INTERNATIONAL STANDARD

ISO 15848-1

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Industrial valves — Measurement, test and qualification procedures for fugitive emissions —

Part 1:
Classification system and qualification procedures for type testing of valves

Robinetterie industrielle — Mesurage, essais et procédures de qualification pour émissions fugitives —

Partie 1: Système de classification et procédures de qualification pour essais de type des appareils de robinetterie

Reference number
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Foreword

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

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 15848-1 was prepared by Technical Committee ISO/TC 153, *Valves*, Subcommittee SC 1, *Design, manufacture, marking and testing*.

ISO 15848 consists of the following parts, under the general title *Industrial valves — Measurement, test and qualification procedures for fugitive emissions*:

- *Part 1: Classification system and qualification procedures for type testing of valves*
- *Part 2: Production acceptance test of valves*

Introduction

The objective of this part of ISO 15848 is to enable classification of performance of different designs and constructions of valves to reduce fugitive emissions.

This part of ISO 15848 defines type test for evaluation and qualification of valves where fugitive emissions standards are specified.

The procedures of this part of ISO 15848 can only be used with the application of necessary precautions for testing with flammable or inert gas at temperature and under pressure.

Industrial valves — Measurement, test and qualification procedures for fugitive emissions —

Part 1:
Classification system and qualification procedures for type testing of valves

1 Scope

This part of ISO 15848 specifies testing procedures, for evaluation of external leakage of valve stem seals (or shaft) and body joints of isolating valves and control valves intended for application in volatile air pollutants and hazardous fluids. End connection joints, vacuum application, effects of corrosion and radiation are excluded from this part of ISO 15848.

This part of ISO 15848 concerns classification system and qualification procedures for type testing of valves.

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 5208, *Industrial valves — Pressure testing of valves*

3 Terms and definitions

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

3.1
body seals
any seal in pressure containing part except stem (or shaft) seals

3.2
Class
a convenient round number used to designate pressure-temperature ratings

NOTE It is designated by the word “Class” followed by the appropriate reference number from the following series: Class 125, Class 150, Class 250, Class 300, Class 600, Class 900, Class 1 500, Class 2 500.

3.3
concentration
ratio of test fluid volume to the gas mixture volume measured at the leak source(s) of the test valve

NOTE The concentration is expressed in ppmv (parts per million volume), which is a unit deprecated by ISO (1 ppmv = 1 ml/m^3 = 1 cm^3/m^3).

3.4
control valve

power operated device which changes the fluid flow rate in a process control system and which consists of a valve connected to an actuator that is capable of changing the position of a closure member in the valve in response to a signal from the controlling system

3.5
fugitive emission

any chemical or mixture of chemicals, in any physical form, which represents an unanticipated or spurious leak from equipment on an industrial site

3.6
leakage

loss of the test fluid through the stem (or shaft) seal or body seal(s) of a test valve under the specified test conditions and which is expressed as a concentration or a leak rate

3.7
leak rate

mass flow rate of the test fluid, expressed in $\text{mg}\cdot\text{s}^{-1}$ per meter of the perimeter of the stem

3.8
local leakage

measurement of the test fluid leakage using a probe at the leak source point

3.9
mechanical cycle of control valves

for linear/rotary control valves, test cycles performed at 50 % of stroke/angle with an amplitude of ± 10 % of full stroke/angle

3.10
mechanical cycle of isolating valves

motion of a valve obturator moving from the fully closed position to the fully open position, and returning to the fully closed position

3.11
nominal size

DN

alphanumeric designation of size for components of a pipework system, which is used for reference purposes and which comprises the letters DN followed by a dimensionless whole number which is directly related to physical size, in millimetres, of the bore or outside diameter of the end connections

NOTE 1 The nominal diameter is designated by the letters DN followed by a number from the following series: 10, 15, 20, 25, 32, 40, 50, 65, 80, 100, 125, 150, 200, 250, 300, 350, 400, etc.

NOTE 2 The number following the letters DN does not represent a measurable value and should not be used for calculation purposes except where specified in the relevant standard.

3.12
nominal pressure

PN

numerical designation which is a convenient rounded number for reference purposes

NOTE 1 All equipment of the same nominal size (DN) designated by the same PN number has the compatible mating dimensions.

NOTE 2 The maximum allowable working pressure depends upon materials, design and working temperatures and should be selected from the pressure/temperature rating tables in the appropriate standards.

NOTE 3 The nominal pressure is designated by the letters PN followed by the appropriate reference number from the following series: 2,5, 6, 10, 16, 20, 25, 40, 50, etc.

3.13
isolating valve
valve intended for use principally in the closed or open position which may be power actuated or manually operated

3.14
performance class
level of the performance of a test valve defined by the criteria specified in Clause 6

3.15
room temperature
temperature in the range of – 29 °C to + 40 °C

3.16
stem
shaft
valve component extending into the valve shell to transmit the linear/rotary motion from the actuating device to the valve obturator

3.17
stem seal
shaft seal
component(s) installed around the valve stem (or shaft) to avoid leakage of internal fluids to atmosphere

3.18
test pressure
pressure used for testing the valve which, unless otherwise specified, shall be the rated pressure specified at the test temperature and the shell material of a test valve in the relevant standards

3.19
test temperature
fluid temperature selected for the test from Table 3 as measured inside the test valve

3.20
thermal cycle
change of the temperature from the room temperature to the specified test temperature and return to the room temperature

3.21
total leakage
collection of leakage of the test fluid at the leak source using an encapsulation method

3.22
type test
a test conducted to establish the performance class of a valve

4 Symbols and abbreviations

M_{alr}	predicted maximum leakage
SSA	stem (or shaft) seal adjustment

NOTE The abbreviation SSA corresponds to the abbreviation of “Stem Seal Adjustement”.

OD_{stem}	external diameter of the stem
RT	ambient temperature

5 Type test

5.1 Test conditions

5.1.1 Preparation of a valve to be tested

Only a fully assembled valve shall be used for the test.

A valve shall be selected from standard production at random. The valve shall have been tested and accepted in accordance with ISO 5208 or any other applicable standard and no subsequent protective coating shall have been applied.

Additional seal arrangements to allow the stem sealing system leakage measurement is permitted and shall not affect the sealing performance of the valve.

The test valve interior shall be dried and lubricants (if any) shall be removed. The valve and test equipment shall be clean and free of water, oil and dust and the packing may be changed prior to the test. If the valve packing is changed prior to the test, it should be done under the supervision of the valve manufacturer.

If a test valve is equipped with a manually adjustable stem (or shaft) seal(s), it shall be initially adjusted according to the manufacturer instructions, and recorded in the test report as provided in Clause 7.

The valve manufacturer shall select the appropriate actuating device.

5.1.2 Test fluid

The test fluid shall be helium gas of 97 % minimum purity or methane of 97 % minimum purity. The same test fluid shall be used throughout the test.

5.1.3 Test temperature

Valve mechanical cycling is carried out at the room temperature or in the steps of the room temperature and the selected test temperature other than the room temperature (see 5.2.4.1).

The test temperature shall be recorded for each leakage measurement.

5.1.4 Measurement of test valve temperature

The temperature of the test valve shall be measured at three locations (X, Y, Z), as shown in Figure 1, and recorded in a test report.

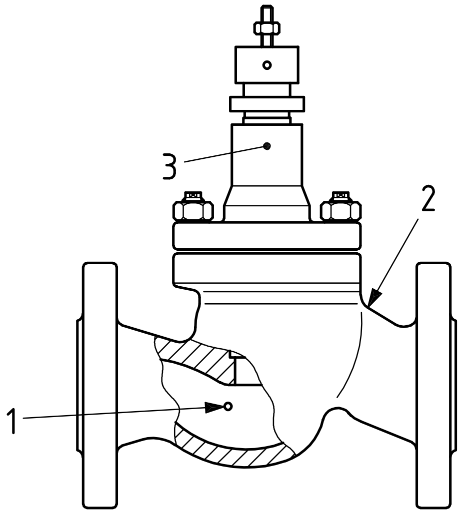
a) Measurement at location “X” shall be used to determine the test temperature.

b) Measurement at location “Z “is used to determine the external valve temperature adjacent to the stem (or shaft) seal(s) for information.

c) Measurement at location “Y” is also made for information. Any use of insulation shall be detailed in the test report.

All temperatures at location X, Y and Z shall be stabilized before leakage is measured (see Figure 2). Temperature at location “Z” shall be stabilized for minimum 10 min prior to leakage measurement.

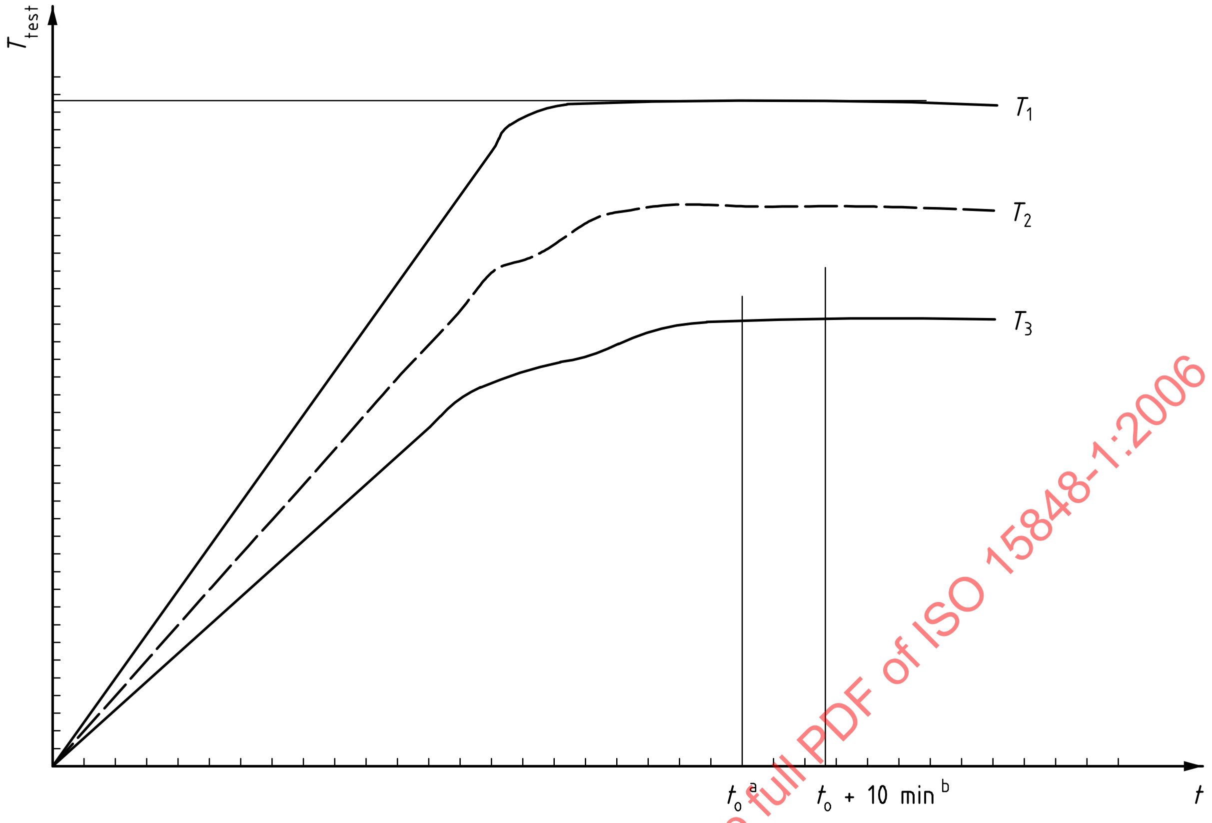
Check if the temperature variation is within ± 5 %.



Key

1	location X:	flow path (temperature T_1)
2	location Y:	valve body (temperature T_2)
3	location Z:	stuffing box (temperature T_3)

Figure 1 — Measurements of temperature at three locations (when the valve is internally heated or cooled)



Key

T_{test}	test temperature, °C
T_1	stabilization temperature at location X (flow path)
T_2	stabilization temperature at location Y (valve body)
T_3	stabilization temperature at location Z (stuffing box)
t	time

[a] Stabilization of temperature at location Z (stuffing box).

[b] Start of mechanical cycles.

Figure 2 — Stabilization of temperatures

5.1.5 Leakage measurement

5.1.5.1 Stem (or shaft) leakage measurement

Leakage shall be measured from a test valve at rest in the partly open position.

The leakage measurement shall be performed by the global method (flushing or vacuum) according to the procedures described in Annex A.

5.1.5.2 Body seal leakage measurement

The leakage shall be measured by the sniffing method according to the procedure described in Annex B and expressed in parts per million volume (1 ppmv = 1 ml/m^3 = 1 cm^3/m^3).

Evaluation of the end connections should be done to insure that they do not affect the results of the evaluation of the body seals.

5.1.5.3 Leakage-measurement records

All results of leakage measurements shall be recorded in a test report as specified in Clause 7.

5.2 Test procedures

5.2.1 Safety rules

Testing with high pressure gas is potentially hazardous and thus all applicable local safety rules and adequate safety measures shall be followed. If methane (CH_4) is used, the combination of the test pressure and temperature shall be reviewed for possible combustion concerns.

5.2.2 Test equipment

The test equipment shall be appropriately selected to

a) apply and maintain the test pressure within a range of ± 5 % of the nominal value;

b) apply valve mechanical cycles;

c) heat or cool the test valve to the selected test temperature, and maintain it within a range of ± 5 % but not exceeding 15°C; no mechanical cycling is permitted during temperature change;

d) measure and record time, pressure, temperature, leakage and duration of a valve mechanical cycle;

e) measure and record actuation forces or torques to operate a test valve;

f) measure and record the stem sealing system loading, if applicable.

5.2.3 Stem (or shaft) seal adjustment (SSA)

5.2.3.1 Number of stem seal adjustment

Mechanical adjustments of stem (or shaft) sealing system during the type test shall be permitted only once, as shown below, for each of qualification stage done according to Figures 3 and 4, if stem (or shaft) leakage has been measured in excess of the target tightness class selected from Tables 1 or 2.

The maximum re-tightening force (or torque) to apply shall be determined prior to the type test.

EXAMPLE — A maximum of one adjustment is accepted for CC1 or CO1;

— A maximum of two adjustments is accepted for CC2 or CO2.

5.2.3.2 Test failure after stem seal adjustment

If a stem (or shaft) sealing arrangement fails to achieve the target tightness class, or it is not possible to continue mechanical cycling, the test shall be considered terminated, and the test valve shall be evaluated for qualification of lower tightness and endurance classes, if applicable.

5.2.3.3 Reporting the number of SSA

The total number of stem (or shaft) seal adjustment shall be recorded in the test report and indicated in the designation of the valve classification as “SSA-1”, “SSA-2” and so forth.

5.2.4 Test description

5.2.4.1 General

The test description is the following.

a) The test valve shall be mounted on a test rig, according to the instructions given by the manufacturer.

b) The valve mounting shall be principally made with a stem (or shaft) positioned vertical. A valve intended for use in other positions shall be mounted with the stem (or shaft) positioned horizontally.

c) All sealing systems shall have been properly adjusted beforehand, according to the manufacturer's instructions. For valves using packings as a stem seal, the tightening torque of the gland boltings shall be measured and recorded at the beginning of the test and after any stem seal adjustment.

d) The target number and combination of mechanical and thermal cycles shall be selected from the endurance classes specified in Figures 3 and 4.

e) Leakage from the stem (or shaft) seal and from the body seals shall be separately measured. If the valve does not allow such a separate measurement the total leakage of both stem (or shaft) and body seals shall be measured at the same time according to Annex A.

f) Actual methods of mechanical cycles other than those specified in 5.2.4.2 and 5.2.4.3 shall be in accordance with the manufacturer's instructions, and opening, closing and dwelling time shall be recorded in the test report. Basically, they shall represent the intended operating conditions of a test valve.

g) Valve opening and closing force (or torque) shall be measured and recorded at the start and at the end of the test, following subsequent stem seal adjustments if applicable.

5.2.4.2 Mechanical cycles of isolating valves

Unless otherwise specified by the valve manufacturer, the valve seating force (or torque) required for tightness under a differential pressure of 0,6 MPa (6 bar), air or inert gas shall be used as the minimum force (or torque) for mechanical cycle of a test valve.

Fully back seating a test valve is not required.

5.2.4.3 Mechanical cycles of control valves

The stem motion of linear action valves shall be between 1 mm/s and 5 mm/s. The shaft motion of rotary control valves shall be between 1°/s and 5°/s.

The actuator to operate a test valve shall withstand only the pressure and friction force (or torque) acting on the valve stem, and these values shall be recorded.

NOTE Measurement of friction force (or torque) is principally intended to check the packing friction usually expressed as the dead band.

5.2.4.4 Preliminary tests at the room temperature (test 1)

The tests are carried out as shown below.

a) Pressurize a test valve with the test fluid to the test pressure as specified in a relevant standard.

b) After the test pressure has been stabilized, measure leakages both from the stem (or shaft) seal and from the body seals, in accordance with Annexes A and B, respectively.

c) Record the test result in a test report.

5.2.4.5 Mechanical cycle test at the room temperature (test 2)

The tests are carried out as shown below.

a) Perform mechanical cycles at room temperature while the test valve is kept pressurized.

b) Measure the leakage from the stem (or shaft) seal only, in accordance with Annex A.

c) Record the test result in the test report.

d) Repeat the test in case of Class CO1 and CC1, as indicated in Figures 3 and 4.

5.2.4.6 Static test at the selected test temperature (test 3)

The tests are carried out as shown below.

a) Pressurize a test valve with the test fluid to the test pressure as specified in a relevant standard for the selected test temperature selected from Table 3.

b) After the test pressure has been stabilized, adjust the valve temperature to the selected test temperature, ensuring that the test pressure does not exceed the level specified in the relevant standard.

c) After the valve temperature has been stabilized with an allowance of ± 5 % with a maximum of 15 °C, measure the leakage from the stem (or shaft) seal only in accordance with Annex A.

d) Record the test result in the test report.

e) Repeat the test in case of Class C01 and CC1, as indicated in Figures 3 and 4.

5.2.4.7 Mechanical cycle test at the selected test temperature (test 4)

The tests are carried out as shown below.

a) Perform mechanical cycles at the selected test temperature while the test valve is kept pressurized.

b) Measure the leakage from the stem (or shaft) seal only in accordance with Annex A.

c) Record the test result in a test report.

d) Repeat the test in case of Class C01 and CC1, as indicated in Figures 3 and 4.

5.2.4.8 Intermediate static test at the room temperature (test 5)

The tests are carried out as shown below.

a) Allow a test valve to return to the room temperature, without artificial cooling (or heating).

b) After the valve temperature has been stabilized, measure the leakage from the stem (or shaft) seal only in accordance with Annex A.

c) Record the test result in a test report.

5.2.4.9 Final test at the room temperature (test 6)

The tests are carried out as shown below.

a) Allow a test valve to return to the room temperature, without artificial measures.

b) After the valve temperature has been stabilized, measure the leakage from the stem (or shaft) seal in accordance with Annex A and from body seals in accordance with Annex B.

c) Record the test results in the test report.

5.2.4.10 Post test examination

After all the tests have been successfully completed, the test valve shall be disassembled and all sealing components shall be visually examined to record notable wear and any other significant observations for information.

5.2.4.11 Qualification

Tested valves shall be qualified when

- all steps of test procedures have been satisfactorily performed for the target performance class;
- all leakage measurements are verified equal or lower than the values specified for the target performance class.

6 Performances classes

6.1 Classification criteria

Valve operating conditions and hazards of the line fluid being handled can result in different levels of valve emission performance.

The purpose of Clause 6 is to define classification criteria resulting from the type test.

A performance class is defined by the combination of the following criteria:

a) “tightness class”: see Tables 1 and 2;

b) “endurance class”: see Figures 3 and 4;

c) “temperature class”: see Table 3.

6.2 Tightness classes

6.2.1 Definition

Tightness classes are defined only for stem (or shaft) sealing systems.

Leakage from body seals shall be $\leqslant$ 50 ppmv in every case.

Table 1 — Tightness classes for stem (or shaft) seals

Class	Measured leak rate[a] $mg \cdot s^{-1} \cdot m^{-1}$	Remarks
A[b]	$\leqslant 10^{-6}$	Typically achieved with bellow seals or equivalent stem (shaft) sealing system for quarter turn valves
B	$\leqslant 10^{-4}$	Typically achieved with PTFE based packings or elastomeric seals
C	$\leqslant 10^{-2}$	Typically achieved with flexible graphite based packings

[a] Expressed in $mg \cdot s^{-1} \cdot m^{-1}$ measured with total leakage method as defined in Annex A.

[b] Class A can be measured only with helium using the vacuum method.

Table 2 — Leakage from body seals

Measured concentration ppmv
$\leqslant 50$
NOTE Expressed in ppmv measured with the sniffing method as defined in Annex B (1 ppmv = 1 ml/m^3 = 1 cm^3/m^3).

6.2.2 Helium as test fluid

When the test fluid is helium, the tightness classes are identified as Class AH, Class BH and Class CH.

6.2.3 Methane as test fluid

When the test fluid is methane, the tightness classes are identified as Class BM and Class CM.

6.2.4 Correlations

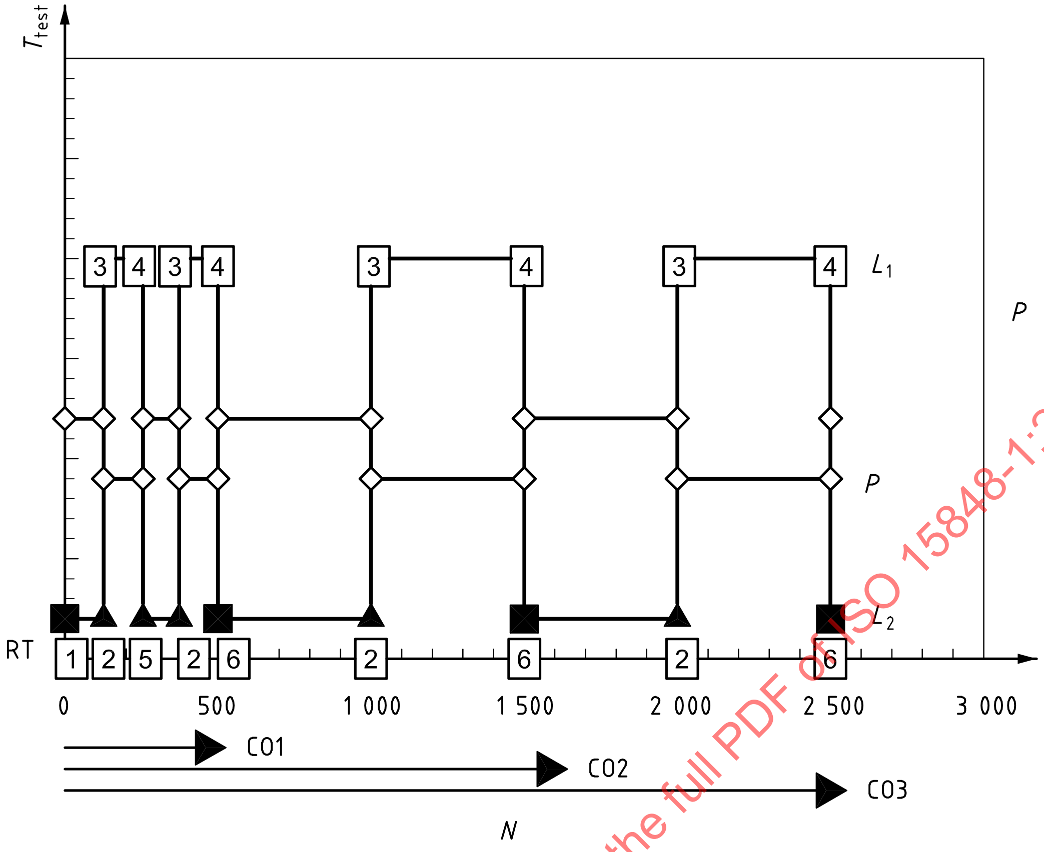
There is no correlation intended between measurements of total leak rate as described in Annex A and local sniffed concentration as described in Annex B.

There is no correlation intended between the tightness classes when the test fluid is helium (Class AH, Class BH and Class CH) and when the test fluid is methane (Class BM and Class CM).

6.3 Endurance classes

6.3.1 Mechanical-cycle classes for isolating valves

The required minimum number of mechanical cycles for isolating valves shall be 500 cycles (full stroke) with two thermal cycles, except for RT. This classification stage shall be identified as CO1. An extension to classification CO2 shall be accomplished by addition of 1 000 mechanical cycles with one thermal cycle. Further extension to CO3 etc shall be achieved by repetition of the requirement for CO2 (see Figure 3).



Key

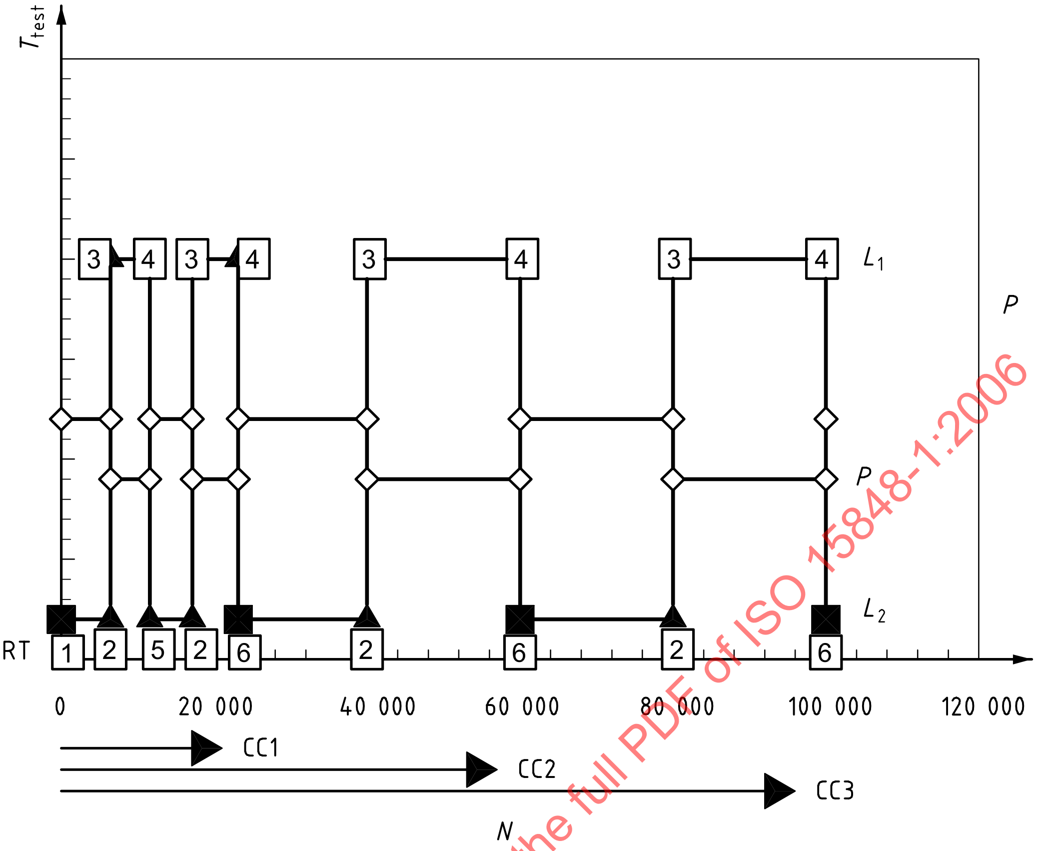
T_{test} test temperature, °C
N number of mechanical cycles
P test fluid pressure
L_1 measurement of leakage of stem seal
L_2 measurement of leakage of body seal

NOTE The numbers 1 to 6 refer to the test sequences test 1 to test 6 as defined in 5.2.4.4 to 5.2.4.9.

Figure 3 — Mechanical-cycle classes for isolating valves

6.3.2 Mechanical-cycle classes for control valves

The required minimum number of mechanical cycles for control valves shall be 20 000 cycles with two thermal cycles, except for RT. This classification stage shall be identified as CC1. An extension to classification CC2 shall be accomplished by addition of 40 000 mechanical cycles with one thermal cycle. Further extension to CC3 etc shall be achieved by repetition of the requirement for CC2 (see Figure 4).



Key

T_{test} test temperature, °C

N number of mechanical cycles

P test fluid pressure

L_1 measurement of leakage of stem seal

L_2 measurement of leakage of body seal

NOTE The numbers 1 to 6 refer to the test sequences test 1 to test 6 as defined in 5.2.4.4 to 5.2.4.9.

Figure 4 — Mechanical-cycles classes for control valves

6.4 Temperature classes

The target temperature class shall be selected from Table 3. If the test is carried out at any temperature other than those specified in the Table, the next lower class shall apply in case of the test temperature being above zero, or the next higher class shall apply in case of the test temperature being below zero.

EXAMPLE If the test temperature is 405 °C, the value shall be classified as (t400 °C).

All test temperatures shall be recorded in the test report.

Table 3 — Temperature classes

(t-196 °C)	(t-46 °C)	(tRT)	(t200 °C)	(t400 °C)
– 196 °C	– 46 °C	Room temperature, °C	200 °C	400 °C

- Test at – 196 °C qualifies the valve in the range – 196 °C up to RT.
- Test at – 46 °C qualifies the valve in the range – 46 °C up to RT.
- Test at RT qualifies the valve in the range – 29 °C to + 40 °C.
- Test at 200 °C qualifies the valve in the range RT up to 200 °C.
- Test at 400 °C qualifies the valve in the range RT up to 400 °C.

To qualify a valve in the range – 46 °C up to 200 °C, two tests are necessary:

- The test at – 46 °C qualifies the valve in the range – 46 °C up to RT;
- The test at 200 °C qualifies the valve in the range RT up to 200 °C.

Alternative temperature classes shall be subject to the agreement between the manufacturer and the purchaser.

6.5 Examples of class designation

- Tightness class: B (reference in Table 1).
- Endurance class:
  - isolating valve CO1 (reference in Figure 3);
  - control valve CC1 (reference in Figure 4).
- Temperature class: a test at t200 °C and a test at t–46 °C.
- Test pressure : according to PN or ANSI class rating depending on a relevant valve standard or in bar at room temperature and at test temperature for specific tests; the standard reference is ISO 15848-1.
- Number of stem seal adjustments (SSA): 1.

6.6 Marking

In addition to the marking required by relevant standards, production valves qualified by type testing in accordance with this part of ISO 15848 may be marked with “ISO FE” - which stands for ISO fugitive emission - and the information as indicated in 6.5.

EXAMPLE 1 Performance class: ISO FE BH (or BM) — CO1 — SSA 1 — t(– 46°C, 200 °C) — PN16 — ISO 15848-1.

EXAMPLE 2 Performance class: ISO FE BH (or BM) — CO1 — SSA 1 — t(– 46°C, 200 °C) — CL150 — ISO 15848-1.

In case of specific tests in bars:

EXAMPLE 3 Performance class: ISO FE BH (or BM) — CO1 — SSA 1 — t200 °C — (40/30) — ISO 15848-1.

7 Reporting

The test report shall include the following information:

a) the name and address of the valve manufacturer;

b) valve sizes and pressure class;

c) valve model number and style;

d) method of sample selection;

e) diagram of the test rig and the data of the test equipment including the detector make and model or the probe flow rate where any sniffing measurement is quoted;

f) the date of test;

g) reference standards with applicable revision numbers;

h) the test fluid;

i) valve performance classes achieved;

j) valve mounting instructions;

k) valve repacking before type test to be reported if applicable;

l) insulation of test valve to be reported if applicable;

m) valve operation data:

  — valve operating torque or force,

  — gland bolt tightening torque,

  — stroke/angle;

n) description of the actuator if applicable;

o) copy of the test profile;

p) detailed results of the test;

q) qualification certificate.

The specific product data file including the following information shall be the responsibility of the manufacturer and shall be included as an annex:

a) cross sectional valve assembly drawing;

b) bill of valve materials;

c) stem or shaft seal description, dimensions and specifications;

d) body seal(s) description, dimensions and specifications;

e) material specifications of stem (or shaft) seal components;

f) hydrostatic test certificate.

8 Extension of qualification to untested valves

Upon the successful completion of the test program as defined in this part of ISO 15848, this qualification may be extended to untested sizes and classes of valves of the same type if the following criteria are met:

a) the stem (or shaft) seals and body seals are of the same material, design (shape) and construction, independent of the size;

b) loading arrangement applies a similar sealing stress to the seal element as that applied in the test valve;

c) the type of motion of the stem (or shaft) is identical;

d) tolerances classes and surface finishes specifications of all valve components which affect sealing performance are identical;

NOTE The tolerances classes are in accordance with ISO 286.

e) stem diameters are within the range of 50 % lower and 200 % higher of those of the test valve;

f) the valve Class or PN designation is equal or lower;

g) the required temperature class falls between the room temperature and the test temperature of the qualified valve;

h) the tightness class required is equal to, or less severe than that of the qualified valve.

The use of gearbox or other actuator does not require separated qualification, provided above criteria are met.

Annex A
(normative)

Total leak rate measurement

A.1 Vacuum method (helium only)

A.1.1 Scope

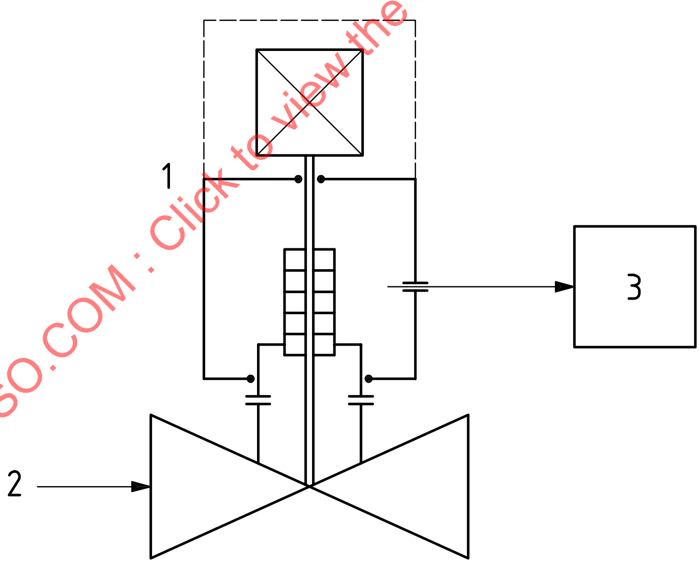
This annex specifies the vacuum method used to measure the total leak rate of the stem sealing system of an industrial valve in using an helium mass spectrometer.

The test fluid is helium (97 % purity).

A.1.2 Principle

The principle of the vacuum method is illustrated in Figure A.1. The leakage source is enclosed in a tight chamber, which is evacuated and then connected to an helium mass spectrometer.

The tight chamber may be fulfilled by the design of the stem sealing system.



Key

1 vacuum chamber

2 pressurized helium

3 vacuum helium detector

Figure A.1 — Principle of the vacuum method

A.1.3 Equipment and definitions

A.1.3.1 Helium mass spectrometer

The helium mass spectrometer type and main characteristics shall be specified.

The sensitivity of the helium mass spectrometer shall be in accordance with the range of the leak rate to be measured.

The helium mass spectrometer measurement corresponds to the rate at which a volume of helium at specified pressure passes a given cross section of the test system (SI unit: $\mathrm{Pa \cdot m^3 \cdot s^{-1}}$).

Then, the leak rate is calculated in milligrams per second (see A.1.7) and reported to the outer stem diameter.

As regards the helium systems, sensitivities ranging from $5\ \mathrm{mg \cdot s^{-1}}$ to $5 \cdot 10^{-10}\ \mathrm{mg \cdot s^{-1}}$ are allowable.

The response time of the helium mass spectrometer is evaluated (or verified) in using the standard calibrated leak. The time is recorded when the standard calibrated leak is opened to the helium mass spectrometer and when the increase in helium mass spectrometer output signal becomes stable.

The elapse time between the helium application and the moment where the reading represents 90 % of the equilibrium signal is the response time of the helium mass spectrometer.

A.1.3.2 Auxiliary pump system

The size of the tested valve can necessitate the use of an auxiliary vacuum pump system. Then the ultimate absolute pressure and pump speed capability shall be sufficient to attain required test sensitivity and response time.

A.1.3.3 Helium pressurisation

It shall be possible to apply helium pressure up to the nominal test pressure of the valve.

A.1.3.4 Standard calibrated leak

In order to evaluate the response time of the whole measuring system, the standard calibrated leak connection should be placed on the vacuum enclosure as near as possible to the stem sealing system.

The standard calibrated leak may be either of a permeation or a capillary type. The standard calibrated leak shall be selected depending on to the tightness class of the tested valve. Depending of the helium mass spectrometer manufacturer, different standard calibrated leaks exist for one item of equipment

A.1.4 Calibration

A.1.4.1 Helium mass spectrometer

A.1.4.1.1 Warm up

The instrument shall be turned on and allowed to warm up for the minimum time specified by the instrument manufacturer prior to calibrating with the calibrated leak standard.

A.1.4.1.2 Calibration

The instrument shall be calibrated as specified by the instrument manufacturer using permeation or a capillary type standard.

The helium mass spectrometer shall be calibrated:

- at the beginning of each test and routinely if the test takes a long time (e.g. calibration once a week);
- over the tightness class range required.

A.1.4.2 System calibration

A standard calibrated leak with 100 % helium shall be attached, where possible, to the component as far as possible from the instrument connection to the component (Figure A.2).

The instrument shall be turned on and allowed to warm up for the minimum time specified by the instrument manufacturer prior to calibrating with the standard calibrated leak. The standard calibrated leak shall remain open during system calibration until the response time has been determined.

a) Evacuation: with the component evacuated to an absolute pressure sufficient for connection of the helium mass spectrometer to the system, the standard calibrated leak shall remain open during system calibration until the response time has been determined.

b) Response time of the full system: the time is recorded when the standard calibrated leak is opened to the system and when the increase in helium mass spectrometer output signal becomes stable. The elapse time between the helium application and the moment where the reading represents 90 % of the equilibrium signal is the response time of the system.

c) Background reading: background is established after determining response time. The standard calibrated leak is closed to the system and the instrument reading shall be recorded when it becomes stable.

A.1.5 Requirements for the test

A.1.5.1 Tight chamber

The tight chamber shall be tight enough to enhance the establishment of a vacuum warranting the measurement accuracy.

The tight chamber shall be so sized as to allow the valve actuator to be moved. During heating, the inside of the tight chamber should be ventilated, or the tight chamber can be removed, to stabilize the temperature and avoid any overheating of the valve body that is not representative of real operating conditions.

A.1.5.2 Instrumented stem sealing system

It shall meet the same tightness requirements as the tight chamber.

In addition, the operator shall check that

- the vacuum tap is correctly positioned for leak rate measurement,
- the vacuum tap remains unclogged throughout the test.

In addition, the sealing of instrumented stem sealing system shall withstand the temperature and mechanical cycling conditions required during testing (durability conditions).

While the stem sealing system is being instrumented, the modifications made on the gland shall maintain operating conditions representative of the real valve stem operation.

A.1.5.3 Pollution and packing degradation

Provision shall be made for a filter to protect the helium mass spectrometer against any pollution, which might result from packing degradation products, and make the leak measurement erroneous.

It is also recommended to properly establish a vacuum within the spectrometer prior to any measurement, so as to make sure of the absence of any pollution and to possibly eliminate them.

A.1.5.4 Safety

All accessories used to contain pressure in the valve body (flanges, bolting, all fittings etc.) shall be suitable for test pressure and temperature.

The valve to be tested shall be carefully fastened before pressurisation and cycling.

The pressure inside the valve body shall be increased slowly.

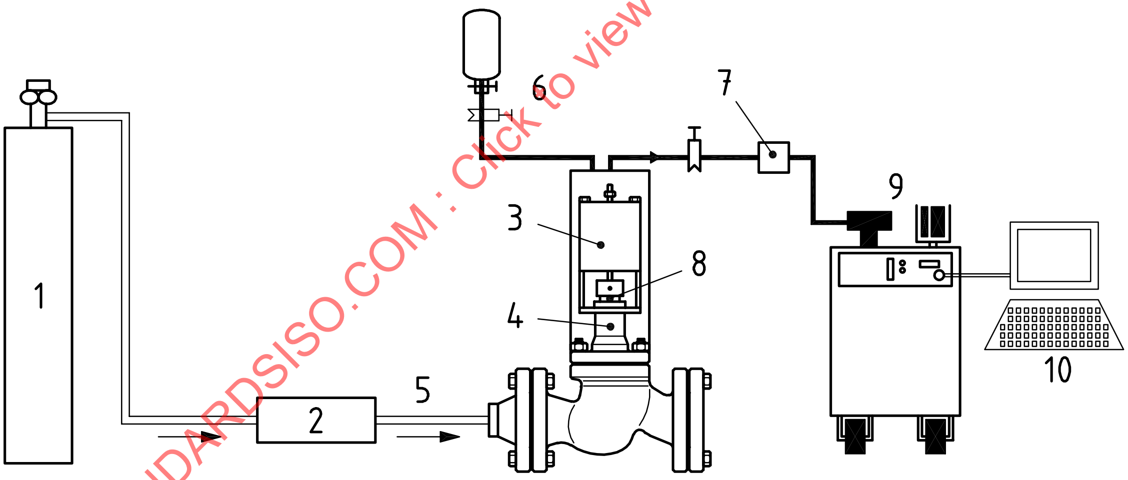
A.1.5.5 Personnel qualification

This method shall be applied by qualified and suitably trained operators.

A.1.6 Testing procedure

A.1.6.1 Test set-up

The test set-up is shown schematically in Figure A.2.



Key

1 helium at 97 % purity
2 pressure control
3 actuator
4 vacuum
5 helium
6 standard calibrated leak
7 vacuum safety
8 tested stem sealing
9 helium mass spectrometer
10 data acquisition

Figure A.2 — Equipment

A.1.6.2 Preparation of the tested valve

Before each test

- the valve is cleaned and dried;
- the packing tightening checked.

The hydrostatic test shall be performed before testing the valve in high pressure and high temperature conditions.

It is required to change packing before any sealing test (when using packing in the stem sealing system).

If the tight chamber encloses the entire valve, connection flanges shall be welded to avoid any leaks that come from them. In this case, the measurements correspond to the leaks from stem sealing system and body seals.

A.1.6.3 Calibration

See A.1.4.

A.1.6.4 Measurement

The measurement is carried out as follows:

a) establishment of a vacuum inside the tight chamber and connection of the helium mass spectrometer to the tight chamber;

b) determination of the system response time (e.g. by use of a calibrated leak as shown in Figure A.2);

c) helium background levels recording;

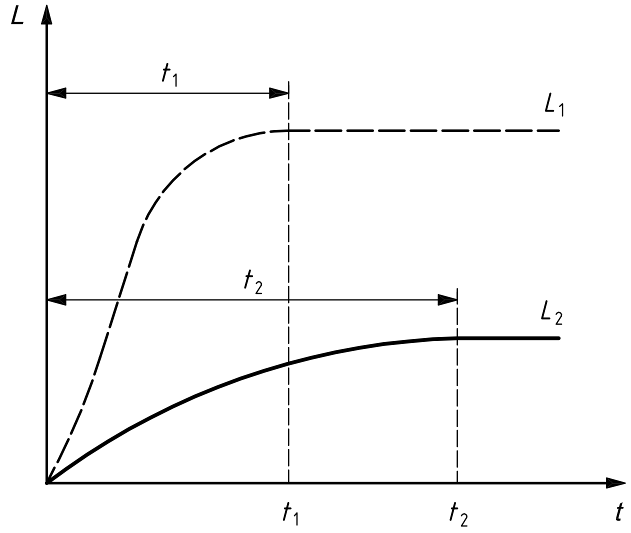
d) valve pressurization;

e) test temperature stabilization;

f) leak recording;

g) leak stabilization (see Figure A.3);

h) leak measurement.



Key

L leak rate, in milligrams per second per metre
L_1 leakage 1
L_2 leakage 2
T time, in seconds
t_1 stabilization time t_1
t_2 stabilization time t_2

Figure A.3 — Examples of stabilization times for leaks measured using the global method

A.1.7 Leak rate calculation

The vacuum method allows the measurement of the total (global) leak rate of the stem sealing system.

The measurement L_v, expressed in milligrams per second, is generally expressed in millibars per litre per second or equivalent atmospheres per cubic centimetre per second.

The mass flow rate, L_m, expressed in milligrams per second, is calculated from L_v by

$$L_m = L_v \times 0{,}164$$

Then the leak rate, L_{mm}, expressed in milligrams per second per meter outer stem perimeter, is calculated from L_m by

$$L_{mm} = \frac{L_m}{(\pi \times \mathrm{OD}_{\mathrm{stem}})}$$

where $\mathrm{OD}_{\mathrm{stem}}$ is the diameter of the stem, expressed in metres.

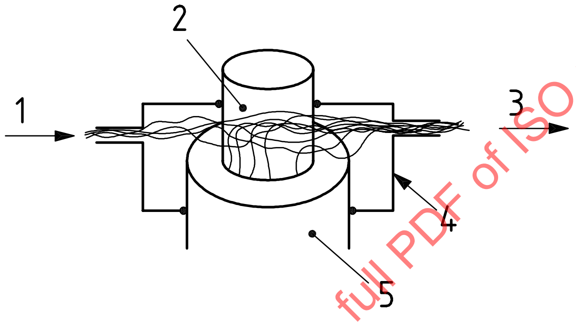
A.2 Flushing method (helium or methane)

A.2.1 Scope

A.2 specifies the flushing method used to measure the total leak rate of the stem sealing system of an industrial valve pressurised with helium (97 % purity) or methane (97 % purity).

A.2.2 Principle

The principle of the flush method is illustrated in Figure A.4. The leakage source is enclosed by a flush chamber. A carrier gas (or flush gas) passes through this chamber, where it mixes with the leakage stream of the test gas. Then it passes down an exhaust line from which it vents to atmosphere. The concentration of the resulting mixture in the exhaust line depends only on the leak rate and the flush gas flow rate. Flush gas flow rate is set to an appropriate value, concentration is measured and leakage is thereby calculated (see A.2.7).



Key

1 flush gas
2 valve stem
3 to detector
4 flush chamber
5 valve body

Figure A.4 — Principle of the flush method for valve stem leak rate measurement

As implemented here, the flush gas is provided from a source of known purity at a measured flow rate.

A.2.3 Equipment and definitions

A.2.3.1 Concentration

Unless otherwise stated, “concentration” shall mean ratio of test gas species volume to gas mixture volume. If the detector scale reads in parts per million by volume (1 ppmv = 1 ml / m^3 = 1 cm^3/m^3), the following equation shall be used to calculate concentration as a dimensionless volumetric ratio :

$$C = 10^{-6} \times C_{\text{ppmv}}$$

where

C is the volumetric concentration of the test fluid;

C_{ppmv} is the concentration in parts per million by volume (1 ppmv = 1 ml/m^3 = 1 cm^3 / m^3).

A.2.3.2 Detector

A.2.3.2.1 General

The concentration detector is an instrument which detects the test gas, reading out in terms of volumetric concentration [usually expressed as parts per million by volume (1 ppmv = 1 ml / m^3 = 1 cm^3/m^3)].

The test fluid detector type may include, but is not limited to, mass spectrometry, infrared absorption and molecular screening.

The instrument shall be equipped with an electrically driven pump to ensure that a sample is provided to the detector at a constant flow rate. The detector shall be selected such that this total probe flow rate is at least 100 times greater than the maximum anticipated leak rate.

The detector shall be equipped with a sensing probe, for operation at atmospheric pressure.

The detector shall measure concentration of helium or methane.

Alternatively, a flow rate detector may be used for concentration measurement, provided the total probe flow rate is known. The flow rate detector is an instrument which detects the test gas, reading out in terms of test gas flow rate into the detector (usually expressed as millibars per litre per second or atmospheres per cubic centimetre per second). If the total probe flow rate is not known, it shall be measured, as described in A.2.4.4. Concentration may be calculated from probe uptake of test gas (i.e. the meter reading): see A.2.7.

A.2.3.2.2 Performance criteria

The scale of the instrument meter shall be readable to within ± 2,5 % of full scale device.

The calibration precision shall be equal to or less than 10 %.

A.2.3.3 Flush chamber

The flush chamber is an enclosure placed around the valve stem seal to prevent leaking test gas dispersing to atmosphere. The flush chamber incorporates external inlet and outlet connections.

A.2.3.4 Flush gas

The flush gas is a carrier gas of known purity fed into the inlet connection to the flush chamber, where it mixes with leakage gas, to be conducted away from the outlet connection of the flush chamber.

The flush gas shall be nitrogen if the test fluid is helium, and pure air if the test fluid is methane, of purity specified in A.2.5.3.2.

A.2.3.5 Flush gas flow rate measurement

An in-line flow meter should be used to measure flush gas flow rate. Suitable equipment may include, but is not limited to, a rotameter with or without upstream flow control valve.

The flow meter shall be calibrated for use in the flush gas at room temperature, with atmospheric pressure downstream.

The flow meter range shall be selected such that the flush gas flow rate (determined as specified in A.2.5) lies between 25 % and 75 % of its full-scale device.

The scale of the flow meter shall be readable to within ± 2,5 % of full-scale device.

A.2.3.6 Lower leakage threshold

The lower leakage threshold is a leak rate (expressed in atmospheres per cubic centimetre per second) below which leakage is considered negligible for the purposes of the test.

A.2.3.7 Maximum anticipated leak rate

The maximum anticipated leak rate is the leak rate (expressed in atmospheres per cubic centimetre per second) corresponding to the upper limit of valve stem leak rate for the target leakage Class rating.

A.2.3.8 Total probe flow rate

The total probe flow rate is the volumetric flow rate (expressed in atmospheres per cubic centimetre per second) of gas drawn into the probe by the detector's pump. Gas is assumed to be predominantly nitrogen (for tests with helium) or predominantly pure air (with methane).

A.2.3.9 Zero gas

The zero gas is a reference gas containing negligible concentration of test gas.

The zero gas shall be nitrogen or air of the same purity as the flush gas (see A.2.5).

A.2.4 Calibration

A.2.4.1 General

At the beginning of the instrument performance evaluation test, assemble and start up the instrument according to the manufacturer's instructions for recommended warm-up period and preliminary adjustments.

A.2.4.2 Calibration gases

Regardless of the detector type used, the flush method relies on measurement of the concentration in the flush exhaust line. Therefore, the monitoring instrument shall be calibrated in terms of volumetric concentration of the test fluid.

The calibration gas shall comprise a known concentration of helium in nitrogen or methane in pure air.

If cylinder calibration gas mixtures are used, they shall be analysed and certified by the manufacturer to be within ± 2 % accuracy, and a shelf life shall be either reanalysed or replaced at the end of the specified shelf life. Alternatively, calibration gases may be prepared by the user according to any accepted gaseous standards preparation procedure that yields a mixture accurate to within ± 2 %. Prepared standards shall be replaced each day of use unless it can be demonstrated that degradation does not occur during storage.

Calibration gas concentration shall be determined from the following equation:

$$C_{\text{cal}} = \frac{M_{\text{alr}}}{Q_{\text{f}}}$$

where

C_{cal} is the calibration gas volumetric concentration;

Q_{f} is the flush-gas flow rate;

M_{alr} is the maximum anticipated leak rate.

The maximum anticipated leak rate is expressed in atmosphere per cubic centimetre per second.

A.2.4.3 Procedure (with concentration detector)

The calibration precision test shall be completed prior to placing the analyser into service, and at subsequent three-month intervals or at the next use whichever is later.

Assemble and start up the detector according to the manufacturer's instructions. After the appropriate warm-up period and zero internal calibration procedure, introduce the calibration gas into the instrument sample probe. When the meter reading reaches a steady value, adjust the instrument meter readout to correspond to the calibration gas value.

A.2.4.4 Procedure (with flow rate detector)

Assemble and start up the detector according to the manufacturer's instructions and run for an appropriate warm-up period.

Many detectors are calibrated by an automatic internal routine involving the use of an internal test leak. If the detector has this facility, run this procedure. Frequent autocalibration cycles are recommended, e.g. every 10 min to 30 min.

If the detector does not offer an autocalibration facility, a certified test leak shall be used. These are provided by the instrument manufacturer. The nearest available value to the maximum anticipated test leak shall be used. Connect the detector probe to the test leak. When the meter reading reaches a steady value, adjust the instrument meter readout to correspond to the test leak value.

The calibrated flow rate detector can now be used to measure concentration.

A.2.4.5 Determination of probe flow rate

Connect the detector's probe to the downstream side of a calibrated flow meter. Leave the upstream side open to atmosphere. With the instrument running and warmed up, note the flow rate indicated on the flow meter.

A.2.4.6 Calibration precision

Make a total of three measurements by alternatively using zero gas and the specified calibration gas. Record the meter readings.

The calibration precision is the degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration:

$$C_\mathrm{p} = \frac{\left(C_\mathrm{av} - C_\mathrm{cal}\right)}{C_\mathrm{cal}} \times 100$$

where

C_av is the average volumetric concentration from meter readings;

C_cal is the known volumetric concentration of calibration gas;

C_p is the calibration precision, expressed in percentage.

A.2.5 Requirement for the test

A.2.5.1 General

Assemble the leakage measurement set-up around the test valve according to the following guidelines.

A.2.5.2 Flush chamber

The flush chamber may be devised from a rigid cover, from flexible material taped in place or by making use of a suitable feature of the valve, such as a lantern ring design. The enclosed volume should be kept to the minimum possible to minimise the time taken for a measurement to reach a steady value. The quality of the seal between the flush chamber and the valve is not critical, but care should be taken to avoid large gaps.

A.2.5.3 Flush gas supply

A.2.5.3.1 Equipment

The flush gas flow meter should be downstream of the pressure and flow regulators.

A pressure regulator rated for low-pressure delivery shall be situated upstream of the flow meter, to protect it from possible over-pressurisation. Flush gas flow rate may be adjusted by a flow control valve. Where the detector is of the flow rate type, volumetric concentration can be calculated from meter reading (see A.2.7).

A.2.5.3.2 Selection of flush gas flow rate

Flush gas flow rate shall be selected to satisfy both of the following conditions:

$$Q_\mathrm{f} \geqslant 4 \times Q_\mathrm{p}$$

and

$$Q_\mathrm{f} > \frac{M_\mathrm{alr}}{C_\mathrm{dfscr}}$$

where

Q_f is the flush gas flow rate, expressed in atmospheres per cubic centimetre per second;

Q_p is the total probe flow rate, expressed in atmospheres per cubic centimetre per second;

C_dfscr is the detector's full scale concentration reading;

M_alr is the predicted maximum leakage, expressed in atmospheres per cubic centimetre per second.

The maximum anticipated leak rate is expressed atmospheres per cubic centimetre per second.

Detector’s full scale concentration reading is expressed as a dimensionless volumetric concentration.

A.2.5.3.3 Flush gas purity

The maximum acceptable percentage error arising from flush gas impurities is incurred at the lower leakage threshold. To keep this below 25 %, the flush gas purity shall be such that the maximum test gas content is given by the following equation:

$$\mathrm{ppm}_{\text{test gas}} < 10^6 \times \left(\frac{Q_\mathrm{min}}{Q_\mathrm{f}}\right) \times 0{,}25$$

where

$ppm_{\text{test gas}}$	is the maximum test gas impurity in flush gas supply, expressed as parts per million volume (1 ppmv = 1 ml / m^3 = 1 cm^3/m^3);
Q_{min}	is the lower leakage threshold, expressed in atmospheres per cubic centimetre per second;
Q_{f}	is the flush gas flow rate, expressed in atmospheres per cubic centimetre per second.

A.2.5.4 Detector

The detector shall be inserted into the flush chamber outlet line through a T-fitting. This fitting shall be situated at least 1 m upstream of the termination of the flush chamber outlet line. The probe tip shall be located approximately level with the centreline of the outlet line.

A.2.5.5 Response time of the system

The time is recorded when, for example, the cylinder calibration gas mixtures is opened to the system and when the increase in detector output signal becomes stable. The elapse time between the cylinder opening and the moment where the reading represents 90 % of the equilibrium signal is the response time of the system.

A.2.5.6 Safety

All accessories used to contain pressure in the valve body (flanges, bolting, all fittings etc.) shall be suitable for test pressure and temperature.

The valve to be tested shall be carefully fastened before pressurization and cycling.

The pressure inside the valve body shall be increased slowly.

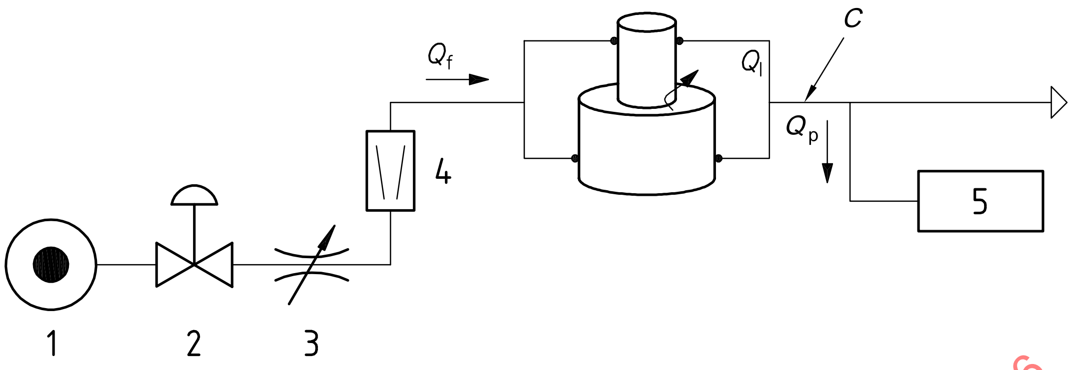
A.2.5.7 Personnel qualification

This method shall be applied by qualified and suitably trained operators.

A.2.6 Testing procedure

A.2.6.1 Test set-up

The test set-up is shown in Figure A.5.



Key

C concentration

Q_f is the flush gas flow rate, expressed in atmospheres per cubic centimetre per second

Q_l is the leak rate, expressed in atmospheres per cubic centimetre per second

Q_p is the total probe flow rate, expressed in atmospheres per cubic centimetre per second

1 flush gas supply
2 pressure regulator
3 flow rate control
4 flow rate measurement
5 detector

Figure A.5 — Schematic illustration of flush method set-up

A.2.6.2 Preparation of the tested valve

Before each test

- the valve is cleaned and dried;
- the packing tightening checked.

The hydrostatic test shall be performed before testing the valve in high pressure and high temperature conditions.

It is required to change packing before any sealing test (when using packing in the stem sealing system).

A.2.6.3 Calibration

See A.2.4.

A.2.6.4 Measurement

a) Establishment of the flush gas stream in the flush chamber.

b) zero gas level recording.

c) determination of the system response time.

d) valve pressurisation.

e) test temperature stabilization.

f) concentration recording.

g) concentration stabilization.

h) concentration measurement.

A.2.7 Leak rate calculation

The leakage rate is calculated from the following equation:

$$Q_\text{l} = C \times Q_\text{f}$$

where

Q_l is the leak rate of test gas from stem seal, expressed in atmospheres per cubic centimetre per second;

C is the volumetric concentration of test gas in flush gas stream;

Q_f is the flow rate of flush gas into the flush chamber, expressed in atmospheres per cubic centimetre per second.

If the detector measures in ppm, the concentration shall be determined from the following equation:

$$C = \text{ppm} \times 10^{-6}$$

Alternatively, if the detector measures probe uptake of test gas, the concentration shall be determined from the following equation:

$$C = \frac{Q_\text{reading}}{Q_\text{p}}$$

where

C is the volumetric concentration of test gas in flush gas stream;

Q_reading is the probe uptake of test gas, i.e. instrument reading, expressed in atmospheres per cubic centimetre per second;

Q_p is the probe flow rate, expressed in atmospheres per cubic centimetre per second.

The mass flow rate, Q_m, expressed in milligrams per second, is calculated from Q_l by

$$Q_\text{m} = Q_\text{l} \times \rho$$

where

Q_l is the leak rate of test gas from stem seal, expressed in atmospheres per cubic centimetre per second;

ρ is the test gas density at the test temperature and is expressed in milligrams per cubic centimetre.

Then the leak rate, Q_mm, expressed in milligrams per second per meter outer stem perimeter, is calculated from Q_m by

$$Q_\text{mm} = \frac{Q_\text{m}}{(\pi \times \text{OD}_\text{stem})}$$

where OD_stem is the diameter of the stem, expressed in metres.

Annex B
(normative)

Leak measurement using the sniffing method

B.1 Use of helium as test fluid

B.1.1 Scope

This annex specifies the use of an helium leak detector, fitted with a detector probe (sniffer), to measure helium concentration due to emissions from stem sealing systems and body seals.

The test fluid is helium.

The measurements are made according to the principle described in EPA procedure 21 (see B.1.2).

B.1.2 Reference

Environmental Protection Agency, *Determination of volatile organic compound leak*. Code of Federal Regulations, Title 40, Part 60, Appendix A, *Reference method 21*. Washington, D.C., U.S. Government Printing Office (Revised June, 1990).

B.1.3 Terms and definitions

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

B.1.3.1
leak definition concentration
local helium concentration at the surface of a leak source that indicates that a leak is present

B.1.3.2
calibration gas
concentration approximately equal to the leak definition concentration

B.1.3.3
no-detectable emission
any helium concentration at a potential leak source (adjusted for local helium ambient concentration) that is less than a value corresponding to the instrument readability specification of B.1.5.1.1 and which indicates that a leak is not present

B.1.3.4
calibration precision
degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration

B.1.3.5
response time
time interval from a step change in helium concentration at the input of the sampling system to the time at which 90 % of the corresponding final value is reached as displayed on the instrument readout master

B.1.4 Principle

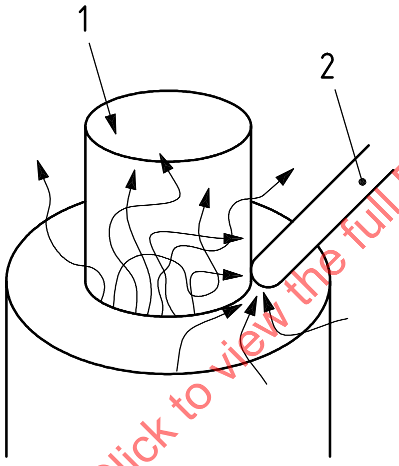
A portable instrument is used to detect leaks from valves. The instrument detector type is not specified. But the selected detector and its sensitivity shall be able to meet the tightness class limits. This procedure is intended to locate and classify leaks only, and is not used as a direct measure of mass emission rates from individual sources.

The detector probe (sniffing) method, see Figure B.1 and Figure B.2, allows the measurement of the local emission of the stem sealing system (production test) and body seals.

The measured concentration is expressed in parts per million volume (1 ppmv = 1 ml / m^3 = 1 cm^3 / m^3).

Some helium mass spectrometers are capable of measuring a local volumetric leak rate. It is expressed in millibars per litre per second or equivalent atmospheres per cubic centimetre per second.

To avoid any correlation between local and global measurement, measurement with the sniffing method is expressed in parts per million volume (1 ppmv = 1 ml / m^3 = 1 cm^3 / m^3).

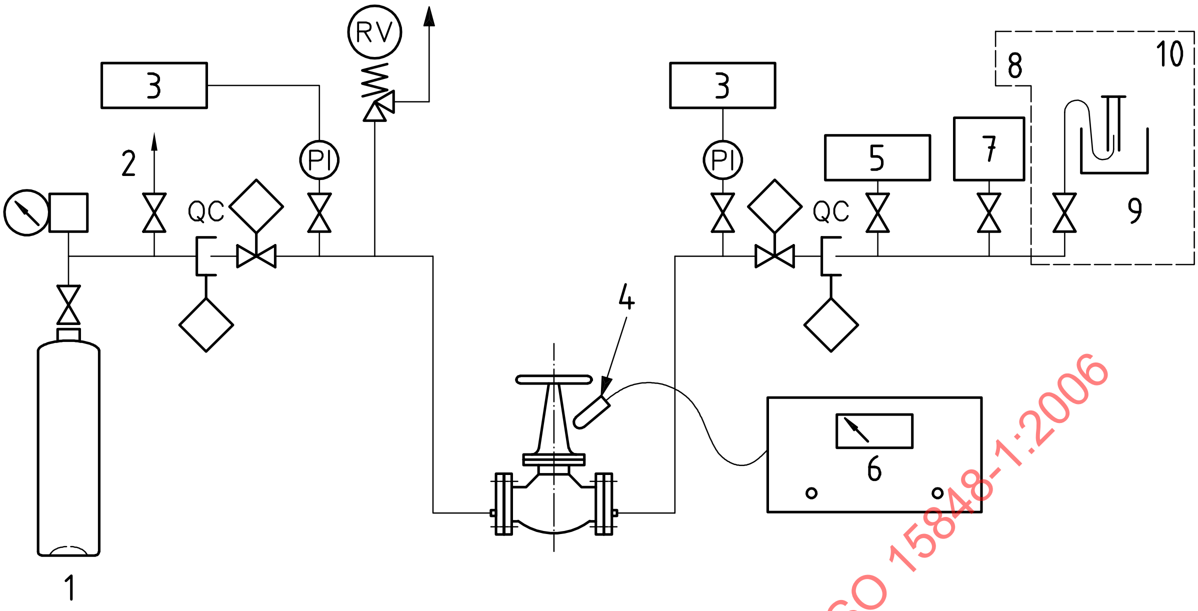


Key

1 valve stem

2 probe

Figure B.1 — Local measurement sniffing



Key

QC quick coupling

1	helium gas supply	6	mass spectrometer
2	vent	7	flow rotameter
3	pressure recorder	8	hose
4	probe	9	measuring cylinder
5	gas flow meter	10	safe location (outside)

Figure B.2 — Local measurement with sniffing method

B.1.5 Apparatus

B.1.5.1 Monitoring instrument

B.1.5.1.1 Specifications

a) The helium instrument detector type may include, but is not limited to, mass spectrometry, infrared absorption, and molecular screening.

b) Both the linear response range and the measurable range of the instrument shall encompass the leak definition concentration specified in the regulation. A dilution probe assembly may be used to bring the helium concentration within this range, however, the specification for helium sample probe diameter shall still be met.

c) The scale of the instrument meter shall be readable to ± 2,5 % of the specified leak definition concentration when performing a no-detectable emission survey.

d) The instrument shall be equipped with an electrically driven pump to insure that a sample is provided to the detector at a constant flow rate. The probe flow rate shall be between 0,5 l·min^{-1} and 1,5 l·min^{-1}.

e) The instrument shall be equipped with a probe or probe extension for sampling not to exceed 1/4 inch in outside diameter, with a single end opening for admission of sample.

B.1.5.1.2 Performance criteria

a) The instrument pump, dilution probe (if any), sample probe and probe filter, that is used during testing, shall all be in place during the response time determination.

b) The calibration precision shall be equal to or less than 10 % of the calibration gas value.

B.1.5.1.3 Performance evaluation requirements

The calibration precision test shall be completed prior to placing the analyser into service, and at subsequent three-month intervals or at the next use whichever is later.

B.1.5.2 Calibration gases

The monitoring instrument is calibrated in terms of parts per million by volume (1 ppmv = 1 ml / m^3 = 1 cm^3/m^3) of helium specified in the applicable regulation. The calibration gases required for monitoring and instrument performance evaluation are a zero gas (air, less than 10 ppmv helium) and a calibration gas in air mixture approximately equal to the leak definition specified in the regulation. If cylinder calibration gas mixtures are used, they shall be analysed and certified by the manufacturer to be within ± 2 % accuracy, and a shelf life shall be either reanalysed or replaced at the end of the specified shelf life. Alternatively, calibration gases may be prepared by the user according to any accepted gaseous standards preparation procedure that yields a mixture accurate to within ± 2 %. Prepared standards shall be replaced each day of use unless it can be demonstrated that degradation does not occur during storage.

B.1.6 Requirements for the test

B.1.6.1 Effect of the temperature

The higher the temperature of the component, the higher the saturating vapour pressure. Consequently, the temperature may modify the concentration measurement. This should be made in a place where the temperature remains stable whatever the external climatic conditions.

B.1.6.2 Weather effect

The leak measurements by sniffing are particularly sensitive to variations in the gaseous atmosphere. This is more particularly true for

- outdoor measurements,
- low-level measurements (see B.1.2).

The atmosphere within the room where the leaks take place shall be calm and the openings shall remain closed throughout the measurement.

B.1.6.3 Safety

High helium pressure levels or vacuum conditions in conjunction with high temperatures require safety rules to be applied by operators during testing and measurement.

B.1.7 Measurements of emissions

B.1.7.1 Calibration procedures

Assemble and start up the helium analyser according to the manufacturer's instructions. After the appropriate warm-up period and zero internal calibration procedure, introduce the calibration gas into the instrument sample probe. Adjust the instrument meter readout to correspond to the calibration gas value.

NOTE If the meter readout cannot be adjusted to the proper value, a malfunction of the analyser is indicated.

B.1.7.2 Measurement

Start-up of the helium mass spectrometer as instructed by the manufacturer, electronics heating.

a) Calibration;

b) Background noise measurement: prior to each measurement, the ambient helium concentration around the source is determined by moving the probe randomly at a distance of 1 m or 2 m from the source. When there is interference in the measurement with a leak nearby, the ambient concentration can be determined closer to the source but the distance should in no case be smaller than 25 cm.

c) The probe is positioned as close as possible to the potential leak source, namely

   - at the interface where the stem exits the packing;
   - at the outer edge of the body seals.

d) Move the probe along the interface periphery while observing the instrument readout.

e) If an increased meter reading is observed, slowly sample the interface where leakage is indicated until the maximum meter reading is obtained.

f) Leave the probe inlet at this maximum reading location for approximately two times the instrument response time.

g) Then the operator reads the maximum value and records it by making the probe remain in the same place during a period of time about twice the instrument response time (e.g. a few seconds for a 5-m standard probe).

h) The difference between this measurement and the background noise determines whether there are no detectable emissions.

i) Detectable emissions from emission source impose the background level to be lower than the acceptable emission level (50 ppmv).

B.2 Methane as test fluid

B.2.1 Scope

This annex specifies the use of a VOC instrument detector, fitted with a detector probe (sniffer), to measure methane concentration due to emissions from stem sealing systems and body seals.

The test fluid is methane.

The measurements are made according to the principle described in EPA procedure 21 (see B.2.2).

B.2.2 Reference

Environmental Protection Agency, *Determination of volatile organic compound leak*. Code of Federal Regulations, Title 40, Part 60, Appendix A, *Reference method 21*. Washington, D.C., U.S. Government Printing Office (Revised June, 1990).

B.2.3 Terms and definitions

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

B.2.3.1

leak definition concentration

local VOC concentration at the surface of a leak source indicating that a VOC emission (leak) is present

NOTE The leak definition is an instrument meter reading based on a reference compound.

B.2.3.2

reference compound

VOC species selected as an instrument calibration basis for specification of the leak definition concentration

EXAMPLE For example, if a leak definition concentration is 10 000 ppmv as methane, then any source emission that results in a local concentration that yields a meter reading of 10 000 on an instrument calibrated with methane would be classified as a leak. In this example, the leak definition is 10 000 ppmv, and the reference compound is methane.

B.2.3.3

calibration gas

VOC compound used to adjust the instrument meter reading to a known value

NOTE The calibration gas is usually the reference compound at a concentration approximately equal to the leak definition concentration.

B.2.3.4

no-detectable emission

VOC concentration at a potential leak source (adjusted for local VOC ambient concentration) that is less than a value corresponding to the instrument readability specification of B.2.5.1.1 and which indicates that a leak is not present

B.2.3.5

response factor

ratio of the known concentration of a VOC compound to the observed meter reading when measured using an instrument calibrated with the reference compound specified in the application regulation

B.2.3.6

calibration precision

degree of agreement between measurements of the same known value, expressed at the relative percentage of the average difference between the meter readings and the known concentration to the known concentration

B.2.3.7

response time

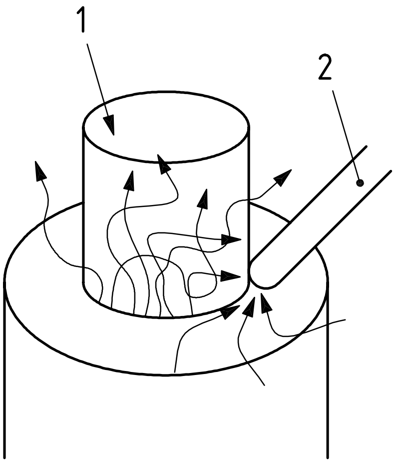
time interval from a step change in VOC concentration at input of the sampling system to the time at which 90 % of the corresponding final value is reached as displayed on the instrument readout meter

B.2.4 Principle

A portable instrument is used to detect VOC leaks from individual sources. The instrument detector type is not specified, but it shall meet the specifications and performance criteria contained in B.2.5.1.2. A leak definition concentration based on a reference compound is specified in each applicable regulation. This procedure is intended to locate and classify leaks only, and is not to be used as a direct measure of mass emission rates from individual sources.

The detector probe (sniffing) method allows the measurement of the local emission of the stem sealing system (production test) and body seals.

The measured concentration is expressed in parts per million volume (1 ppmv = 1 ml / m^3 = 1 cm^3 / m^3).



Key

1 valve stem

2 probe

Figure B.3 — Local measurement (sniffing)

B.2.5 Apparatus

B.2.5.1 Monitoring instrument

B.2.5.1.1 Specifications

a) The VOC instrument detector shall respond to the compounds being processed. Detector types which may meet this requirement include, but are not limited to, catalytic oxidation, flame ionization, infrared absorption and photo ionization.

b) Both the linear response range and the measurable range of the instrument for each of the VOC to be measured, and for the VOC calibration gas that is used for calibration, shall encompass the leak definition concentration specified in the regulation. A dilution probe assembly may be used to bring the VOC concentration within both ranges; however, the specifications for instrument response time and sample probe diameter shall still be met.

c) The scale of the instrument meter shall be readable to ± 2,5 % of the specified leak definition concentration when performing a no-detectable emission survey.

d) The instrument shall be equipped with an electrically driven pump to insure that a sample is provided to the detector at a constant flow rate. The nominal sample flow rate, as measured at the sample probe tip, shall be 0,10 $l \cdot min^{-1}$ to 3,0 $l \cdot min^{-1}$ when the probe is fitted with a glass wool plug or filter that may be used to prevent plugging of the instrument.

e) The instrument shall be intrinsically safe as designed by the applicable U.S. standards (e.g. *National Electric Code* by the National Fire Prevention Association) for operation in any explosive atmospheres that may be encountered in its use. The instrument shall, at a minimum, be intrinsically safe for Class 1, Division 1 conditions, and Class 2, Division 1 conditions, as defined by the example Code. The instrument shall not be operated with any safety device, such as an exhaust flame arrestor.

f) The instrument shall be equipped with a probe or probe extension for sampling not to exceed 1/4 inch in outside diameter, with a single end opening for admission of sample.

B.2.5.1.2 Performance criteria

a) The instrument response factors for each of the VOC to be measured shall be less than 10. When no instrument is available that meets this specification when calibrated with the reference VOC specified in the applicable regulation, the available instrument may be calibrated with one of the VOC to be measured, or any other VOC, so long as the instrument then has a response factor of less than 10 for each of the VOC to be measured.

b) The instrument response time shall be equal to or less than 30 s. The instrument pump, dilution probe (if any), sample probe and probe filter, that is used during testing, shall all be in place during the response time determination.

B.2.5.1.3 Performance evaluation requirements

a) A response factor shall be determined for each compound that is to be measured, either by testing or from reference sources. The response factor tests are required before placing the analyser into service, but do not have to be repeated at subsequent intervals.

b) The calibration precision test shall be completed prior to placing the analyser into service, and at subsequent three-month intervals or at the next use whichever is later.

c) The response time test is required prior to placing the instrument into service. If a modification to the sample pumping system or flow configuration is made that would change the response time, a new test is required prior to further use.

B.2.5.2 Calibration gases

The monitoring instrument is calibrated in terms of parts per million by volume (1 ppmv = 1 ml / m^3 = 1 cm^3 / m^3) of the reference compound specified in the applicable regulation. The calibration gases required for monitoring and instrument performance evaluation are a zero gas (air, less than 10 ppmv VOC) and a calibration gas in air mixture approximately equal to the leak definition specified in the regulation. If cylinder calibration gas mixtures are used, they shall be analysed and certified by the manufacturer to be within ± 2 % accuracy, and a shelf life shall be specified. Cylinder standards shall be either reanalysed or replaced at the end of the specified shelf life. Alternatively, calibration gases may be prepared by the user according to any accepted gaseous standards preparation procedure that yields a mixture accurate to within ± 2 %. Prepared standards shall be replaced each day of use, unless it can be demonstrated that degradation does not occur during storage. Calibrations may be performed using a compound other than the reference compound if a conversion factor is determined for that alternative compound, so that the resulting meter readings during source surveys can be converted to reference compound results.

B.2.6 Requirements for the test

B.2.6.1 Effect of the temperature

The higher the temperature of the component, the higher the saturating vapour pressure. Consequently, the temperature can modify the concentration measurement. This should be made in a place where the temperature remains stable whatever the external climatic conditions.

B.2.6.2 Weather effect

The leak measurements by sniffing are particularly sensitive to variations in the gaseous atmosphere. This is more particularly true for:

- outdoor measurements;
- low-level measurements (see B.2.2).

The atmosphere within the room where the leaks take place shall be calm and the openings shall remain closed throughout the measurement.