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Vacuum technology — Valves — Leak test

Technique du vide — Vannes à vide — Essai d'étanchéité des vannes à vide

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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

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

ISO 27895 was prepared by Technical Committee ISO/TC 112, *Vacuum technology*.

Introduction

Vacuum valves are the most common parts in vacuum systems. Valve manufacturers provide technical data for vacuum valves based on their own test methods and end users use these data to select valves. However, until the time of publication, there has been no International Standard specifying leak test methods for vacuum valves even though leak rate data are among the most fundamental. For example, the leak rate of the valve may vary in the time interval between gas filling and leak testing.

There are three different types of leak: a) real leaks, i.e. macroscopic cracks or holes allowing gases to pass through; b) virtual leaks, caused by outgassing of volatile material inside a vacuum system or trapped volume; c) permeation leaks, i.e. microscopic holes of diameter comparable to that of an atom, which occur throughout the construction material, e.g. in elastomers.

Virtual leaks are not measurable by the leak test method specified in this International Standard. Valve design and the materials used should therefore be chosen to minimize the risk of virtual leaks occurring.

Vacuum technology — Valves — Leak test

1 Scope

This International Standard specifies methods for the leak testing of vacuum valves used for control of gas flow or vacuum pressure in a vacuum system. It is applicable to vacuum valves that can be closed to leak rates less than 1×10^{-5} Pa m^3/s for trace gas. The methods employ a sealing arrangement for the valve body, which is also specified in this International Standard. The methods are suitable for the verification of valve specifications.

A valve leak rate less than the nominal leak rate specified by the manufacturer during and after the operation enables the specification of such valve operating conditions as operating pressure range, permissible pressure difference between ports, bake-out temperature or operating temperature, and life cycle.

NOTE 1 The data for large valves and valves without a valve body can vary from those obtained during delivery inspection depending on the accuracy of the attachment surface of the vacuum device.

NOTE 2 The data obtained from this procedure is based on the testing conducted on an individual unit of a vacuum valve and they can be different from those obtained during delivery inspection if the test is performed with the valve incorporated into the equipment.

2 Normative references

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

ISO 3530, *Vacuum technology — Mass-spectrometer-type leak detector calibration*

3 Terms and definitions

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

3.1
leak rate
q
⟨vacuum valve technology⟩ throughput of a trace gas, which passes through a crack, hole or gap in the wall, seat or sealing material of a valve under specific conditions

NOTE 1 Adapted from ISO 3530:1979, 2.5.1.

NOTE 2 The leak rate is expressed in pascal cubic metres per second.

NOTE 3 The leak rate of the trace gas can be measured using a mass spectrometer-type leak detector. The leak rate depends on type of gas, pressure difference, and temperature.

NOTE 4 The definitions **standard air leak rate** (3.2) and **equivalent standard air leak rate** (3.3) are more specific.

3.2
standard air leak rate
throughput, through an opening such as a crack or hole, of atmospheric air having a dew point of less than −25 °C under standard conditions: an inlet pressure of (100 ± 5) kPa; an outlet pressure of less than 1 kPa; and a temperature of (23 ± 7) °C

NOTE 1 Adapted from ISO 3530:1979, 2.5.2.

NOTE 2 The standard conditions are taken from ISO 3530.

3.3
equivalent standard air leak rate
short-path leaks of the molecular type having standard air leak rates of less than 10^{-7} Pa m^3/s

EXAMPLE Helium (relative atomic mass 4) passes through such leaks more rapidly than air (average relative molecular mass 29,0), and a given flow rate of helium corresponds to a smaller flow rate of air.

NOTE 1 “Equivalent standard air leak rate” is taken as $(4/29)^{1/2} = 0{,}37$ times the helium leak rate under the standard conditions specified in ISO 3530.

NOTE 2 Adapted from ISO 3530:1979, 2.5.3.

3.4
trace gas
gas used to detect leaks

NOTE Mass-spectrometer-type leak detectors are used as the leak measurement instrument. If a helium mixture is used, the leak rate is reported as a helium-equivalent value.

3.5
operating pressure
p_o
⟨vacuum valve technology⟩ pressure range for a valve in working condition

NOTE If a pressure is within the operating pressure range, the valve can have a leak rate smaller than that specified by the manufacturer.

3.6
maximum operating pressure
$p_{o, max}$
⟨vacuum valve technology⟩ highest pressure at which the valve operates within its specifications

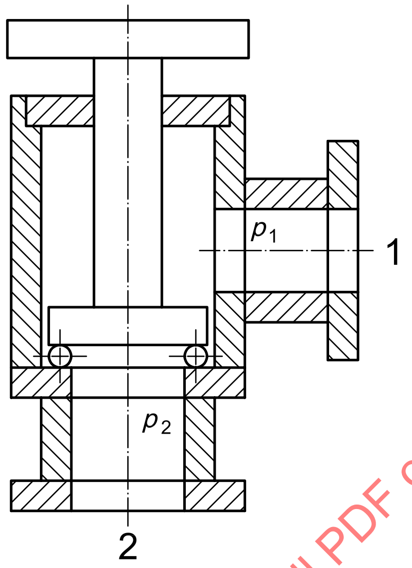
3.7 Pressure difference

NOTE 1 Figures 1 and 2 show schematic diagrams of angle valves and gate valves, respectively.

NOTE 2 Manufacturers of bellow-sealed angle valves often specify a maximum pressure difference separated as differential pressures in the opening and closing directions. Usually, the critical case is the differential pressure in the opening direction (p_1 at “vacuum” and p_2 at maximum pressure).

3.7.1
pressure difference
Δp
⟨conventional angle and gate valves⟩ pressure difference between p_1 and p_2, where p_2 is the pressure at the space toward the valve disc with elastomer on the valve seat and p_1 is the pressure of the opposite side within the valve

3.7.2
pressure difference
Δp
⟨bellow-sealed angle valves⟩ pressure difference between p_1 and p_2, where in the opening direction p_1 is the residual pressure at "vacuum" and p_2 is the maximum pressure

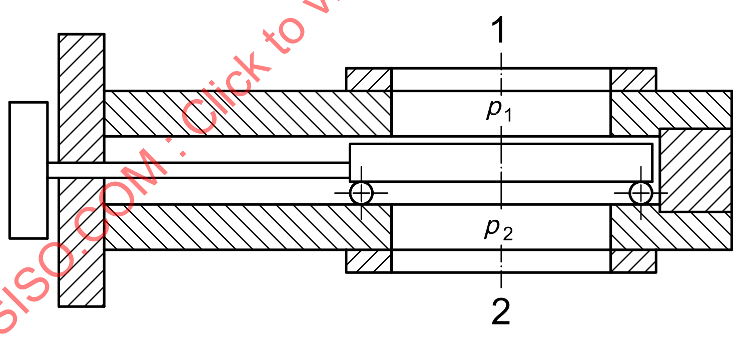


Key

1 port A

2 port B

Figure 1 — Angle valve



Key

1 port A

2 port B

Figure 2 — Gate valve

3.8
maximum pressure difference
Δp_{max}
greatest pressure difference at which the valve can operate normally

NOTE If a pressure difference is lower than Δp_{max}, the valve can have a leak rate smaller than that specified by the manufacturer.

3.9
pressure range of compressed air for a pneumatic valve
p_p
pressure range of the compressed air specified by the manufacturer for a pneumatic valve closed or opened by compressed air

NOTE The compressed air pressure can be specified not only as an absolute pressure but also as a pressure relative to atmospheric, i.e. the gauge pressure.

3.10
torque range for valves with an operating torque specified
τ
torque range specified by the manufacturer for a valve operated by torque wrench

3.11
operating temperature
T_o
temperature at which the valve operates under normal conditions

NOTE An operating temperature range is specified by the manufacturer, within which a valve can be operated under normal working conditions with a leak rate smaller than that specified by the manufacturer.

3.12
baking temperature
T_b
temperature at which the valve is baked

NOTE Baking reduces the outgassing from the inside wall of a valve during the pumping process. This is sometimes necessary for an accurate leak test. The appropriate baking temperature is specified by the manufacturer.

3.13
valve temperature
T_v
temperature of the body of the valve under test

4 Symbols

Symbol	Designation	Unit
p_n	atmospheric pressure	Pa
p_o	operating pressure	Pa
$p_{o, max}$	maximum operating pressure	Pa
p_{out}	pressure of the hood	Pa
p_p	pressure range of the compressed air for pneumatic valve	Pa
p_1	pressure at upper stream side (port A)	Pa
p_2	pressure at down stream side (port B)	Pa
q	leak rate	Pa m^3/s
T_o	operating temperature	°C
T_b	baking temperature	°C
T_v	valve temperature	°C
Δp	pressure difference	Pa
Δp_{max}	maximum pressure difference	Pa
τ	torque	N m

5 Requirements

5.1 All tests shall be made within the limitations of the operating conditions specified by the manufacturer.

5.2 During leak rate measurement, all sealing surfaces shall be clean and dry.

5.3 The mass-spectrometer-type leak detector shall be capable of measuring the leak rate of the test valve. The leak detector shall have a better detection limit than the nominal leak rate of the test valve and sufficient leak rate measurement capabilities.

5.4 The mass-spectrometric leak detector needs sufficient warm-up time, which shall be specified by the leak detector manufacturer. The leak detector shall be tuned and calibrated with reference to a standard leak. The time interval shall be determined taking into account the performance of the leak detector.

5.5 Since temperature affects the leak rate, ambient temperature shall be (23 ± 7) °C.

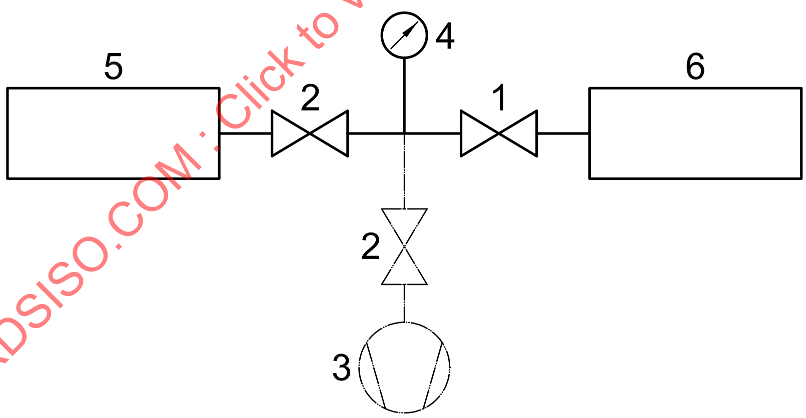
5.6 For an accurate leak test, ISO 3530 is recommended.

6 Test methods

6.1 Valve seat leak test

CAUTION — Leakage of helium to the test environment should be minimized to avoid the increase in background levels close to the leak detector.

The configuration of the valve seat leak test is shown in Figure 3. Evacuate the test valve before the leak test is carried out.



Key

1 valve under test
2 valve
3 vacuum pump (optional)
4 vacuum gauge
5 trace gas reservoir
6 leak detector system

Figure 3 — Schematic diagram for valve seat leak measurement

The trace gas reservoir may have a regulator and a gauge to control the pressure of the gas. The vacuum pump can be useful for controlling partial pressures of the trace gas.

Table 1 specifies four different configurations for the valve seat leak test.

Table 1 — Methods for valve seat leak test

Configuration No.	p_1	p_2	Port A connected to	Port B connected to
1 (basic)	Vacuum	(100 ± 5) kPa trace gas	Leak detector system	Trace gas reservoir
2 (optional)	Vacuum	$p_{o,\,max}$	Leak detector system	Trace gas reservoir
3 (optional)	(100 ± 5) kPa trace gas	Vacuum	Trace gas reservoir	Leak detector system
4 (optional)	$p_{o,\,max}$	Vacuum	Trace gas reservoir	Leak detector system

Configuration 1 in Table 1 is commonly used for the basic valve seat leak test. If needed or upon customer request, configurations 2, 3 or 4 may be used.

Ports A and B are connected to the leak detector system and to the trace gas reservoir, respectively, for configurations 1 and 2. For configurations 3 and 4, ports A and B are connected to the trace gas reservoir and to the leak detector system, respectively. The trace gas supply line is evacuated before filling with trace gas.

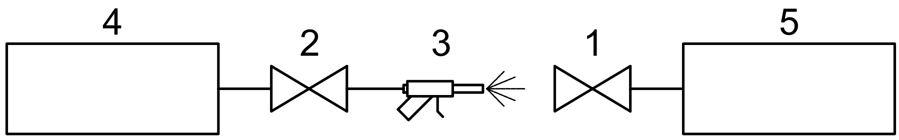
In each configuration, after a waiting period that is typically shorter than 30 s, start the leak rate measurement once the valve is filled with trace gas. The partial pressure of the trace gas and the sensitivity of the leak detector should be taken into account in the correction of the measured value.

Normally, helium or a helium mixture is used as the trace gas. If a helium mixture is used, the volume fraction of helium during the test should be controlled to a constant value and should be higher than 10 %. A correction shall be made for trace gas volume fractions of less than 100 %.

Perform rate measurements for real leaks before permeation leaks become apparent at the leak detector. Since the appearance time of permeation depends on the permeation rate of helium gas flow through the gasket and the valve type, it is necessary to fill the valve with trace gas in as short a time as possible and to measure the leak rate before permeation starts. The waiting time is typically shorter than 30 s.

Leakage of some valves may not be detectable after a waiting time of 30 s. Choice of the appropriate waiting time depends on the structure and material of the valve.

The probe leak test (see Figure 4) is practical, but less quantitative than the method shown in Figure 3. If the probe method is applied, a proper correction should be made. This method is only recommended for comparison or qualitative measurement.



Key

1 valve under test
2 valve
3 probe
4 trace gas reservoir
5 leak detector system

Figure 4 — Schematic diagram for valve seat leak test using the probe method

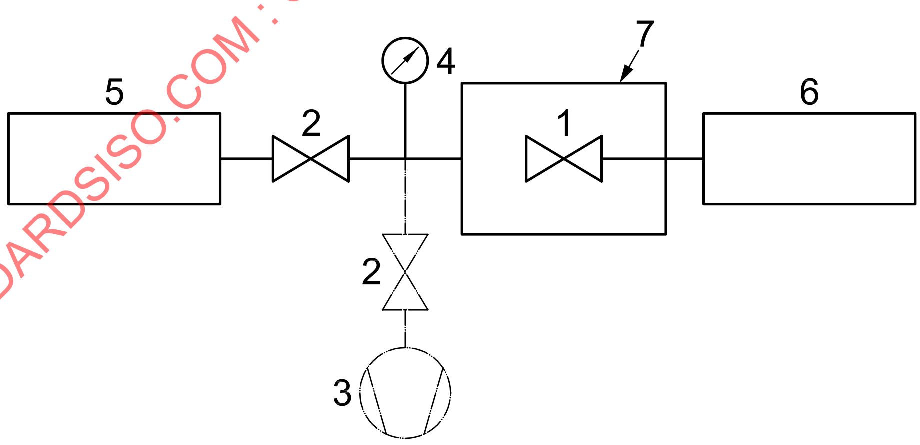
The pressure of the trace gas is regulated to (100 ± 5) kPa or to the maximum operating pressure ($p_{o,\ max}$) specified by the manufacturer.

According to valve driving type, there are many kinds of valves such as handle-type manual valves, torque-wrench-type manual valves, motor-driven valves, and solenoid valves. Variations in driving power can affect the results of the valve seat leak test.

The structure of the part on which the valve is mounted should be sufficiently rigid.

6.2 Valve body leak test

Figure 5 shows a test valve enclosed by a tracer gas hood. The hood is filled with trace gas, at a pressure, p_{out}, whose value should be (100 ± 5) kPa (i.e. approximately $p_n \pm 5$ %, where p_n is atmospheric pressure) during the leak test. If the atmospheric pressure is below 95 kPa, make a suitable correction to 100 kPa.



Key

1 valve under test
2 valve
3 vacuum pump (optional)
4 vacuum gauge
5 trace gas reservoir
6 leak detector system
7 hood

Figure 5 — Schematic diagram for valve body leak test

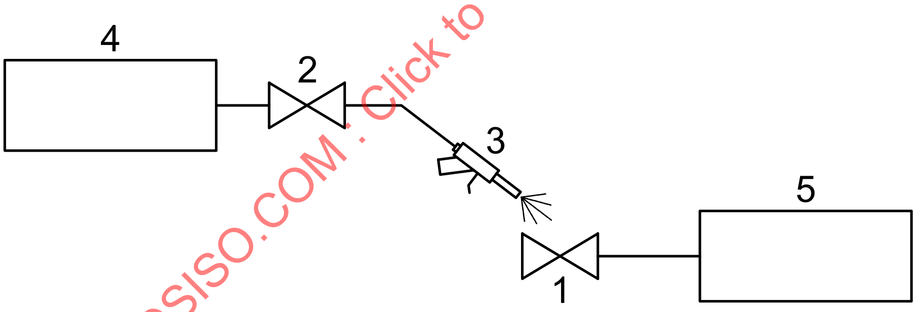
NOTE Evacuation of the hood before filling with trace gas is effective when determining the purity of the trace gas for precise measurement.

Table 2 specifies four different configurations for the valve body leak test. The test is usually done only in configuration 1. When an opening, such as a crack or hole, or a leak has to be located, hood the valve partially, and use configurations 2 or 3 or the spray method.

Table 2 — Methods for valve body leak test

Configuration No.	Test valve	Port A connected to	Port B connected to
1 (basic)	Open	Leak detector system	Blank flange
2 (optional)	Close	Leak detector system	Blank flange
3 (optional)	Close	Blank flange	Leak detector system
4 (basic)	Opening and closing	Leak detector system	Blank flange

The shaft seal parts of the valves generally develop leaks while the parts are still moving. In that case, overall valve leak tests include those of the shaft seal parts in accordance with the valve body leak test. The leak test should be done with the valve initially open and then by closing and opening it. If it is not possible to open and close the valve in the hood, the probe method (see Figure 6) can be used for the leak test.



Key

1 valve under test

2 valve

3 probe

4 trace gas reservoir

5 leak detector system

Figure 6 — Schematic diagram for valve body leak test using the probe method

In each configuration, after a waiting time that is typically shorter than 30 s, start the leak rate measurement once the valve is filled with trace gas. The partial pressure of the trace gas and the sensitivity of the leak detector should be taken into consideration in the correction of the measured value.

Normally, helium or a helium mixture is used as the trace gas. If a helium mixture is used, the volume fraction of helium during the test should be controlled to a constant value and should be higher than 10 %. A correction shall be made for trace gas volume fractions of less than 100 %.