not specified
P_{min}	Atmospheric pressure
P_{max}	For safety valves, $P_{max} = 0{,}9 \times P_{set}$
	For others components, $1{,}0 \times PS$[a]
f	200 Hz
s	0,012 mm
L	200 mm

[a] 1,0 × *PS* is proposed because of safety issues for tests on big components.

The test fluid shall not be a liquid.

7.6.4.2 Procedure

7.6.4.2.1 Fit the test samples on a test rig in accordance with the instructions of the manufacturer.

7.6.4.2.2 Fix the test parameters in accordance with Table 9.

7.6.4.2.3 Submit the test samples to the test pressure according to Table 9.

7.6.4.2.4 Check the tightness of the joints by sniffing gas in order to detect leaks before test.

7.6.4.2.5 Tighten again the joints which leak according to the instructions of the manufacturer.

7.6.4.2.6 Place the test samples in the climatic enclosure and submit them to n pressure and temperature cycles in accordance with Figure 5 and Table 9 and simultaneously submit the component assembly to the vibrations test of frequency f and displacement s.

7.6.4.2.7 Before the n pressure, temperature cycles and vibrations test, submit the joints to the operating cycle if necessary according to Table 2, as described in 7.7.

7.6.4.2.8 Repeat the procedure of 7.6.4.2.6 and 7.6.4.2.7 five times in total.

7.6.4.2.9 Expose the joints to the tightness test as specified in 7.4. The pass/fail criteria shall be the tightness control levels according to the test gas shown in Table 6.

7.6.5 Method 2 — Combined pressure temperature cycle test with a separate vibration test

7.6.5.1 General

The combined pressure temperature cycle test shall be performed separately from the vibration test.

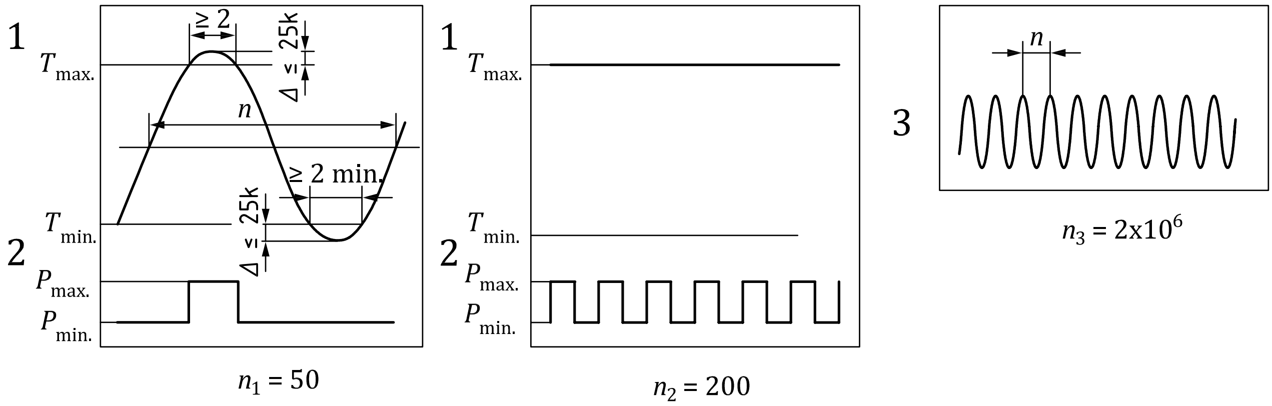
7.6.5.2 Requirements for the combined pressure temperature cycle test.

The samples shall be submitted to a defined number n_1 of cycles of temperature and pressure, between maximal values (T_{max}, P_{max}) and minimal values (T_{min}, P_{min}), and n_2 cycles of pressure between maximum value (P_{max}) and minimum value (P_{min}) with fixed temperature value (T_{max}).

The test characteristics shall be applied to the components according to Table 10.

A typical temperature pressure cycle is given in Figure 6.

Principle: PTV test method 2



Key

1 temperature

2 pressure

3 vibration

Figure 6 — Typical temperature pressure cycle test with a separate vibration test

Table 10 — Test parameters

Parameters	Value
n_1	50
n_2	200
n_3	2×10^6
T_{min}	Minimum temperature as specified by the manufacturer or -40 °C if this is not specified
T_{max}	Maximum temperature as specified by the manufacturer +10 °C or 140 °C if this is not specified
P_{min}	Atmospheric pressure
P_{max}	For safety valves, $P_{max} = 0{,}9 \times P_{set}$
	For others components 1,0 × *PS*[a]

[a] 1,0 × *PS* is proposed because of safety issues for tests on big components. In method 2, the number of cycles and the level of vibration are extended to compensate for the reduced pressure.

The test fluid shall not be a liquid.

7.6.5.3 Procedure

7.6.5.3.1 Fit the test samples on a test bed in accordance with the instructions of the manufacturer.

7.6.5.3.2 Fix the test parameters in accordance with Table 10.

7.6.5.3.3 Submit the test samples to the test pressure according to Table 10.

7.6.5.3.4 Check the tightness of the joints by sniffing gas in order to detect leaks before test.

7.6.5.3.5 Tighten again the joints which leak according to the instructions of the manufacturer.

7.6.5.3.6 Place the joints in the climatic enclosure and submit them to n_1 and n_2 pressure and temperature cycles in accordance with Figure 6 and Table 10.

7.6.5.3.7 Carry on the operation simulation according to 7.7

7.6.5.4 Vibration test

7.6.5.4.1 General

The component and joints shall be submitted to an n_3 vibration test. This test is executed as a stand-alone test.

7.6.5.4.2 Vibration test specifications

The joint samples shall be submitted to the specifications as given in Table 11.

The component samples shall be submitted to the specifications as given in Table 12 and Table 14.

7.6.5.4.3 Test of joint

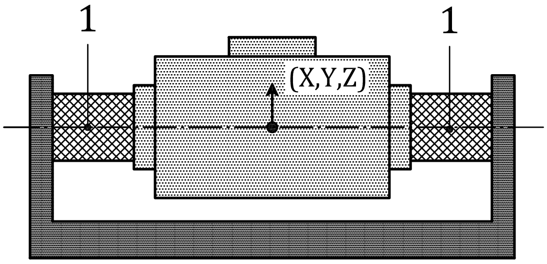
The test samples shall be mounted as shown in Annex B in accordance with the number of joints to be tested and with the dimension of the climatic enclosure in which the tests are carried out.

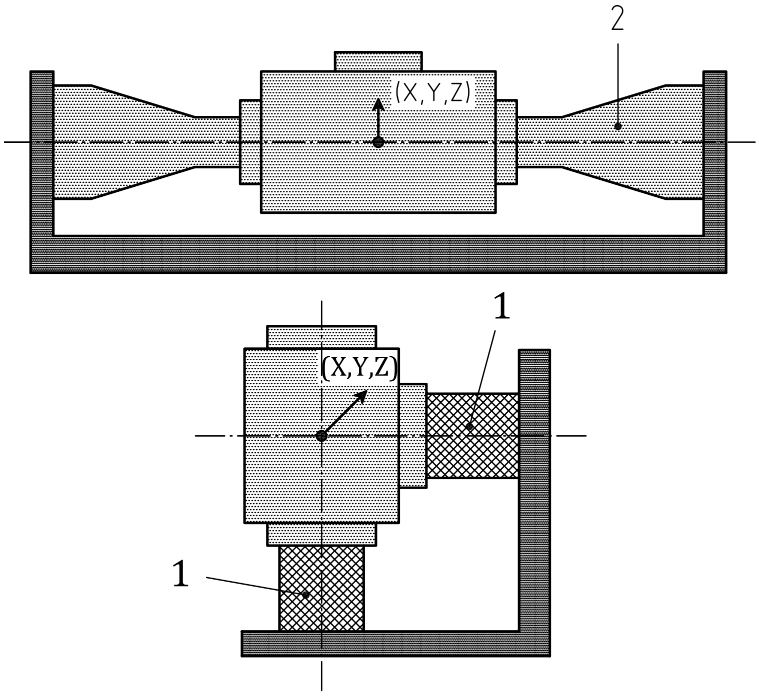
Table 11 — Test parameters for joints

Pipe diameter *DN*	**Length** *L* mm	**Displacement** *s* mm	**Frequency** Hz	**Number of excitation**
< 10	200	0,30	≤ 200	2 000 000
≥ 10 and < 20		0,25		2 000 000
≥ 20 and < 30		0,20		2 000 000
≥ 30 and ≤ 50		0,15		2 000 000

7.6.5.4.4 Examples of component

Examples of vibration assembly for a component are given in Figure 7.





Key
1 joint
2 extension pipe

Figure 7 — Vibration assembly for components

7.6.5.4.5 Test of component

a) Component test 1

Sinusoidal testing based on requirements in accordance with IEC 60068-2-6:1995.

The components shall be submitted to the specifications as given in Table 12.

Table 12 — Test parameters for components

Parameters	Value
Frequency range	10 Hz – 200 Hz
Minimum displacement (peak-peak)	10 Hz = 3,48 mm – 200 Hz = 0,008 7 mm
Minimum acceleration	0,7 g
Sweep speed	1 octave/min
Number of excitation directions[a]	3 (x-y-z)
Minimum duration	2 h in each direction (x-y-z)
[a] The number of excitation directions can be reduced to two on rotational symmetric structures.	

b) Component test 2

Random testing requirement covers installation of components subjected to vibration exceeding 0,5 g, e.g. components mounted on compressors.

Random vibration shall be at least the PSD values in Table 13 and linearly interpolated values as shown in Figure 8.

Test parameters of components are given in Table 14.

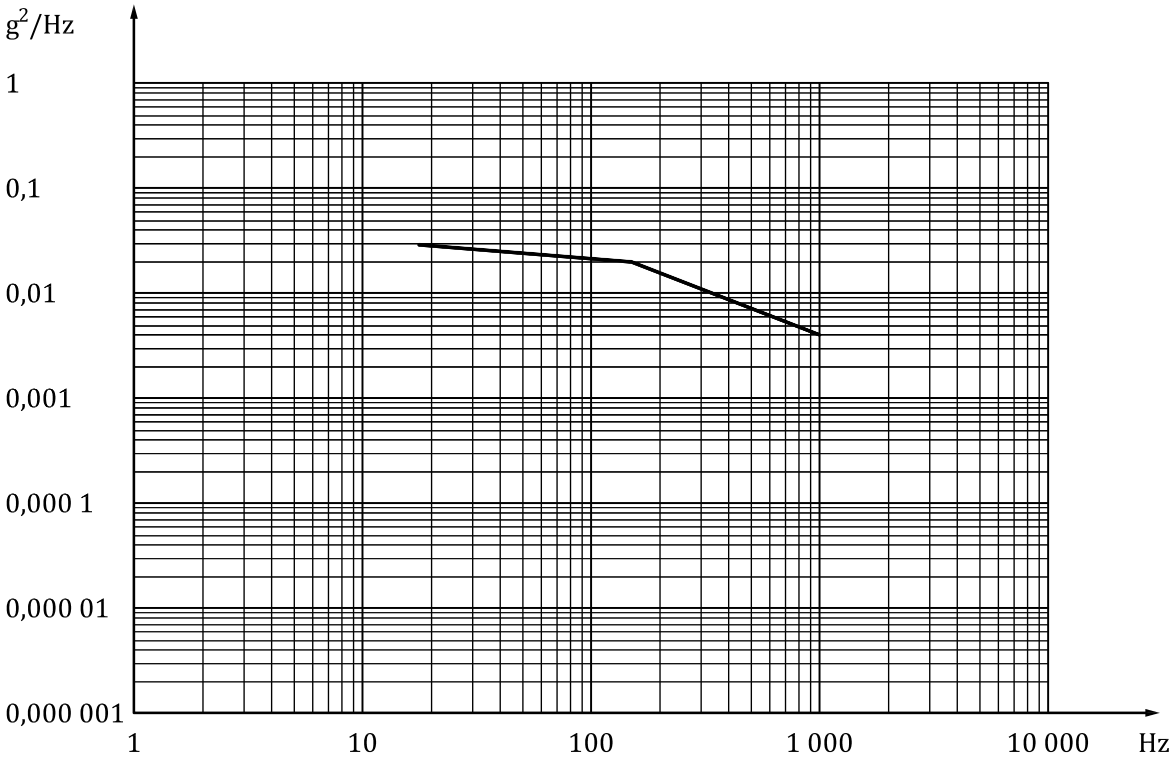


Figure 8 — Power spectral density

Table 13 — PSD values

Power spectral density (PSD)	
Hz	g^2/Hz
18	0,03
150	0,02
1 000	0,004

Table 14 — Test parameters for components

Parameters	**Value**
Displacement (max)	2,4 mm peak-peak
Acceleration (*RMS*)	3,1 g
Duration	90 min in each direction (x-y-z)
Number of excitation directions[a]	3 (x-y-z)

[a] The number of excitation directions can be reduced to two on rotational symmetric structures.

Testing shall be carried out in accordance with IEC 60068-2-64, 1993.

7.6.5.4.6 Procedure

7.6.5.4.6.1 Fit the test samples on a test bed in accordance with the instructions of the manufacturer.

7.6.5.4.6.2 Fix the test parameters for joints in accordance with Table 11.

7.6.5.4.6.3 Fix the test parameters for components in accordance with component test 1 and component test 2 as specified in 7.6.5.4.5.

7.6.5.4.6.4 Submit the joints and components to the vibration test according to the number of tests specified in the respective tables.

7.6.5.4.6.5 At the end of the vibrations test, submit the joints or components to the tightness test specified in 7.4. The pass/fail criteria shall be the tightness control levels according to the test gas shown in Table 6.

7.7 Operation simulation

The operation of maintenance and operating shall be carried out according to Table 15.

Table 15 — List of operations

Components	**Operations**		**Maintenance and operating**
	Method 1	Method 2	
Components with non-permanent body joints (e.g. valves)	5 times before each *n* cycle, a total of 25 operations (open and close)	10 times before n_1, 10 times before n_2 and 5 times before n_3, a total of 25 operations (open and close).	Disassembly/reassembly of the cap if any
Non-permanent piping joints (e.g. fittings)	5 times before each *n* cycle, a total of 25 operations (disassembly/reassembly)	10 times before n_1, 10 times before n_2 and 5 times before n_3, a total of 25 operations (disassembly/reassembly).	Gasket change

At the end of this test, the value of Q_{max} shall be measured and shall not exceed the required value of 7.4.

7.8 Freezing test

The freezing test shall be applied to joints specified for use below 0 °C.

The freezing test shall be performed on five samples that have been degreased to prevent the possibility of an air bubble.

The joint shall be assembled according to the instructions of the manufacturer.

It should be ensured that the joint is tight by testing.

Both ends of the pipe shall be tightly hermetically sealed to prevent water from entering into the pipes.

The test shall be carried out according to following procedure (see also Figure 9):

a) Put the sample into a vacuum test chamber:

— fill the test chamber with water of maximum 5 °C so all gases of the joint are submerged under water;

reduce the pressure in the test chamber to $-500\,^{0}_{-100}$ mbar, and maintain it for at least 10 min.;

— increase the pressure in the test chamber to atmospheric pressure, to fill gaps in the joint with water.

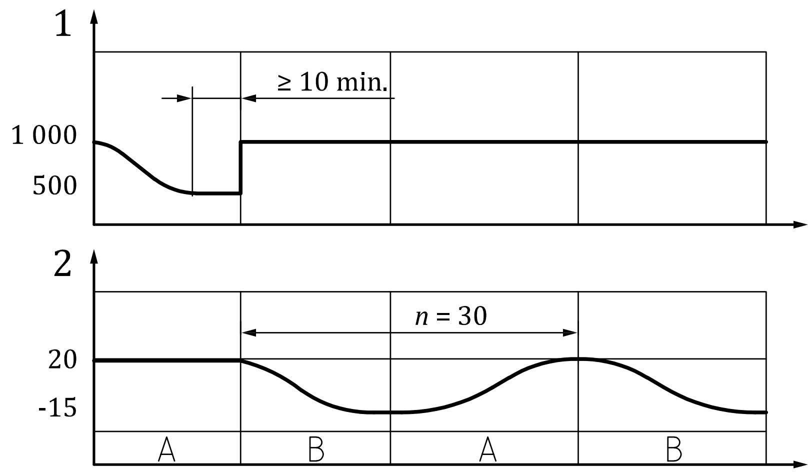
b) Remove the water from the test chamber.

c) Reduce the temperature until the temperature of the component has reached −15 °C or lower and maintain the temperature of the test chamber for at least 30 min. Samples shall be put in the most unfavourable direction so that the injected water is contained.

d) Immerse the sample into water at ambient temperature for at least 5 minutes so that the ice in gaps melts.

Repeat b), c) and d) 30 times.

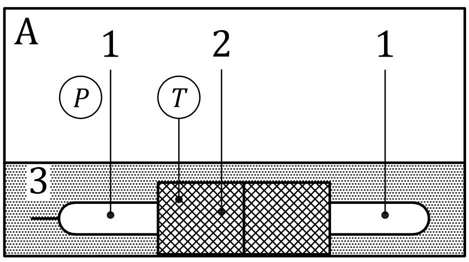
After the freezing test, test samples shall satisfy the test according to 7.4.



Key

1 pressure
2 temperature

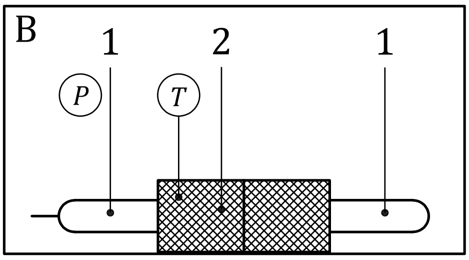
Figure 9 a — Examples of freezing test assembly



Key

1 pipe
2 joint
3 water

Figure 9 b — Examples of freezing test assembly



Key

1 pipe

2 joint

Figure 9 c — Examples of freezing test assembly

7.9 Additional pressure test for hermetically sealed joints

Pressure shall be applied to at least three assembled joints with tubes. Tubes shall have a thickness according to the appropriate standard withstanding at least 6 times the design pressure. Pressure shall be increased until it reaches 5 times the design pressure. Pressure shall be increased gradually, for example at a rate of less than 10 bar per minute. Assembly shall withstand at least six times the design pressure for 1 min.

The fluid used for this test shall be liquid such as oil, water, etc.

Other joints shall satisfy the requirements of ISO 5149-2:—.

7.10 Vacuum test

Test two samples to confirm that they are capable of withstanding a vacuum of 6,5 kPa absolute pressure for 1 h without leakage. Leakage shall be checked by monitoring the pressure and confirming that the pressure rise after 1 h is less than 0,02 kPa. The effect of temperature change on joints shall be taken into account.

NOTE 1 Prior to applying the test parameters all components are degassed and moisture free, for instance by applying a deep vacuum.

NOTE 2 Temperature changes may change the pressure.

7.11 Compatibility screening test

7.11.1 General

When joints use sealing material, either solid or liquid, compatibility of the sealing material with the refrigerant, the lubricant, etc., to be used shall be checked. Where the manufacturer can document a method showing equivalent results, that method can be accepted. This screening test describes the method of evaluating the resistance of rubber and thermoplastic seals to the action of refrigerant and lubricants by measurement of properties of the seals before and after exposure to selected refrigerant-lubricant systems.

7.11.2 Test fluids

Sealing materials for multipurpose components shall be tested with fluids recommended by the manufacturer (refrigerants and oils). The material compatibility with refrigerants blends/oil mixtures shall be evaluated on the basis of the single components or defined blends.

Oil: Using sealing designs intended for operating with oil, oil shall be added to the test fluid (5 wt. % oil).

For refrigerants, the content of the different refrigerant components shall fulfil the requirement given in Table 16.

Table 16 — Composition of test fluid

Actual fluid	Test fluid
C[a] ≤ 5	C- actual - 0 / + 10
5 < C ≤ 10	C- actual - 0 / + 15
10 < C ≤ 20	C- actual - 5 / + 20
20 < C ≤ 40	C- actual - 10 / + 25
40 < C ≤ 60	C- actual - 15 / + 30
60 < C ≤ 100	C- actual - 20 / + 40

[a] C is the actual composition mass %.

7.11.3 Test specimens

The following test conditions need to be fulfilled:

— minimum of five test pieces are used for testing;

— the general requirements for test specimens shall comply with ISO 175.

7.11.4 Test setup parameters

The following conditions shall be fulfilled:

— the exposure shall be carried out in a test chamber (autoclave) suitable for safely handling refrigerants under high pressure;

— the test chamber shall be filled to a maximum of 75% of its volume with the refrigerant-lubricant fluid mixture, allowing expansion of the fluid under the elevated test temperature;

— the exposure shall be carried out at a temperature of 50 °C, either by placing the test chamber in an oven or by direct heating of the test chamber.

NOTE If the critical temperature for the actual refrigerant is below 45 °C, the test temperature may be selected to $T_{critical}$ – 5 °C.

The minimum exposure time period is:

— 14 days (two weeks) for rubber seal materials;

— 42 days (six weeks) for thermoplastic seal materials.

7.11.5 Tests procedure

With respect to chemical compatibility, the significant measures for evaluation of possible suitability of the test material inserted in the component are hardness, volume and mass measures and in addition the visual observations (e.g. blisters, tearing, etc).

The following procedure shall be applied (see Figure 10):

— the initial rubber hardness, mass and volume of the 'as-received' test pieces are measured and recorded;

— the test pieces are placed in the test chamber in such as way that the test pieces are not in contact with each other, or with the test chamber wall. The surface of the test pieces shall be completely submerged into the liquid phase of the refrigerant;

— the appropriate amount of lubricant oil is introduced in the test chamber;

— the test chamber is closed and the appropriate amount of refrigerant fluid is introduced to the test chamber;

— the test chamber is subsequently heated to the exposure test temperature and the test conditions are maintained;

— after the exposure time period, the test chamber is allowed to cool down to the standard laboratory temperature and the test pieces are taken out from the test chamber;

— lubricant remains should be removed from the surfaces of each test piece;

— at wet state: the hardness, mass and volume of the test pieces are determined within 30 min of removal from the test chamber;

NOTE Elastomers tested with CO_2, can accumulate significant amount of CO_2. The CO_2 cannot escape immediately, when the test samples are exposed to atmospheric pressure (de-gassing). Thus, it and can create an immediate volume change larger than 25 %.

— at dry state: the test pieces are subsequently degassed in an oven maintained at 50°C until a constant mass is reached, and the resulting hardness, mass and volume are determined;

7.11.6 Pass/fail criteria for sealing elements

The seal shall meet the following maximum changes after exposure. For volume change the application condition (static or dynamic) shall be included.

The acceptance criteria shall be selected prior to commencing the ageing test.

For visual observation, the material shall show no tendency towards dissolution, cracking, blistering or physical deformation.

The maximal acceptable limits given in Table 17 shall be met.

Table 17 — Maximal acceptable limit according to test

Test	Maximal acceptable limit
Hardness change (IRHD)	
Wet[a]	± 15 IRHD
Dry[b]	± 10 IRHD
Volume change (%)	
Wet[c]	−5 % to + 25 %
Dry	± 10 %
Mass (%)	
Wet	± 12 %
Dry	± 7 %

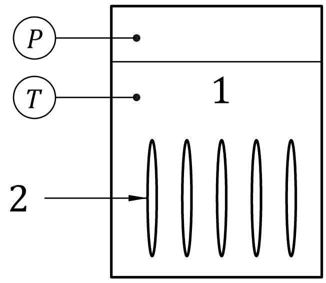
[a] Test shall be performed within 30 min after removal from the exposure vessel.

[b] Material shall be out-gassed/heated (50 °C) to a constant mass prior to testing.

[c] Provided that no surface damage is made, volume change above 25% is acceptable for CO_2.

NOTE The above limits for changes in material characteristics caused by exposure of test fluids are maximum values. For specific designs, e.g. dynamic operation, lower values may be required.

The actual design, with the sealing material mounted, shall be tested according to 7.4 before and after it has been exposed to test fluid.



Key

1 liquid refrigerant
2 test samples
P pressure
T temperature

Figure 10 — Example of testing device

7.12 Fatigue test for hermetically sealed joints

At least five samples shall be provided for this test.

The joint shall be assembled according to the instructions of the manufacturer.

The tightness of the joint shall be assured by testing.

The samples shall be subjected to a pressure cycle between atmospheric pressure and the design pressure *PS*. The high and low pressure shall be maintained for at least 0,1 s.

Pressure cycle shall be between 20 and 60 cycles/min. The total of pressure cycles shall be 250 000 times or more.

After the fatigue test, the joint shall satisfy the test according to 7.4.

8 Test report

The test report shall include the following information:

a) reference to this International Standard;

b) identification of the component/joint;

c) test parameters;

d) number of components/joints to be tested;

e) nature, aspect and assessment of leakages noted at each stage of the test;

f) report giving the test results, the date of the test, the name of the laboratory and the name of the signatory of the tests.

9 Information to the user

The component/joint manufacturer shall specify to the user the operating conditions of his component, in particular:

a) fluid(s) or type(s) of fluid for which the component/joint or the liaison fits or not;

b) maximal pressure of use;

c) range of minimal/maximal temperatures;

d) procedure and fitting instructions.

The report mentioned in 8 f) shall be provided upon request of the purchaser of the joint and/or the component.

NOTE The user can be an installer, a manufacturer, a maintenance operator and an end-user.

Annex A
(normative)

Equivalent tightness control levels

A.1 Calculation models

Exact conversion by calculation of tightness control levels is not possible. The following model calculations are based on simplifying assumptions:

— the leaking fluid shall be in the gaseous state;

— the temperature shall be approximately 20 °C (normal ambient temperature);

the flow shall be in the viscous laminar regime at least valid for leaks in the $1 \cdot 10^{-6}$ mbar·l/s to $1 \cdot 10^{-4}$ mbar·l/s range;

— the ideal gas equation shall be applied;

— the Poiseuille equation for gaseous flow in a long straight tube having circular cross-section is used as model, such as:

$$Q = \frac{\pi \cdot d^4}{256 \cdot \eta \cdot l} \cdot \left(p_1^2 - p_2^2\right) \cdot 10 \qquad \text{(A.1)}$$

where

Q	is the leak rate, expressed in mbar l/*s*;
d	is the diameter of the hole, expressed in metres (m);
η	is the dynamic viscosity, expressed in Pa·s;
l	is the length of the hole, expressed in metres (m);
p_1	is the inlet pressure, expressed in Pascal (Pa);
p_2	is the outlet pressure, expressed in Pascal (Pa);
256	is the geometry factor inherent to the Poiseuille equation;
10	is the unit conversion factor: 1 Pa·m^3/s = 10 mbar·l/s.

For fixed geometry Equation (A.1) simplifies to the form:

$$Q = K \cdot \frac{p_1^2 - p_2^2}{\eta} \tag{A.2}$$

where

$$K = \frac{\pi \cdot d^4 \cdot 10}{256 \cdot l} \tag{A.3}$$

Calculating the equivalent tightness control level at fixed geometry for change of viscosity (using another gas) or change of one or both pressures can be done by means of the following proportioning equation based on Equation (A.2):

$$\frac{Q_1}{Q_2} = \frac{\eta_2}{\eta_1} \cdot \frac{(p_1)_1^2 - (p_1)_2^2}{(p_2)_1^2 - (p_2)_2^2} \tag{A.4}$$

Considering change of viscosity only, Equation (A.3) simplifies to:

$$\frac{Q_1}{Q_2} = \frac{\eta_2}{\eta_1}$$

where

Q_1 is the leak rate of first gas, expressed in millibar litres per second (mbar·l/s);

Q_2 is the leak rate of second gas, expressed in millibar litres per second (mbar·l/s);

η_1 is the viscosity of first gas, expressed in pascal seconds (Pa·s);

η_2 is the viscosity of second gas, expressed in pascal seconds (Pa·s).

Considering change of pressures only, Equation (A.3) simplifies to:

$$\frac{Q_1}{Q_2} = \frac{(p_1)_1^2 - (p_1)_2^2}{(p_2)_1^2 - (p_2)_2^2} \tag{A.5}$$

where

$(p_1)_1$ is the inlet pressure of first gas, expressed in pascal (Pa);

$(p_1)_2$ is the outlet pressure of first gas, expressed in pascal (Pa);

$(p_2)_1$ is the inlet pressure of second gas, expressed in pascal (Pa);

$(p_2)_2$ is outlet pressure of second gas, expressed in pascal (Pa).

NOTE In Equations (A.3), (A.4) and (A.5) changing the dimensions of all *Q*s (for instance from mbar·l/s to Pa·m^3/s) has no consequence for the numerical result. Likewise changing the dimensions of all *p*s (for instance from Pa to bar) has no consequence.

A.2 From volumetric flow to mass flow

Volumetric flow may have the dimension of m^3/s which makes sense if the flowing fluid is in the liquid (incompressible) state. For (compressible) gases, volumetric flow makes no sense unless pressure and temperature is also stated. Gas flow having, for instance, the units Pa·m^3/s contains information about pressure and, if nothing else, its stated ambient temperature is assumed. For gas flow having, for instance, the dimension normal l/s, information about pressure and temperature is contained in the word normal, meaning at 1,013 bar and 0 °C.

Gas flows calculated by Equations (A.1) to (A.5) can be converted to mass flow by means of the ideal gas equation.

The ideal gas equation:

$$p \cdot V = n \cdot R \cdot T \tag{A.6}$$

where

- p is the pressure, expressed in pascal (Pa);
- V is the volume, expressed in cubic metres (m^3);
- n is the amount of substance, expressed in mole (mol);
- R is 8,314 J·mol/K (universal gas constant);
- T is the temperature, expressed in kelvin (K).

Dividing both sides of Equation (A.6) by time and converting amount of substance to mass gives:

$$\frac{p \cdot V}{t} = \frac{m}{t} \cdot \frac{R \cdot T}{M} \tag{A.7}$$

where

- t is the time, expressed in seconds (s);
- m is the mass, expressed in kilograms (kg);
- M is the molar mass, expressed in kilograms per mole (kg/mol);

Because $\frac{Q}{10} = \frac{p \cdot V}{t}$ = flow (leak rate) $Pa{\cdot}m^3/s$ and $\Theta = \frac{m}{t}$ = flow (leak rate) kg/s Equation (A.7) can be transformed to:

$$q_m = \frac{Q}{10} \cdot \frac{M}{R \cdot T} \cdot 31{,}536 \cdot 10^9 \tag{A.8}$$

where

- q_m is the mass flow (leak rate), expressed in grams per year (g/year);
- $31{,}536 \cdot 10^9$ is the unit conversion factor: 1 kg/s = $31{,}536 \cdot 10^9$ g/year.

Values of dynamic viscosity and molar mass for some gases are presented in Table A.1 below. Note that the viscosity is a strong function of temperature (gas viscosity increases as temperature increases). Gas viscosity is a weak function of pressure (at pressures larger than atmospheric pressure).

Table A.1 — Dynamic viscosity and molar mass

Gas	Dynamic viscosity at 20 °C and atmospheric pressure 10^{-6} Pa·s	Molar mass 10^{-3}kg/mol
Nitrogen	17,4	28,0
Helium	19,3	4,0
Air	18,0	29,0
R22	12,0	86,5
R134a	11,1	102,0
R404A	11,9	97,6
R407A	12,3	86,2
R407C	12,0	86,17
R410A	13,2	72,6
R290	7,9	44,1
R507	11,95	98,86
R600a	7,4	58,1
R717	9,7	17,0
R744	14,9	44,0

A.3 Tightness control level stated as bubbles of air in unit time

No bubble shall appear in a period of 1 min at a pressure identical to *PS.*

In order to calculate a leak rate in volumetric or mass units, the following assumptions shall be made:

— the test object is immersed in water;

— the test object is subjected to an inside air pressure *PS* (maximum working pressure);

— the test object is subjected to normal atmospheric pressure on the outside;

NOTE 1 The hydrostatic pressure from the water column is neglected.

— the test is performed at normal ambient temperature;

— the minimum period of time between bubbles leaving the test object is 1 min;

— the volume of each bubble is assumed to be 1 mm^3 (“standard bubble”).

The largest allowed volumetric flow of air can be calculated from:

$$Q=\frac{p\cdot V}{t}\cdot 10=\frac{1{,}013\cdot 10^{5}\cdot 1\cdot 10^{-9}}{60}\cdot 10=1{,}68\cdot 10^{-5}\ \text{mbar l/s} \qquad \text{(A.9)}$$

NOTE 2 By model calculations, it can be shown that a $1{,}68\cdot 10^{-5}$ mbar·l/s leak is likely to produce bubbles smaller than 1 mm^3 coupled with a smaller time interval than 1 min between bubbles. Experience has shown that unless rigorous procedures are used, bubble tests with air and a water tank cannot be used to detect leaks smaller than approximately $1\cdot 10^{-4}$ mbar·l/s.

EXAMPLE See Figure A.1. A valve has a *PS* (maximum working pressure) of 40 bar and a maximum air leak of $1{,}68\cdot 10^{-5}$ mbar l/s at 40 bar inside pressure. It is chosen to test the tightness by means of a helium leak detector at 10 bar inside pressure in the valve. Calculate the equivalent tightness control level.

By slight re-arrangement, Equation (A.3) takes the form:

$$Q_1 = Q_2 \cdot \frac{\eta_2}{\eta_1} \frac{(p_1)_1^2 - (p_1)_2^2}{(p_2)_1^2 - (p_2)_2^2} \tag{A.10}$$

where:

Q_2 is equal to $1{,}68 \cdot 10^{-5}$ mbar·l/s (air);

Q_1 is the equivalent tightness control level (helium);

η_1 is the helium viscosity, expressed in pascal seconds (Pa s);

η_2 is the air viscosity, expressed in pascal seconds (Pa s);

$(p_1)_1$ is the helium pressure in the valve, expressed in bar;

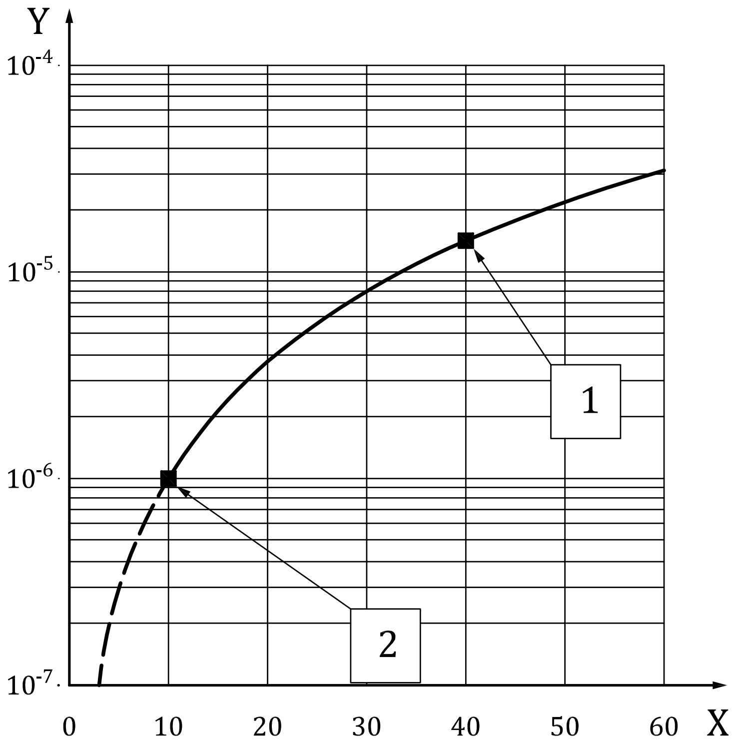
$(p_1)_2$ is the helium pressure outside the valve, expressed in bar;

$(p_2)_1$ is the air pressure in the valve, expressed in bar;

$(p_2)_2$ is the air pressure outside the valve, expressed in bar.

Setting $(p_1)_2 = (p_2)_2 = 0$ and inserting in Equation (A.10), Q_1 can be calculated:

$$Q_1 = 1{,}68 \cdot 10^{-5} \cdot \frac{18 \cdot 10^{-6}}{19{,}3 \cdot 10^{-6}} \cdot \frac{10^2}{40^2} = 0{,}98 \cdot 10^{-7} \sim 1 \cdot 10^{-6} \text{ mbar·l/s (equivalent tightness control level)} \tag{A.11}$$



Key

X pressure in bar

Y tightness control level

1 actual test pressure — tightness control level

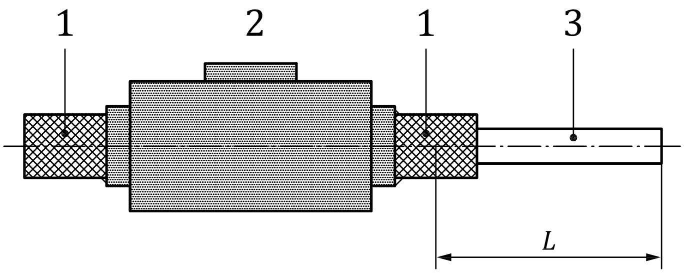
2 reference tightness control level (10 bar)

Figure A.1 — Equivalent tightness control level

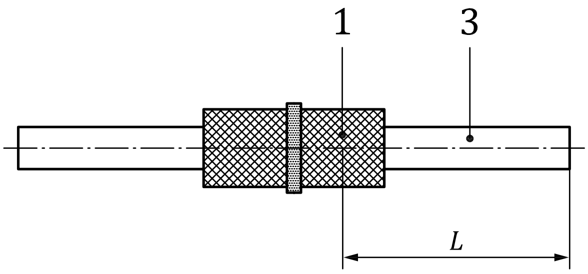
Annex B
(informative)

Test arrangements

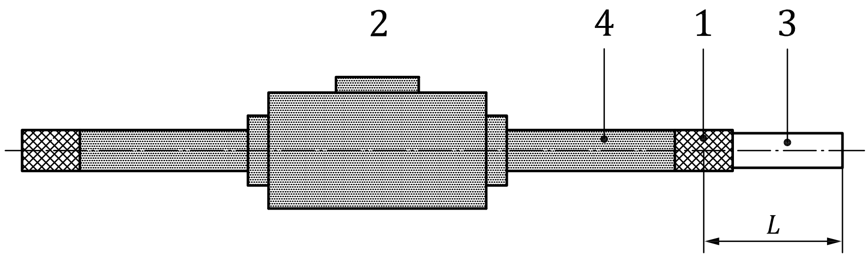
The samples are fixed according to the manufacturer's instructions. Otherwise the main body of the sample should be fixed as close as possible to the joint.



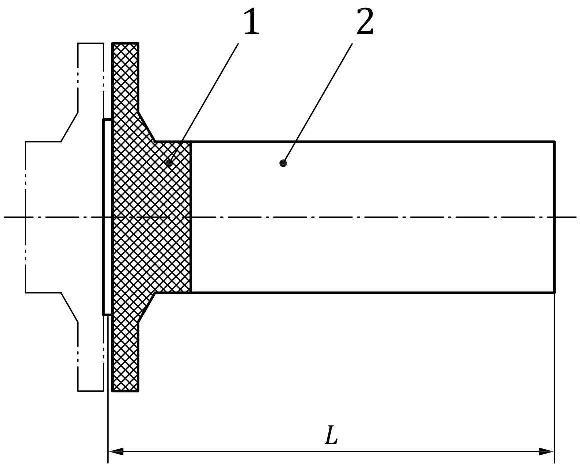
a) Component (e.g valve)



b) Brazed joint



c) Component (e.g. valve)



d) Flange

Key

1 joint
2 component
3 pipe
4 extension pipe
L length

Figure B.1 — Component-joint test arrangements

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