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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

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 182, *Refrigerating systems, safety and environmental requirements*, in collaboration with ISO Technical Committee TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 1, *Safety and environmental requirements for refrigerating systems*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 14903:2012), which has been technically revised.

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

1 Scope

This document provides 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 relevant parts of ISO 5149. The sealed and closed components, joints and parts concerned are, in particular, fittings, bursting discs, flanged or fitted assemblies. The tightness of flexible piping made from non-metallic materials is dealt with in ISO 13971. Metal flexible piping are covered by this document.

The requirements contained in this document are applicable to joints of maximum DN 50 and components of internal volume of maximum 5 l and maximum weight of 50 kg.

This document is intended to characterize their tightness stresses met during their operations, 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.

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

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

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1817, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

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

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

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

IEC 60068-2-64, *Environmental testing — Part 2-64: Tests — Test Fh: Vibration, broadband random and guidance*

EN 1593, *Non-destructive testing — Leak testing — Bubble emission techniques*

EN 13185:2001, *Non-destructive testing — Leak testing — Tracer gas method*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
mass flow rate
Q_m
value of the leak mass flow rate at any point of the component

Note 1 to entry: The mass flow rate is expressed in grams (g) per year.

3.2
volume flow rate
Q
value of the leak volume flow rate at any point of the component

Note 1 to entry: The volume flow rate is expressed in Pascal cubic metres per second (Pa·m^3/s).

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 g per year under a pressure of at least a quarter of the maximum allowable pressure

Note 1 to entry: 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, technology, and material for each functional part and sealing materials

3.5
closed joint
joint other than hermetically-sealed joints where there is no movement between the sealing surfaces except for service purposes

EXAMPLE Flanged joints.

3.6
closed component
component other than hermetically-sealed components where there is no movement between the sealing surfaces except for service purpose

EXAMPLE Stop valves, service ports, pressure-relief valves.

3.7
hermetically-sealed joint
joint that are made tight by welding, brazing or a similar permanent connection

3.8
hermetically-sealed component
component that are made tight by welding, brazing or a similar permanent connection

3.9
permanent joint
joint which cannot be disconnected except by destructive methods

[SOURCE: Pressure Equipment Directive 2014/68/EU, modified]

3.10
reusable joint
joint made without replacing the sealing material in general procedure

Note 1 to entry: In some cases, the tube is used as sealing material (e.g. flared joint).

3.11
same base material
material belonging to the same group

EXAMPLE Steel group, aluminium and aluminium alloy group or copper group.

Note 1 to entry: Subgroups of these material groups are considered to be same base materials (refer to EN 14276-2).

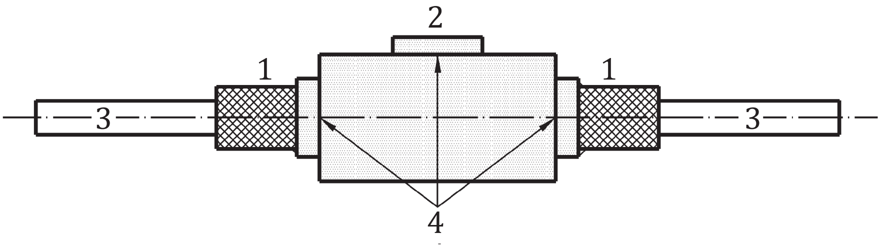
4 Symbols

Symbol	Denomination	Unit
D_K	Percentage deviation of the minimum and maximum torque from the average of the minimum and maximum torque, $(K_{max} - K_{min})/(K_{min} + K_{max})$	—
f	Frequency of vibrations	Hz
K_{ave}	Average torques of the respective joint standard	Nm
K_{max}	Required maximum torques of the respective joint standard, if specified. Otherwise, the maximum torque values supplied by the manufacturer.	Nm
K_{min}	Required minimum torques of the respective joint standard, if specified. Otherwise, the minimum torque values supplied by the manufacturer.	Nm
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 leakage rate	mbar l/s
Q_m	Mass flow leakage rate	g/a
s	Vibration displacement (peak to peak value)	mm
t_{max}	Maximal temperature of cycle	°C
t_{min}	Minimal temperature of cycle	°C

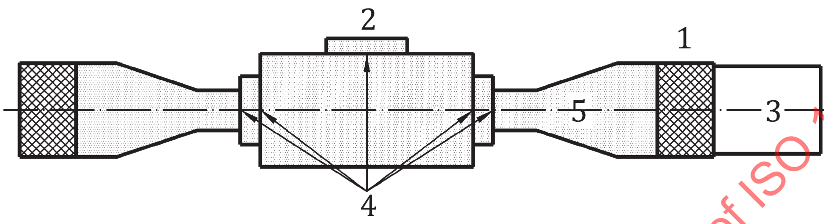
5 Test requirements

The required tests to be applied to component bodies and joint used in refrigerating systems and heat pumps are given in Table 1 and in Table 2.

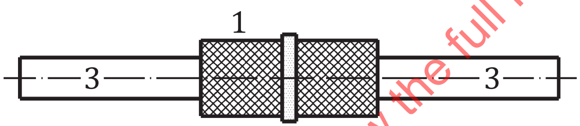
Figure 1 illustrates the principle of a component and a joint and their corresponding requirements in Table 1 or Table 2.



a) According to Table 1



b) According to Table 1



c) According to Table 2

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 may be connected with different types of joints, one of these joints shall be tested with the component according to Table 1. The other possible types of joints shall be tested independently according to Table 2.

Table 1 — Requirements for component bodies

Components (including valves)	**Requirements**							
	Tightness test	**PTV- test** (pressure-temperature-vibration)	**Operation simulation**	**Freezing test**	**Chemical compatibility with materials**	**Vacuum test**	**Additional test for hermetically sealed**	
							Pressure test	**Fatigue test**
Subclause	7.4	7.6	7.7	7.8	7.11	7.10	7.9	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

By 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.).

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

NOTE Other qualifications for this chemical compatibility done according to other standards are equivalent.

Table 1 *(continued)*

Components (including valves)	**Requirements**							
	Tightness test	**PTV- test** (pressure-temperature-vibration)	**Operation simulation**	**Freezing test**	**Chemical compatibility with materials**	**Vacuum test**	**Additional test for hermetically sealed**	
							Pressure test	**Fatigue test**
Subclause	7.4	7.6	7.7	7.8	7.11	7.10	7.9	7.12
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							

By 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.).

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

NOTE Other qualifications for this chemical compatibility done according to other standards are equivalent.

Table 2 — Requirements for the joining of components

Joints and parts	Requirements							
	Tightness test	PTV- test (pressure-temperature-vibration)	Operation simulation	Freezing test	Chemical compatibility with materials	Vacuum test	Additional test for hermetically sealed	
							Pressure test	Fatigue test
Subclause	7.4	7.6	7.7	7.8	7.11	7.10	7.9	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 which have their tightness control level qualified as A1 or A2 as per Table 3 or Table 4. These components and joints shall be submitted to the relevant tests as specified in Tables 1 and 2.

7 Test procedures

7.1 General

The components, joints and part shall pass the tightness test before the other tests are executed. The different tests are shown in Figure 2.

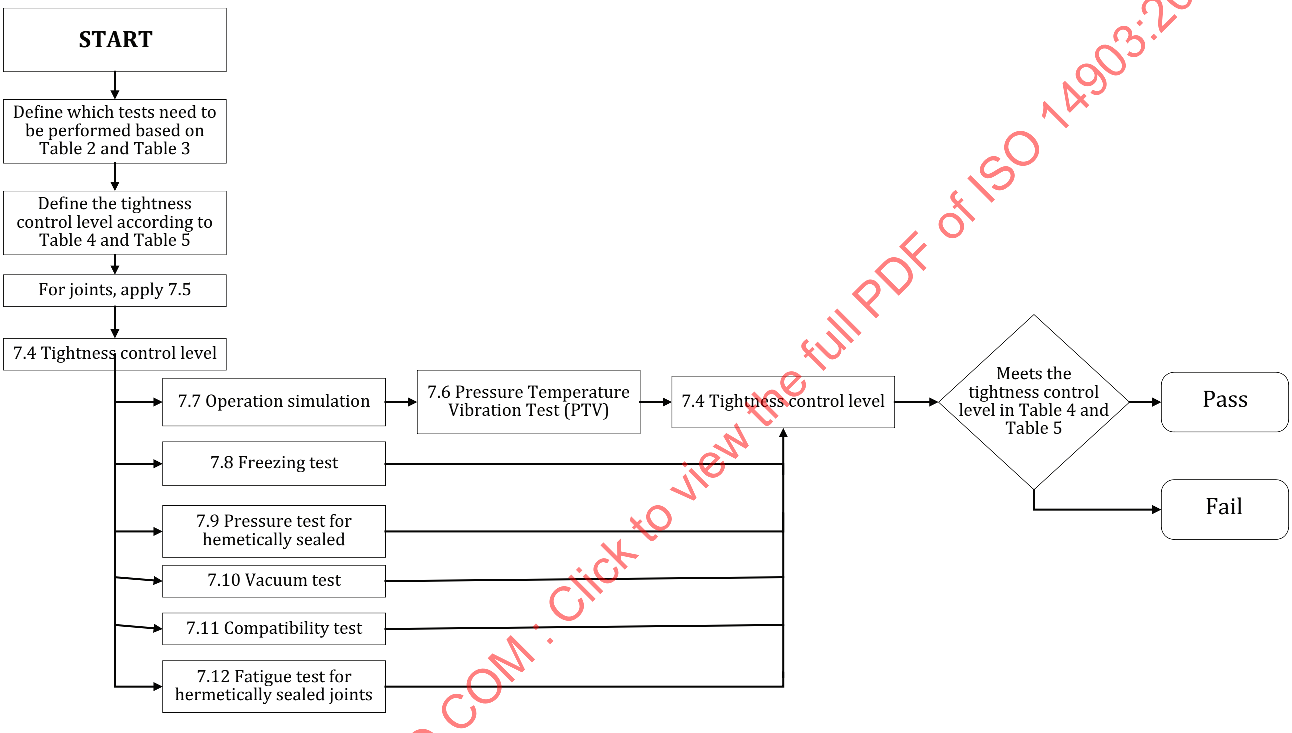


Figure 2 — Test procedure

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 1 or Table 2. The samples used for pressure-temperature vibration test (7.6) and for operation simulation (7.7) shall be the same. For each of the other tests (7.8, 7.9, 7.10, 7.11, 7.12), different samples may be used.

7.3 Test temperature

Test temperature (ambient and gas) shall be 15 °C to 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 according to the following test pressures.

For pressure relief devices, P = 0,9 × P_{set} (−2) %;

For all other components and joints the test pressure P shall be defined as: P = PS (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 level 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 (Annex A).

The maximum tightness control level depends on the size of the tested component or joint. Tightness control levels are specified in accordance with the joints used in Table 3. These are levels for each individual joint.

Table 3 — Tightness control level according to joints nominal diameter

Joints	DN	Tightness control levels
Hermetically sealed joints	≤ 50	A1
Closed joints	≤ 50	B1

For components, the tightness control level depends on the component internal volume and the type of component as specified in Table 4. These are levels for each individual component.

Table 4 — 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
Closed components	> 2,0 up to 5,0	B2

The manufacturer can choose more stringent tightness control level if adequate.

Table 5 — Equivalence of test gas flow according to tightness control levels

Component type	Tightness control level at +20 °C, 10 bar	Helium reference leak $Q_{he\text{-}ref}$ Pa·m³/s	Equivalent air leak $Q_{air\text{-}ref}$ Pa·m³/s	Equivalent iso-butane leak $m_{R\text{-}600a}$ g/a
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 × 10^{-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 R-600a in Table A.1.				

7.4.2 Tightness level control

7.4.2.1 Test method

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

The tightness control level of joints and components shown in Table 3 and Table 4 shall be measured by the vacuum chamber technique which sum all leak.

It is preferable to use tracer gas technique as defined in EN 13185:2001, Clause 10.

The component to be tested is pressurized with the tracer gas and placed in the vacuum chamber in which the sum of all components leak is measured.

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 tracer gas pressure generator (in the vacuum chamber) (see Figure 3);

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

— adjust and calibrate the leak detector according to EN 13185:2001, 9.1.1;

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

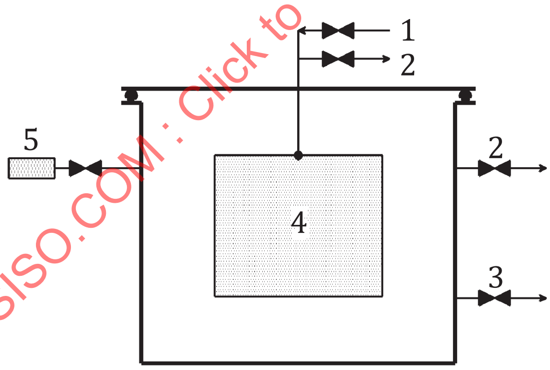
— adjust the test pressure in the component;

— measure the leak signal of the component;

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

— calculate the leak level according to the formula given 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 (P)

2 vacuum

3 mass spectrometric leak detector

4 test object

5 calibrated leak

Figure 3 — Principle of tightness control — Tracer gas

7.4.2.2 Alternative test methods

Two alternative methods may be applied.

a) Alternative method 1

The control by pressure technique by accumulation, in accordance with EN 13185:2001, 10.4.1, could be a method to measure the leak rate of the component.

b) Alternative method 2

Bubble test methods shown in Figure 4 can be acceptable for tightness control level B, provided that the method is capable to measure the actual leakage rate. The bubble test methods shall be carried out in accordance with 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:

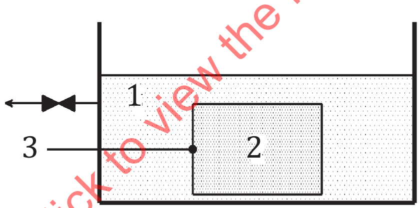
1) the test object shall be subjected to an internal air pressure = *PS* (maximum allowable pressure). Reduced pressure is not acceptable;

2) the test object shall be immersed in water;

3) the test object shall be exposed to atmospheric pressure;

4) the test shall be performed at normal ambient temperature;

5) 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 Test samples

All joints tested shall be tested in the final form as the customer receives the part.

All joints shall be submitted to the tests as indicated in Table 2.

7.5.2 Torque

Tube joints shall be tested both at the minimum torque, K_{min}, and the maximum torque, K_{max}, defined in Table 6.

Table 6 — Torque for the test, K_{min} and K_{max}

	K_{min}	K_{max}
IF D_K > or = 20 %	K_{min}	K_{max}
IF 20 % > D_K	0,8 × K_{ave}	1,2 × K_{ave}

7.5.3 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 6;

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

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

7.5.4 Requirements for hermetically sealed joints

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

NOTE Special tools are other than screw-drivers, parallel wrenches, simple gripping tool, etc.

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

7.6 Pressure-temperature vibration tests (PTV)

7.6.1 General

For pressure-temperature vibration tests, method 1 or method 2 as described as follows shall be applied.

The test on 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 level.

7.6.2 Samples

For the combined cycle test, the number of samples is determined based on tightness control level according to Table 7.

Table 7 — 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) regulated enclosure for environment tests, able to maintain temperatures varying regularly between t_{min} and t_{max};

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

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

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

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

f) temperature sensor capable to monitor 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 weight 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) 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 test, 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

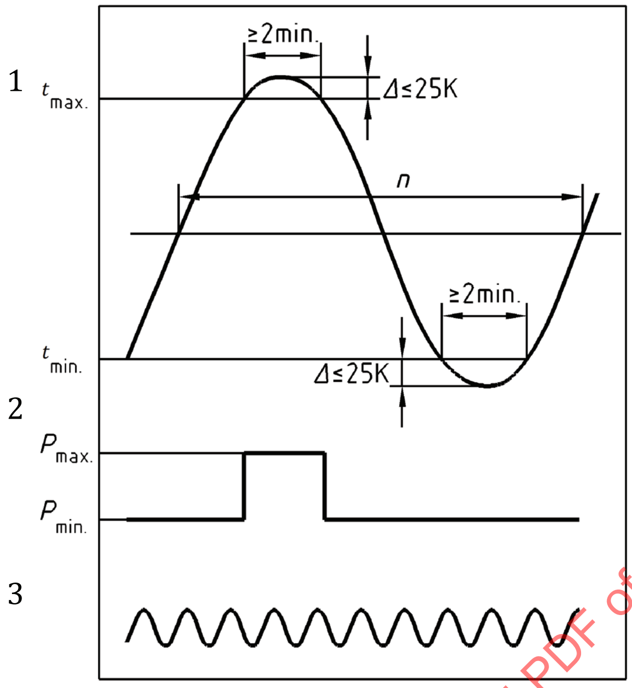
The samples (joints fitted on a tube) shall be submitted to a defined number n of cycles of temperature and pressure, between maximal values (t_{max}, P_{max}) and minimal values (t_{min}, P_{min}).

The test characteristics shall be applied to the components according to Table 8.

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

The pressure shall be held for 2 min.

Principle PTV-test method 1



Key

1 temperature
2 pressure
3 vibration

Figure 5 — Temperature-pressure cycle test

Table 8 — Test parameters

Parameters	Value
n	160
n_{total}	5 × 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 or +10 °C or 140 °C if this is not specified
P_{min}	Atmospheric pressure
P_{max}	For safety valves, P_{max} = 0,9 × P_{set}
	For others components, 1,0 × PS[a]
f	200 Hz
s	0,012 mm
L	200 mm

[a] 1,0 × PS is proposed because of safety issue for test on big component.

The test fluid shall not be a liquid.

7.6.4.2 Procedure

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

7.6.4.2.2 Fix the test parameters (n, t_{max}, t_{min}, P_{max}, P_{min}, f, s) in accordance with Table 8.

7.6.4.2.3 Submit the test items to the test pressure according to Table 8.

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 items in the climatic enclosure and submit them to n pressure and temperature cycles in accordance with Figure 5 and Table 8. Simultaneously submit the component assembly to the vibration 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 operation simulation if it is needed according to Table 1 or 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 5.

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

7.6.5.1 General

In contrast with method 1, the combined pressure-temperature cycle test shall be performed separately from the vibration test.

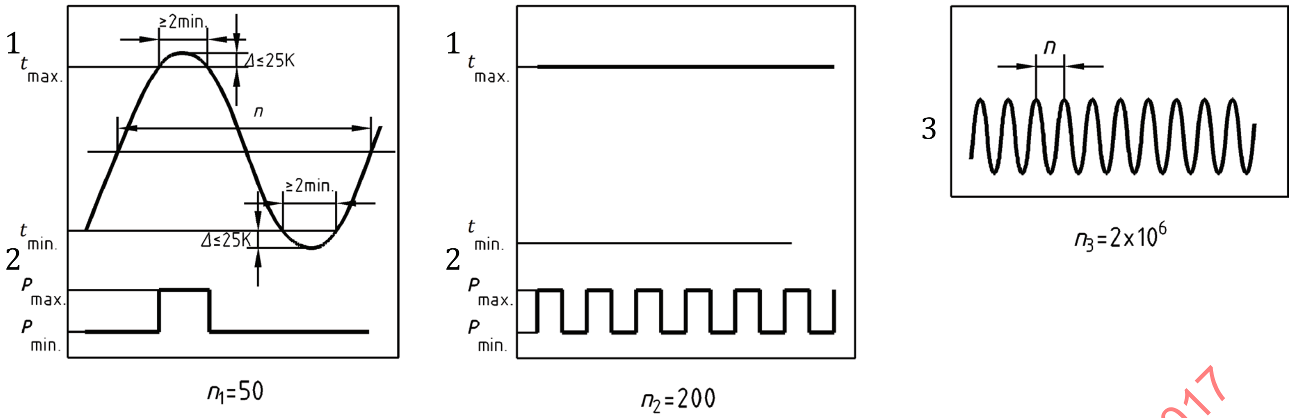
7.6.5.2 Requirements for the combined pressure-temperature cycle test

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 to be applied to the components are defined in Table 9.

A typical temperature-pressure cycle is given in Figure 6.

NOTE The shape of the curve is theoretical.



Key

1 temperature

2 pressure

3 vibration

Figure 6 — Temperature-pressure cycle test with a separate vibration test

Table 9 — Test parameters

Parameters	Value
n_1 n_2 n_3	50 200 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 or +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 issue for test on big component. 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 items on a test-bed in accordance with the instructions of the manufacturer.

7.6.5.3.2 Fix the test parameters (n_1, n_2, t_{max}, t_{min}, P_{max}, P_{min}) in accordance with Table 9.

7.6.5.3.3 Submit the test items to the test pressure according to Table 9.

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 Execute the operation simulation according to 7.7.

7.6.5.3.7 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 9.

7.6.5.4 Vibration test

7.6.5.4.1 General

The component and joints shall be submitted to a vibration test performing n_3 cycles. 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 10.

The component samples shall be submitted to the specifications as given in Table 11 and Table 13.

7.6.5.4.3 Test of joint

The test samples shall be mounted on the components 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.

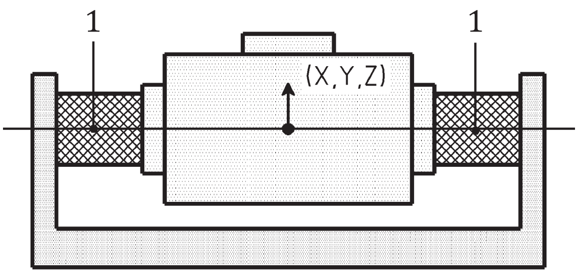
The frequency measurement shall be made on the component.

Table 10 — Test parameters for joints

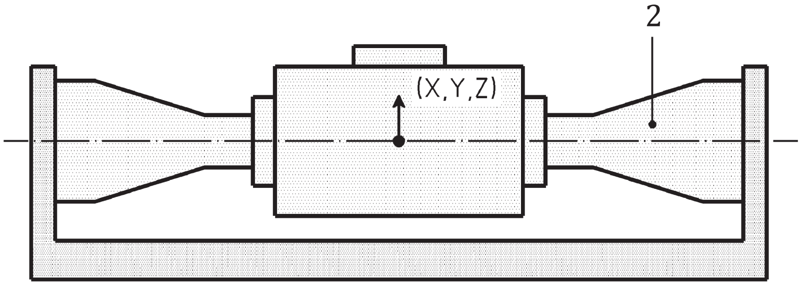
Pipe diameter *DN*	Length *L* mm	Displacement *s* mm	Frequency Hz	Number of excitation
0 ≤ *DN* < 10	200	0,30	≤200	2 000 000
10 ≤ *DN* < 20		0,25		2 000 000
20 ≤ *DN* < 30		0,20		2 000 000
30 ≤ *DN* ≤ 50		0,15		2 000 000

7.6.5.4.4 Examples of component

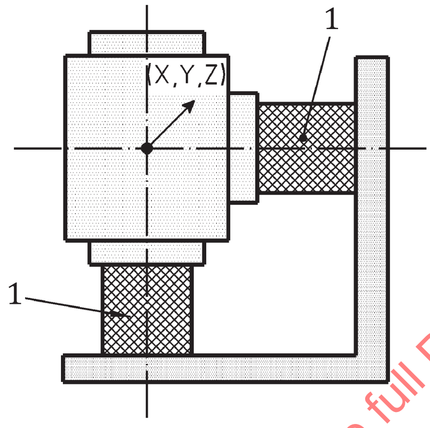
Examples of vibration assembly for component are given in Figure 7.



a)



b)



c)

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.

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

Table 11 — Test parameters for component test 1

Parameters	Value
Frequency range	10 Hz to 200 Hz
Displacement (peak-peak)	10 Hz = 3,48 mm to 200 Hz = 0,008 7 mm
Acceleration	0,7 g
Sweep speed	1 octave/min
Number of excitation directions[a]	3 (x-y-z)
Duration	2 h in each direction (x-y-z)
[a] Numbers of excitation directions can be reduced to two on symmetric shaped components.	

b) Component test 2

Random testing requirement covers installations near the source of vibration.

Test parameters of components are given in Table 13.

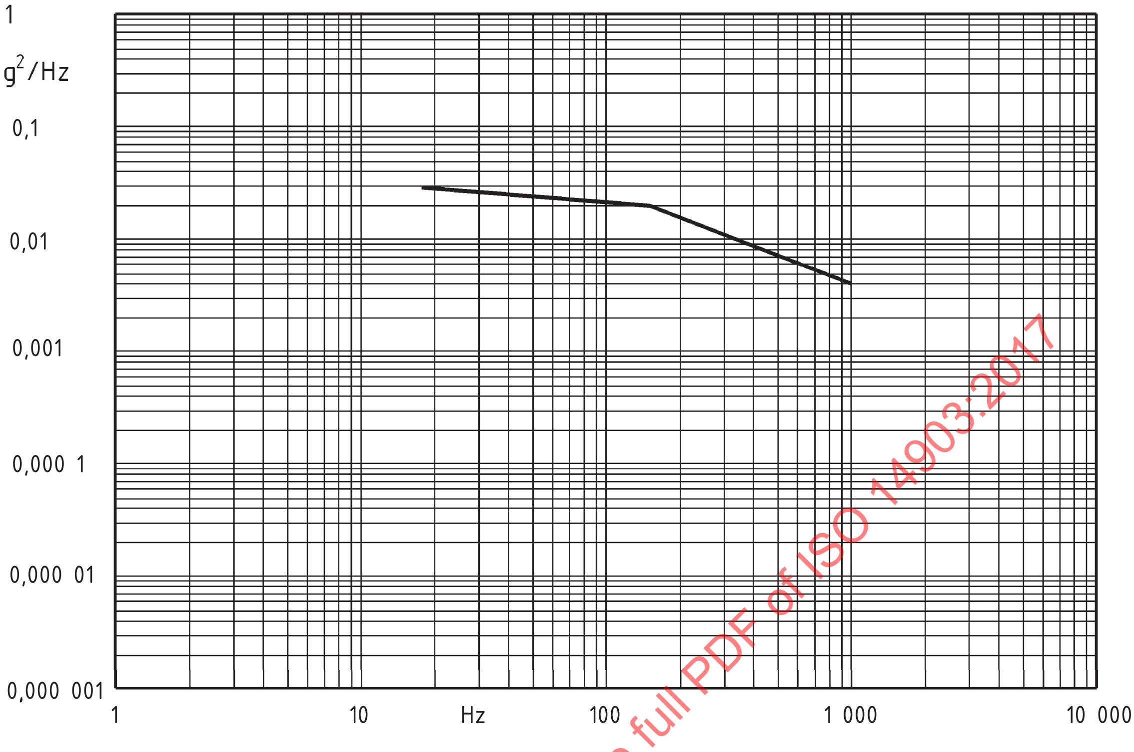


Figure 8 — Power Spectral Density

Table 12 — PSD values

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

Table 13 — Test parameters for component test 2

Parameters	Value
Displacement (max.)	2,4 mm peak-peak
Acceleration (RMS)	3,1 g

Testing is carried out in accordance with IEC 60068-2-64.

7.6.5.4.6 Procedure

7.6.5.4.6.1 Before testing, execute the operation simulation according to 7.7.

7.6.5.4.6.2 Fit the test items on a test-bed in accordance with the instructions of the manufacturer.

7.6.5.4.6.3 Fix the test parameters for components in accordance with Table 11 and Table 13.

7.6.5.4.6.4 Submit the joints and components to the vibration test according to the numbers 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 5.

7.7 Operation simulation

The operation of maintenance and operating shall be carried out according to Table 14.

Table 14 — List of operations

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

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

The test shall be performed on three samples.

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

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

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

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

a) Put the sample into a vacuum test chamber.

  1) Fill the test chamber with water so all parts of the joint are submerged under water.

  2) Reduce the pressure in the test chamber to −500 (−100) mbar, and maintain it for at least 10 min.

  3) Increase the pressure in the test chamber to atmospheric pressure, to fill gaps in the joint with water.

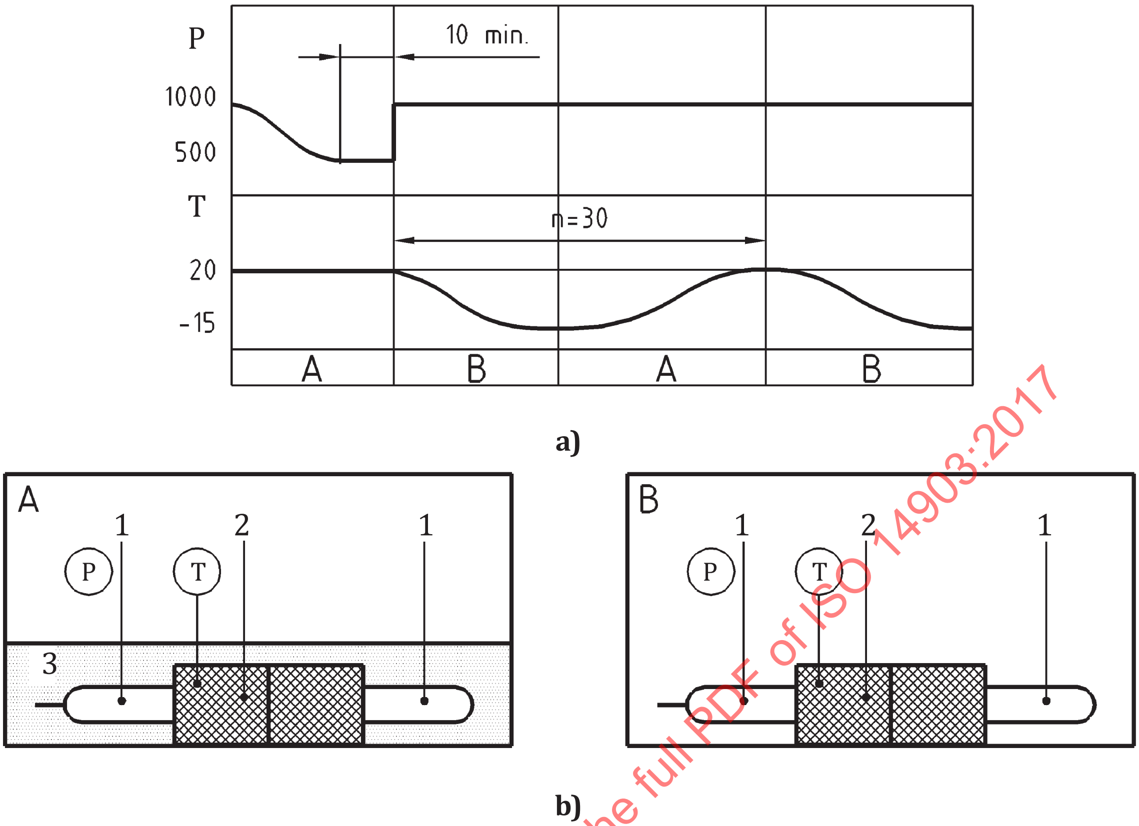
b) Remove the water from the test chamber.

c) Reduce the temperature until the temperature of 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 min so that the ice in gaps melts.

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

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



Key

1 pipe
2 joint
3 water
P pressure
T temperature

Figure 9 — Freezing test

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 appropriate standard withstanding at least five times the design pressure. Pressure shall be increased until it reaches five times of the design pressure. Pressure shall be increased gradually where the increase may be faster at the beginning and shall be reduced in the relevant pressure range accordingly, so that the target-pressure can be reached clearly. Assembly shall withstand at least five times of the design pressure for 1 min.

For the test on joints where it is not feasible to use a stronger tube since the tube is an essential part of the joint, the test pressure should be the strength-pressure of the tube.

The fluid used for this test shall be liquid such as oil, water, etc. The liquid shall be totally removed before the tightness test.

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 be less than 0,2 kPa. The effect of temperature change on joint shall be taken into account.

NOTE Temperature changes can 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, content of the different refrigerant components shall fulfil the requirement given in Table 15.

Table 15 — 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 weight %.

7.11.3 Test specimens

The following test conditions need to be fulfilled:

— minimum of five test pieces is used for testing;

— the general requirements for test items shall comply with ISO 1817 rubber seal materials and ISO 175 for thermoplastic seal materials.

7.11.4 Test setup parameters

The following conditions need to be fulfilled:

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

— the test chamber is to 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 is 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.

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 Test procedure

With respect to chemical compatibility, the significant measures for evaluation of possible suitability of the test material inserted in the component are measured of hardness, volume and weight and visual observations (Blisters and Tearing).

The following procedure shall be applied (refer to Figure 10):

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

— the test pieces are placed in the test chamber in such a 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 ambient temperature and the test pieces are taken out from the test chamber;

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

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

NOTE 1 Elastomers tested with CO_2, can accumulate significant amount of CO_2. The CO_2 cannot escape immediately when the test items are exposed to atmospheric pressure (de-gassing). Thus, it can create an immediate volume change larger than 25 %. Provided that no surface damage is made, volume change above 25 % is acceptable for CO_2.

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

NOTE 2 For recovery, reuse and disposal of refrigerants, see ISO 5149-4.

7.11.6 Pass/fail criteria for sealing elements

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

Maximal acceptable limits given in Table 16 shall be met.

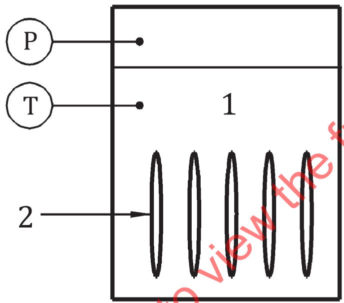
Table 16 — Maximal acceptable limit according to test

Test	Maximal acceptable limit
Hardness change (IRHD)	
Wet[a]	±15 IRHD
Dry[b]	±10 IRHD
Volume change (%)	
Wet	−5 % to + 25 %
Dry	±10 %
Weight (%)	
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 weight prior to testing.

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 can be required.



Key

1 liquid refrigerant

2 test items

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 ensured by testing.

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

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

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

The test medium shall be water. Before the tightness test, water shall be totally removed.

8 Test report

The test report shall include the following information:

a) a reference to this document, ISO 14903;

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:

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

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 Clause 8 f) shall be provided upon request of purchaser of the joint and/or the component.

Annex A
(informative)

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:

— leaking fluid shall be in the gaseous state;

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

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

— ideal gas equation shall be applied;

— Poiseuille equation [given in Formula (A.1)] for gaseous flow in a long straight tube having circular cross section is used as model.

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

where

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

d is the diameter of the hole, expressed in metres (m);

η is the dynamic viscosity, expressed in pascal seconds (Pa·s);

l is the length of the hole, expressed in metres (m);

p_1 is the inlet pressure, expressed in pascals (Pa);

p_2 is the outlet pressure, expressed in pascals (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, Formula (A.1) simplifies to Formula (A.2):

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

where

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

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 Formula (A.4) based on Formula (A.2):

$$\frac{Q1}{Q2} = \frac{\eta 2}{\eta 1} \times \frac{(p1)_1^2 - (p1)_2^2}{(p2)_1^2 - (p2)_2^2} \tag{A.4}$$

Considering change of viscosity only, Formula (A.4) simplifies to Formula (A.5):

$$\frac{Q1}{Q2} = \frac{\eta 2}{\eta 1} \tag{A.5}$$

where

$Q1$ is the leak rate of first gas, expressed in millibar litres per second (mbar l/s);

$Q2$ is the leak rate of second gas, expressed in millibar litres per second (mbar l/s);

$n1$ is the viscosity of first gas, expressed in pascal seconds (Pa s);

$n2$ is the viscosity of second gas, expressed in pascal seconds (Pa s).

Considering change of pressures, only Formula (A.4) simplifies to Formula (A.6):

$$\frac{Q1}{Q2} = \frac{(p1)_1^2 - (p1)_2^2}{(p2)_1^2 - (p2)_2^2} \tag{A.6}$$

where

$(p1)_1$ is the inlet pressure of first gas, expressed in pascals (Pa);

$(p1)_2$ is the outlet pressure of first gas, expressed in pascals (Pa);

$(p2)_1$ is the inlet pressure of second gas, expressed in pascals (Pa);

$(p2)_2$ outlet pressure of second gas, expressed in pascals (Pa).

NOTE In Formulae (A.3), (A.4) and (A.6), changing dimensions of all Qs (for instance, from mbar l/s to Pa m^3/s) have no consequence for the numerical result. Likewise, changing of dimensions of all ps (for instance, from Pa to bar) have 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 is 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 Formulae (A.1) to (A.6) can be converted to mass flow by means of the ideal gas equation given in Formula (A.7):

$$p \times V = n \times R \times T \tag{A.7}$$

where

p is the pressure, expressed in pascals (Pa);

V is the volume, expressed in cubic metres (m^3);

n is the amount of substance, expressed in moles (mol);

R 8,314 J/(mol·K) (universal gas constant);

T is the temperature, expressed in Kelvin (K).

Dividing both sides of Formula (A.7) by time and converting amount of substance to mass gives Formula (A.8):

$$\frac{p \times V}{t} = \frac{m}{t} \times \frac{R \times T}{M} \tag{A.8}$$

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 $\frac{Q}{10} = \frac{p \times V}{t}$ = flow (leak rate) Pa m³/s and $\Theta = \frac{m}{t}$ = flow (leak rate) kg/s, Formula (A.8) can be transformed to Formula (A.9):

$$\Theta = \frac{Q}{10} \times \frac{M}{R \times T} \times 31{,}536 \times 10^9 \tag{A.9}$$

where

Θ is the mass flow (leak rate), expressed in grams per year (g/a);

$31{,}536 \times 10^9$ is the unit conversion factor: 1 kg/s = $31{,}536 \times 10^9$ g/a.

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