BS EN 16084:2011

BSI Standards Publication

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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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

Kälteanlangen und Wärmepumpen - Qualifizierung der Dichtheit der Bauteile und Verbindungen

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Foreword

This document (EN 16084:2011) has been prepared by Technical Committee CEN/TC 182 “Refrigerating systems, safety and environmental requirements”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2011, and conflicting national standards shall be withdrawn at the latest by October 2011.

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1 Scope

This European 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 EN 378. 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 EN 1736. Metal flexible piping are covered by this standard.

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 characterise 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 European Standard specifies additional requirements for mechanical joints that can be recognised as hermetically sealed joints.

2 Normative references

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

EN 378-1:2008, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 1: Basic requirements, definitions, classification and selection criteria*

EN 1330-8:1998, *Non-destructive testing — Terminology — Part 8: Terms used in leak tightness testing*

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

EN 1736, *Refrigerating systems and heat pumps — Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes — Requirements, design and installation*

EN 12284, *Refrigerating systems and heat pumps — Valves — Requirements, testing and marking*

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

EN 13134, *Brazing — Procedure approval*

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

EN 60068-2-6, *Environmental testing — Part 2-6: Tests — Tests Fc: Vibration (sinusoidal) (IEC 60068-2-6:2007)*

EN 60068-2-64, *Environmental testing — Part 2-64: Tests — Test Fh: Vibration, broadband random and guidance (IEC 60068-2-64:2008)*

EN 60335-2-34, *Household and similar electrical appliances — Safety — Part 2-34: Particular requirements for motor-compressors (IEC 60335-2-34:2002)*

EN ISO 175, *Plastics — Methods of test for the determination of the effects of immersion in liquid chemicals (ISO 175:2010)*

ISO 1817, *Rubber, vulcanized — Determination of the effect of liquids*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1330-8:1998 and EN 378-1:2008 and the following apply.

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

NOTE 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 The volume flow rate is expressed in pascal cubic metres per second (Pa·m³/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 Sealed systems as defined in EN 378-1:2008 equal 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

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

[Adapted from the Pressure Equipment Directive 97/23/EC]

3.6
reusable joint
joint made without replacing the sealing material in general procedure

NOTE In some cases the tube is used as sealing material (e.g. flared joint).

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

— steel group;
— aluminium and aluminium alloy group; or
— copper group

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

4 Symbols

Symbols used in this standard are given in Table 1.

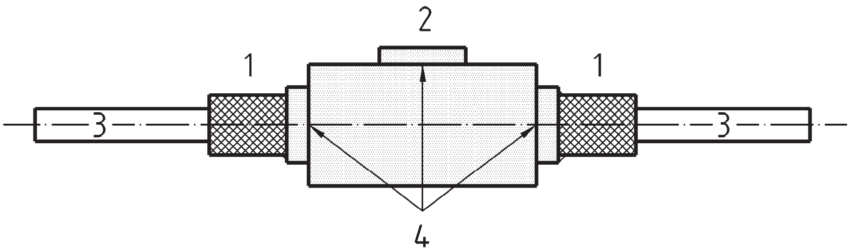
Table 1 — Symbols

Symbol	Denomination	Unit
DK_{rel}	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 rate	$Pa \cdot m^3/s$
Q_m	Mass flow rate	g/yr
s	Vibration displacement (peak to peak value)	mm
T_{max}	Maximal temperature of cycle	°C
T_{min}	Minimal temperature of cycle	°C

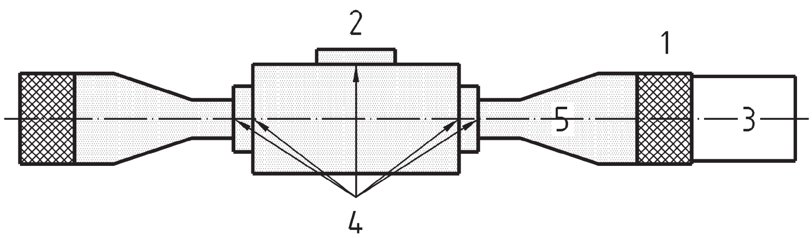
5 Test requirements

The required tests to be applied to component bodies and joint used in refrigerating systems and heat pumps are given in Table 2 and in Table 3.

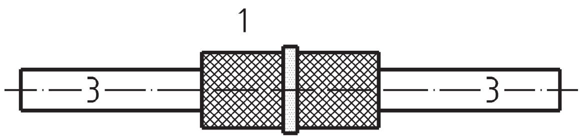
The following figures show in Figure 1 the principle of a component and a joint and their corresponding requirements in Table 2 or Table 3.



a) According to Table 2



b) According to Table 2



c) According to 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 may be 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 component bodies

Components (including valves):	**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	
							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

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

Table 2 *(continued)*

<table>
<tr><th rowspan="3">Components (including valves):</th><th colspan="8">Requirements</th></tr>
<tr><th rowspan="2">Tightness test
7.4</th><th rowspan="2">PTV- test (pressure-temperature -vibration)
7.6</th><th rowspan="2">Operation simulation
7.7</th><th rowspan="2">Freezing test
7.8</th><th rowspan="2">Chemical compatibility with materials
7.11</th><th rowspan="2">Vacuum test
7.10</th><th colspan="2">Additional test for hermetically sealed</th></tr>
<tr><th>Pressure test
7.9</th><th>Fatigue test
7.12</th></tr>
<tr><td>Capped valves and capped service ports for hermetically sealed systems</td><td>YES</td><td>YES</td><td>YES</td><td>YES
if operating temperature below 0 °C</td><td>YES
if non metallic parts</td><td>YES</td><td>YES</td><td>YES</td></tr>
<tr><td>Safety valves</td><td>YES</td><td>YES</td><td>NO</td><td>NO</td><td>YES
if non metallic parts</td><td>Not applicable</td><td>Not applicable</td><td>Not applicable</td></tr>
<tr><td>Flexible piping</td><td colspan="8">Test according to EN 1736</td></tr>
<tr><td colspan="9">By exception compressors that comply with the requirements of EN 12693 or EN 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 Other qualifications for this chemical compatibility done according to other standards are equivalent.</td></tr>
</table>

Table 3 — Requirements for the joining of components

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	
							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 which have their tightness control level qualified as A1 or A2 as per Table 4 or Table 5. 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 components, joints and part shall pass the tightness test before the other tests are executed. The different tests are shown in Figure 2.

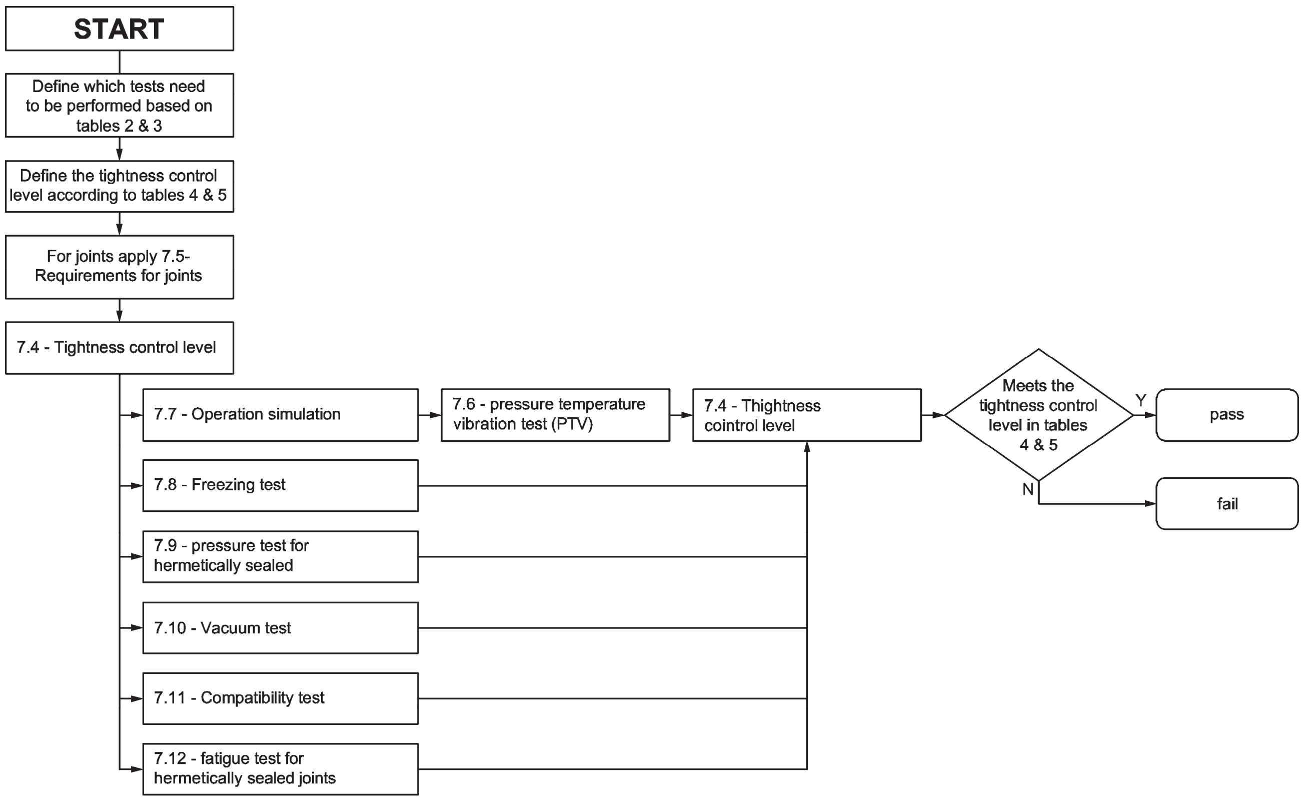


Figure 2 — Test procedure

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 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 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.

For pressure relief devices	P	$= 0{,}9 \times P_{set}$ (+ 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 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 4. These are levels for each individual joint.

Table 4 — 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 5. These are levels 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
Closed components	> 2,0 up to 5,0	B2

The required tightness control level is stated in Table 5. The manufacturer can choose more stringent tightness control level if adequate.

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

Component type	**Tightness control level**	**$Q_{he\text{-}ref}$ helium reference leak +20 °C, 10 bar** Pa·m³/s	**Equivalent air leak ($Q_{air\text{-}ref}$) +20 °C, 10 bar** Pa·m³/s	**Equivalent iso-butane leak (m_{R600a}) +20 °C, 10 bar** 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 × 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 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 Table 4 and Table 5 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 pressurised with the tracer gas and placed in the vacuum chamber which measure the sum of all the component's leak..

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 drawing below;

— 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;

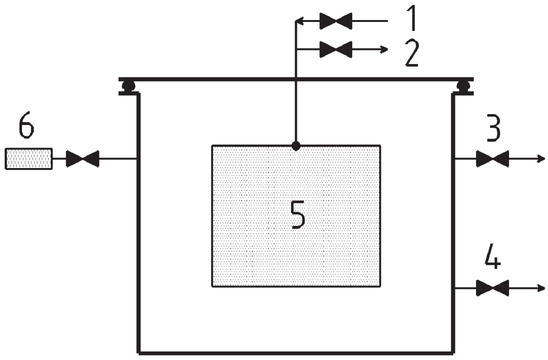
— adjust the test pressure in the component;

— 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 (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.

a) Alternative method 1:

The control by pressure technique by accumulation, in accordance with 10.4.1 of EN 13185:2001, 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:

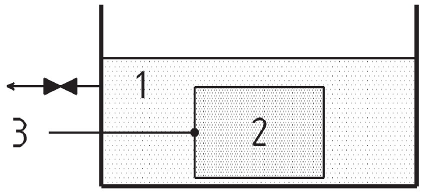
1) the test object shall be subjected to an internal air pressure = PS (maximum allowable pressure). Reduced pressure is not acceptable;

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 3.

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 7.

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

	K_{min}	K_{max}
IF DK_{rel} > or = 20 %	K_{min}	K_{max}
IF 20 % > DK_{rel}	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 7;

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 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) 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 assure 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

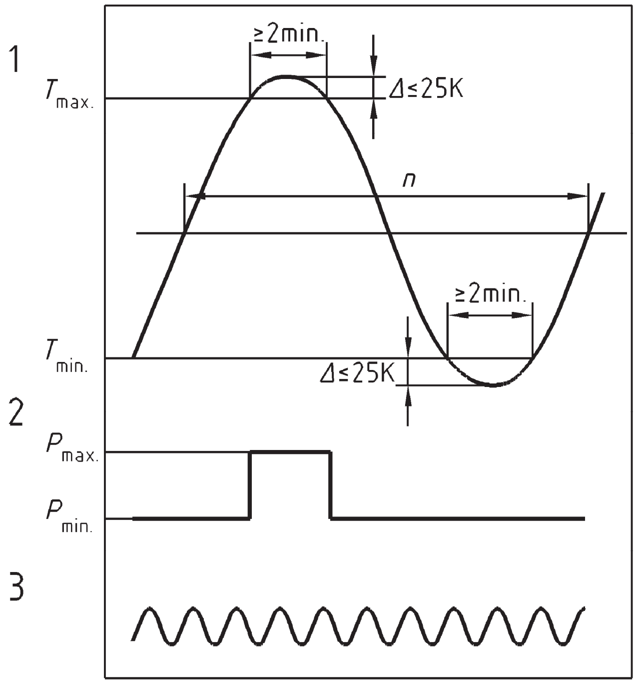
7.6.4.1 General

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 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 × 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 × 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 9.

7.6.4.2.3 Submit the test items 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 items in the climatic enclosure and submit them to n pressure and temperature cycles in accordance with Figure 5 and Table 9. 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 2 or 3, 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

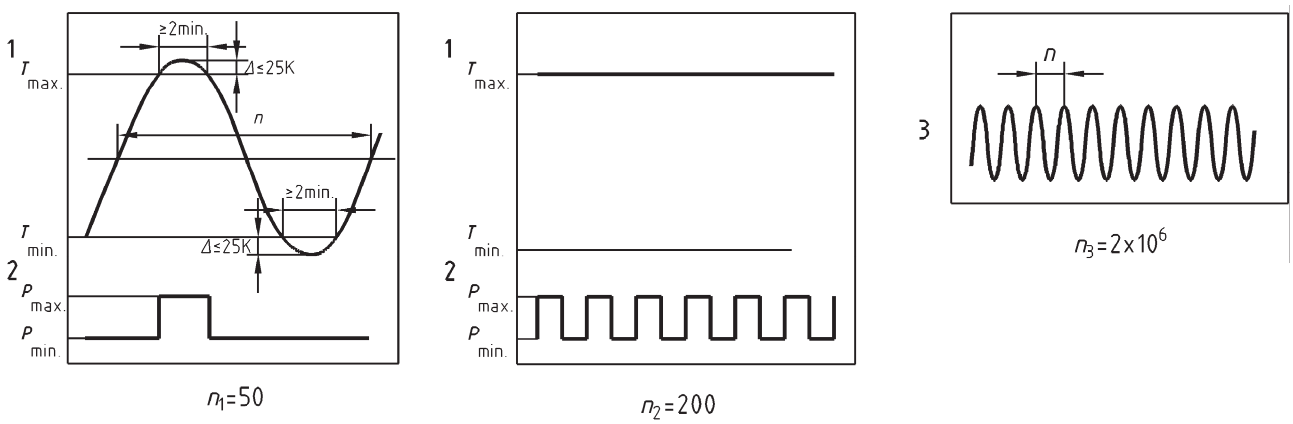
In contrast with method 1, the combined pressure-temperature cycle test shall be performed separately from the vibration test.

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 10.

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



Key

1 temperature
2 pressure
3 vibration

Figure 6 — 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 × 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 10.

7.6.5.3.3 Submit the test items 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 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 10.

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

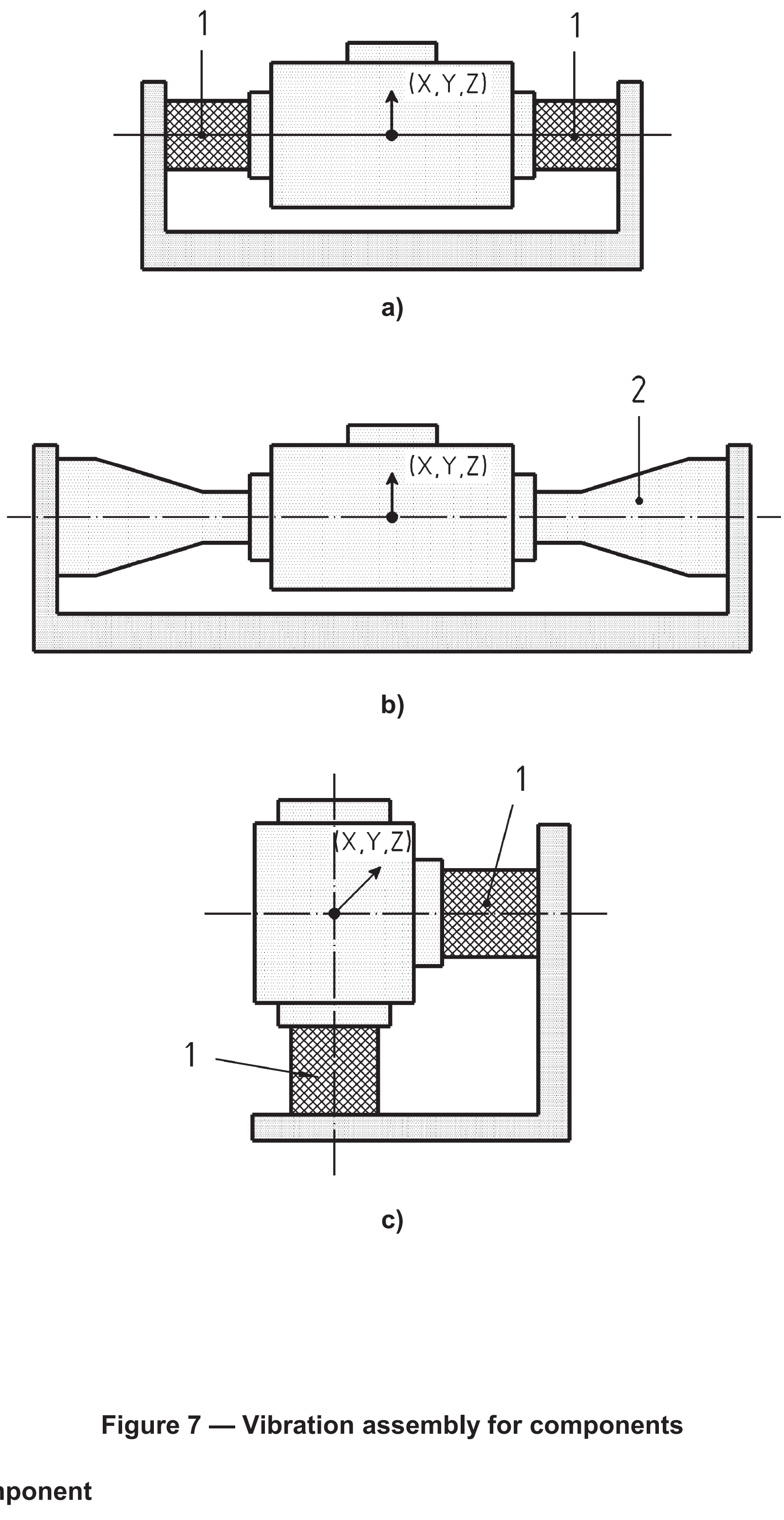
The test samples shall be mounted as shown in Annex B in accordance with the number of joints to be tested and with the dimension of the climatic enclosure in which the tests are carried out.

Table 11 — Test parameters for joints

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

7.6.5.4.4 Examples of component

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



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 EN 60068-2-6.

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

Table 12 — Test parameters for component test 1

Parameters	Value
Frequency range	10 Hz to 200 Hz
Displacement (peak-peak)	10 Hz = 3,48 mm to 200Hz = 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 14.

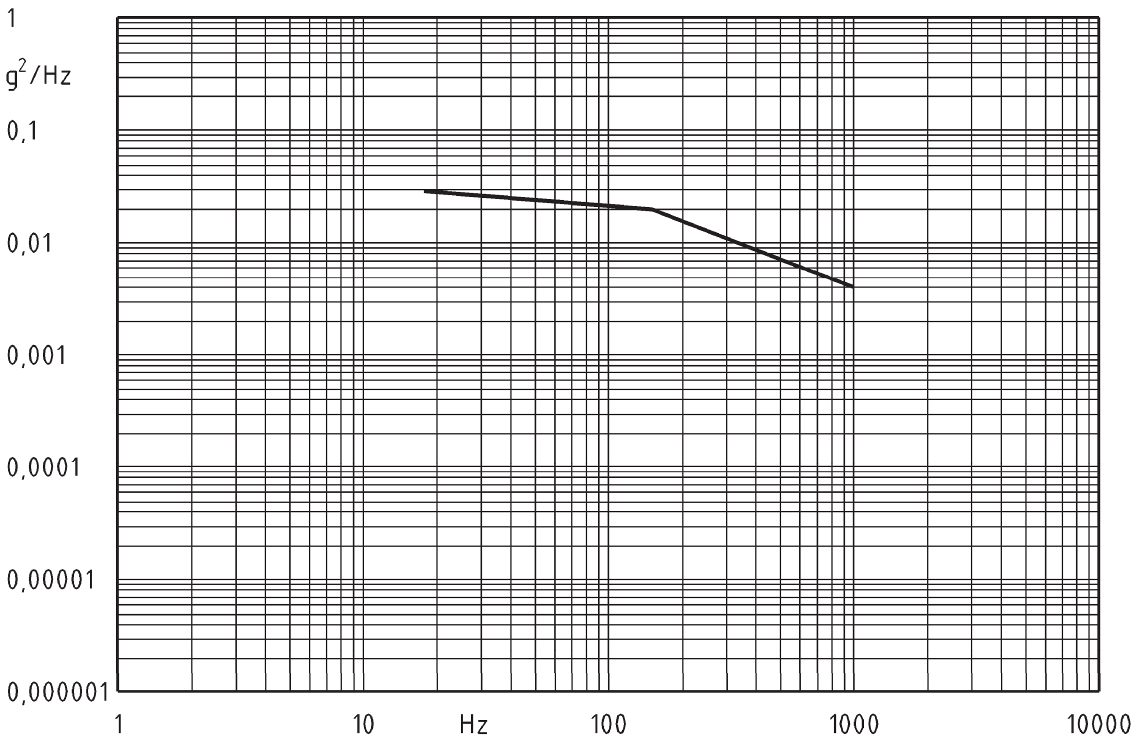


Figure 8 — Power Spectral Density

Table 13 — PSD values

Power Spectral Density (PSD)	
Hz	g²/Hz
18	0,03
150	0,02
1 000	0,004

Table 14 — 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 EN 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 joints in accordance with Table 11.

7.6.5.4.6.4 Fix the test parameters for components in accordance with Table 12 and Table 14.

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

7.6.5.4.6.6 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)	Five times before each n cycle, totally 25 operations (open and close)	Ten times before n_1, ten times before n_2 and five times before n_3, totally 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, totally 25 operations (disassembly/reassembly)	Ten times before n_1, ten times before n_2 and five times before n_3, totally 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 five samples.

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;

  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 $-500\,^{0}_{-100}$ 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;

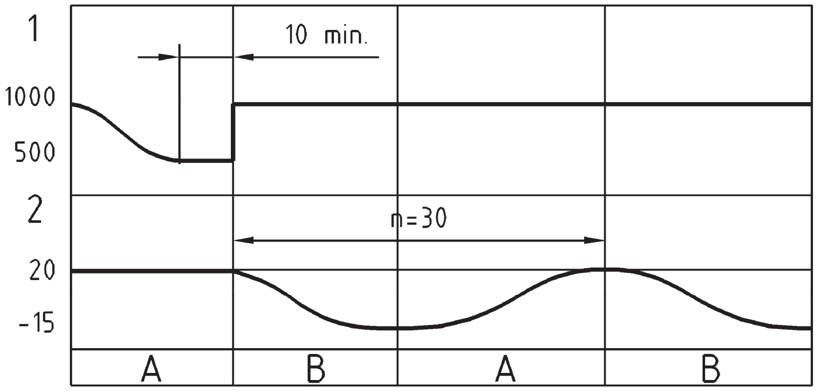
b) Remove the water from the test chamber;

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.

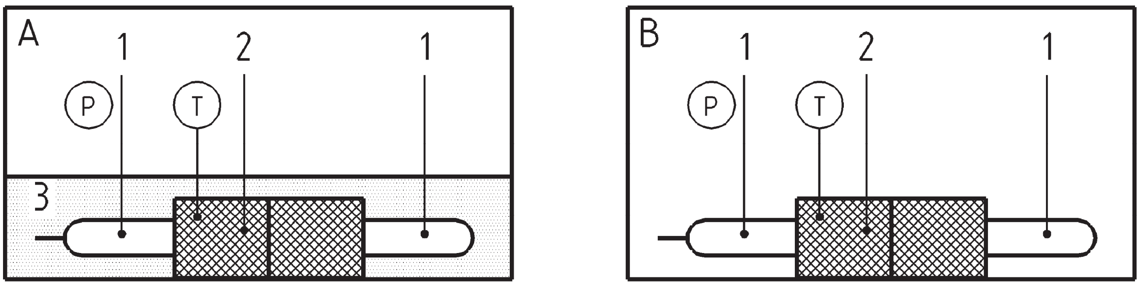
Repeat the process b)-c)-d) 30 times.

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



a)

Key
1 pressure
2 temperature



b)

Key
1 pipe
2 joint
3 water

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 six times the design pressure. Pressure shall be increased until reaches six times of design pressure. Pressure shall be increased gradually such as less than 10 bar/min. Assembly shall withstand at least six times of design pressure for 1 min.

NOTE 1 The fluid used for this test should be liquid such as oil, water, etc.

NOTE 2 Other joints should satisfy requirements of EN 378-2.

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 0,02 kPa. The effect of temperature change on joint shall be taken into account.

NOTE 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 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 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 EN 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.

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 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 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 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 EN 378-4.

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 17 shall be met.

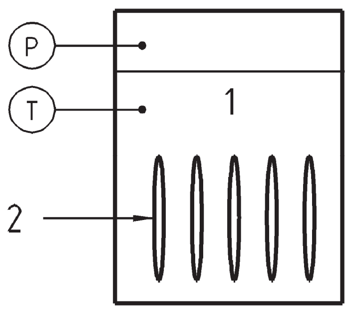
Table 17 — Maximal acceptable limit according to test

Test	Maximal acceptable limit
Hardness change (IRHD)	
Wet[a]	± 15 IRHD
Dry[b]	± 10 IRHD
Volume change (%)	
Wet	- 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 may 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 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 cycles/min and 60 cycles/min. Total of pressure cycles shall be 250 000 times or more.

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

8 Test report

The test report shall include the following information:

a) reference to this 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:

NOTE The user can be an installer, a manufacturer, a maintenance provider and -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 8, f) shall be provided upon request of purchaser of the joint and/or the component.

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:

- 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 for gaseous flow in a long straight tube having circular cross section is used as model.

The Poiseuille equation:

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

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 Equation (A.1) simplifies to the form:

$$Q = K \times \frac{p_1^2 - p_2^2}{\eta} \qquad \text{(A.2)}$$

where

$$K = \frac{\pi \times d^4 \times 10}{256 \times l} \qquad \text{(A.3)}$$

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):

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

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

$$\frac{Q1}{Q2} = \frac{\eta 2}{\eta 1}$$

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);

$\eta 1$ is the viscosity of first gas, expressed in pascal seconds (Pa·s);

$\eta 2$ is the viscosity of second gas, expressed in pascal seconds (Pa·s);

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

$$\frac{Q1}{Q2} = \frac{(p1)_1^2 - (p1)_2^2}{(p2)_1^2 - (p2)_2^2} \quad \text{(A.5)}$$

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 Equations (A.3), (A.4) and (A.5) changing dimensions of all Q's (for instance from mbar·l/s to Pa·m^3/s) have no consequence for the numerical result. Likewise changing of dimensions of all p's (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 Equations (A.1) to (A.5) can be converted to mass flow by means of the ideal gas equation.

The ideal gas equation:

$$p \times V = n \times R \times T \quad \text{(A.6)}$$

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 Kelvins (K).

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

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

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 $\frac{Q}{10} = \frac{p \times V}{t}$ = flow (leak rate) *Pa·m³/s* and $\Theta = \frac{m}{t}$ = flow (leak rate) *kg/s,* Equation (A.7) can be transformed to:

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

where

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

$31{,}536\times10^9$ is the unit conversion factor: 1 kg/s = $31{,}536\times10^9$ g/year.

Values of dynamic viscosity and molar mass for some gases are presented in the table below. 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).

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
NOTE For R22 see national regulations		

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

No bubble shall appear in period of 1 min at a pressure identical to PS, in accordance with EN 12284.

In order to calculate a leak rate in volumetric or mass units some assumptions about the statement in EN 12284 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:

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

NOTE 2 By model calculations it can be shown that a 1,68×10^{-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 test with air and a water tank cannot be used to detect leaks smaller than approximately 1×10^{-4} mbar·l/s.

EXAMPLE See Figure B.1.

A valve has a *PS* (maximum working pressure) of 40 bar and a maximum allowed leak rate as specified in EN 12284. 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.

The maximum air leak is 1,68×10^{-5} mbar·l/s at 40 bar inside pressure.

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

$$Q1 = Q2 \times \frac{\eta_2}{\eta_1} \frac{(p1)_1^2 - (p1)_2^2}{(p2)_1^2 - (p2)_2^2} \quad \text{(A.10)}$$

letting

$Q2$ is equal to 1,68×10^{-5} mbar·l/s (air);

$Q1$ 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);

$(p1)_1$ is the helium pressure in valve, expressed in bars (bar);

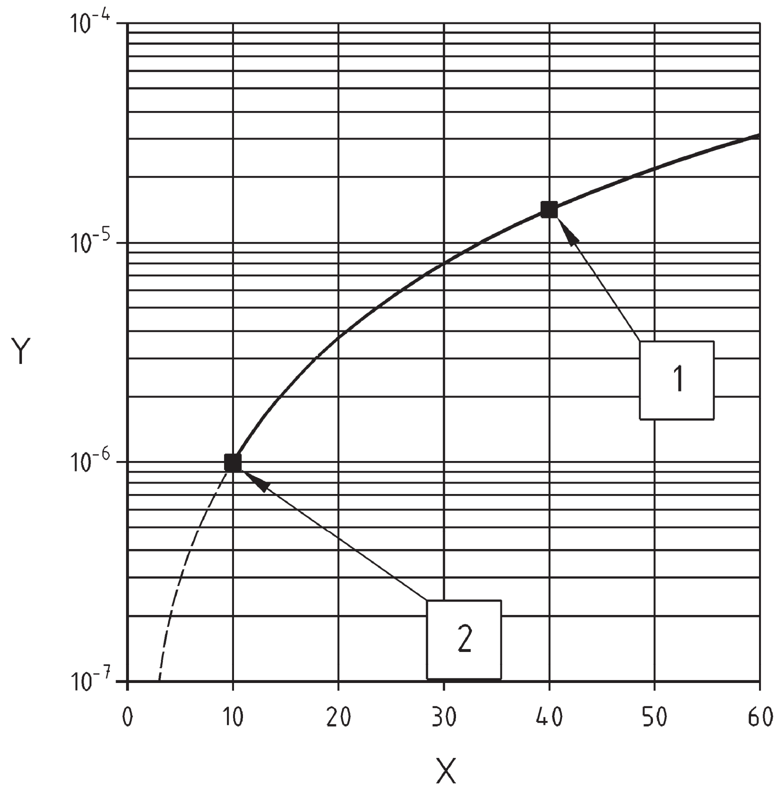
$(p1)_2$ is the helium pressure outside valve, expressed in bars (bar);

$(p2)_1$ is the air pressure in valve, expressed in bars (bar);

$(p2)_2$ is the air pressure outside valve, expressed in bars (bar).

Setting $(p1)_2 = (p2)_2 = 0$ and inserting in Equation (A.10) Q1 can be calculated:

$$Q1 = 1{,}68 \times 10^{-5} \times \frac{18 \times 10^{-6}}{19{,}3 \times 10^{-6}} \times \frac{10^2}{40^2} = 0{,}98 \times 10^{-7} \sim 1 \times 10^{-6} \text{ mbar·l/s (equivalent tightness control level)} \quad \text{(A.11)}$$



Key

X pressure in bars (bar)

Y tightness control level

1 actual test pressure – tightness control level

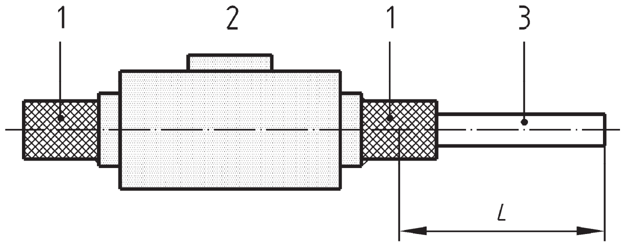
2 reference tightness control level (10 bar)

Figure A.1 — Equivalent tightness control level

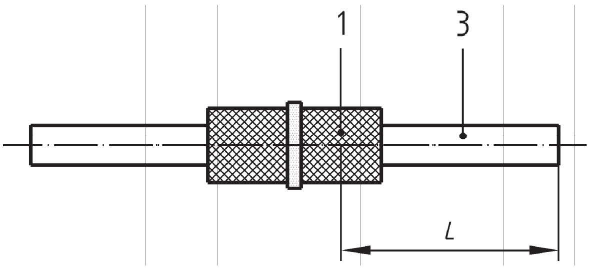
Annex B
(informative)

Test arrangements

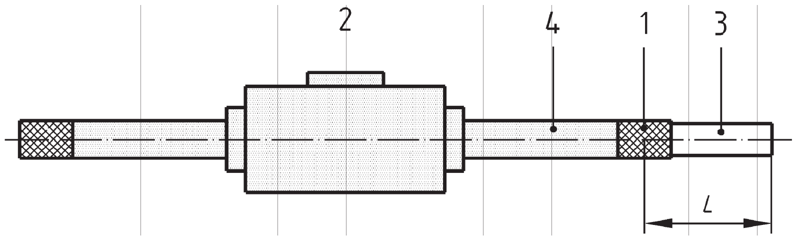
The samples are fixed according to the manufacturer's instructions. Otherwise, the main body of the sample should be fixed as close as possible to the joint.



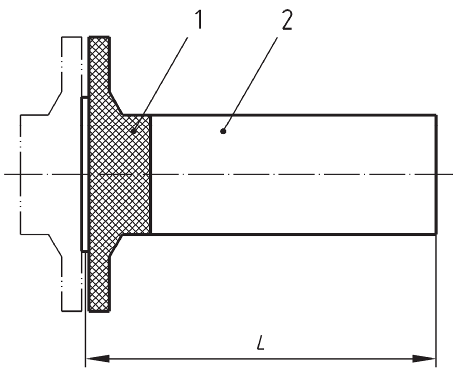
a) Component (ex valve)



b) Brazed joint



c) Component (ex 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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