

BS EN 14624:2012



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Performance of portable leak detectors and of room monitors for halogenated refrigerants

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National foreword

This British Standard is the UK implementation of EN 14624:2012. It supersedes BS EN 14624:2005 which is withdrawn.

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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English Version

Performance of portable leak detectors and of room monitors for halogenated refrigerants

Performances des détecteurs de fuite portables et des contrôleurs d'ambiance de fluides frigorigènes halogénés

Leistung von mobilen Leckdetektoren und Raumüberwachungsgeräten für halogenierte Kältemittel

This European Standard was approved by CEN on 19 November 2011.

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Foreword

This document (EN 14624:2012) has been prepared by Technical Committee CEN/TC "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of an identical text or by endorsement, at the latest by July 2012, and conflicting national standards shall be withdrawn at the latest by July 2012.

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

This document supersedes EN 14624:2005.

The following changes have been made during revision:

- a) Clause 3 "Terms and definitions" has been revised;
- b) Clause 11 "Performance tests" has been completely revised;
- c) Annex B "Correlation between test gas concentration and leakage rate" has been modified;
- d) Annex C "Guideline for monitoring a machinery room or space for gas leaks" has been included.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

The purpose of this European Standard is to qualify the performance of portable sniffing leak detectors and room monitors for halogenated refrigerants. These leak detectors are designed for the detection of CFC, HCFC, HFC and PFC halogenated gases, and their detection limit is checked with a calibration leak or calibration gas.

2 Normative references

Not applicable.

3 Terms and definitions

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

3.1

chloro-fluoro-carbon (CFC)

fully halogenated halocarbon composed only of chlorine, fluorine and carbon

NOTE The hydrogen is completely substituted.

3.2

hydro-chloro-fluoro-carbon (HCFC)

partly halogenated halocarbon composed only of hydrogen, chlorine, fluorine and carbon

3.3

hydro-fluoro-carbon (HFC)

partly fluorinated halocarbon composed only of hydrogen, fluorine and carbon

3.4

perfluoro-carbon (PFC)

fully fluorinated halocarbon composed only of fluorine and carbon

NOTE The hydrogen is completely substituted.

3.5

gas concentration

ratio in weight or in volume of a given gas to the total weight or volume of the gas mixture

NOTE 1 The concentration is dimensionless and is designated either with ppm (m/m) = parts per million (mass) or ppm (V/V) = parts per million (volume).

NOTE 2 ppm: statement of concentration for gases; parts per million expressed in volume per volume ratio.

3.6

leakage rate

gas flow through a fissure, an orifice or aperture of specified size

NOTE 1 The usual leakage rate unit is gram per year (g/a), see Annex A (informative).

NOTE 2 The gas flow channels are some micrometers of diameter and have a large length/diameter ratio.

3.7
room monitor
fixed device, with one or several sensors, permitting the indication or the measurement of concentrations of halogen gases in the atmosphere at one or several points in one room or in several rooms

3.8
locating leak detector
either indicating or measuring portable leak detector with a detector probe capable of localizing a leak by measuring a local gas concentration with short response time

3.9
indicating leak detector
leak detector indicating one or several levels of concentration or leakage rate thresholds, but with no indication of the measured value

3.10
measuring leak detector
leak detector that measures leakage rates or concentrations and displays the respective value

3.11
calibration leak
device with a defined flow rate of a given gas under defined pressure and temperature conditions used to calibrate a leak detector

NOTE Calibration leaks are themselves calibrated according to operation conditions (upstream and downstream pressure) against a primary or secondary standard that is traceable to national standards (standard leak).

3.12
response time
time elapsing from the moment the probe is placed into a concentration or exposed to a calibration gas or in front of a leak until an alarm is triggered

3.13
recovery time
time required for a leak detection system or room monitor to indicate the lower detection limit again after exposure to a specified large leakage rate or concentration without any manual zeroing operation

3.14
zeroing time (for leak detectors)
time from immersion of the probe into a fixed concentration of halogen gas until indicated zero is stable (automatically or after a zeroing action specified by the manufacturer)

3.15
detection limit (lower, upper)
minimum or maximum detectable concentration or leakage rate which can be indicated with specified uncertainty and/or for which an alarm level can be set and is repeatedly triggered

3.16
alarm set points
one or more preset alarm set points/thresholds at which an alarm level(s) can be set and which can be repeatedly triggered by the appropriate concentration

4 Symbols and abbreviations

Table 1 — Symbols and abbreviations

Symbol	Description	Unit
V_{acc}	accumulation volume	m^3
V_{mol}	molar volume	m^3
M	molar mass	g/mol
\dot{m}	mass flow	kg/s or g/a
\dot{V}	molar mass flow rate	mol/s
\dot{q}_{pV}	Leakage rate (pV-throughput)	mbar - l/s or Pa - m^3/s
C	Concentration	V/V or m/m

5 Types of portable leak detectors and room monitors

The types of detectors shown in Table 2 are concerned in this European Standard:

Table 2 — Types of detectors

	Indicating	Measuring
Room monitor	A	B
Locating leak detector	C	D

Both the indicating leak detector and room monitor can be designed with thresholds: either one fixed threshold which is not adjustable or several fixed or adjustable thresholds.

Both the measuring leak detector and the room monitor comprise a scale and permit assigning of a measurement value to a gas concentration in the atmosphere.

6 General requirements for all portable leak detectors and room monitors

6.1 Gas type

The manufacturer shall specify the gas or the gas(es) that the leak detector is able to detect or measure.

6.2 Capabilities

Locating leak detectors or room monitors are single-gas or multi-gas measuring devices. They are selective or non-selective and shall be able to measure or indicate a concentration or leakage rate threshold of halogen gas.

Selective locating detectors or room monitors shall be able to identify a specific halogen gas among other gases. Non-selective locating detectors or room monitors cannot identify a specific halogen gas among other gases but they shall detect all halogen gases present in a gas mixture as a sum value.

6.3 Output signal

The indication or the measurement mode of the leak detector can be instantaneous or continuous and shall generate a signal (audible and/or visual) to indicate that a pre-set alarm level is exceeded (the signal alerts operators in charge of the leak tightness inspection or responsible for the supervision of the system charged with halogen gas).

6.4 Response time

The manufacturer shall specify the response time for the output signal.

6.5 Recovery time (clean up time)

The manufacturer shall specify the recovery time after the portable leak detector probe has been indicating the leakage rate of the largest refrigerant leak (upper detection limit).

6.6 Repeatability

For identical concentration values of a defined halogen gas, the leak detector or the room monitor shall give identical readings at repeated measurements within an uncertainty range specified by the manufacturer.

6.7 Calibration

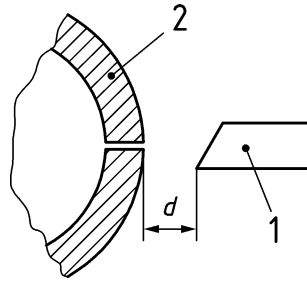
Checks/calibration, at least annually, shall be carried out in accordance with the manufacturer recommendations. For portable leak detectors a calibration leak shall be used. In the case of room monitors, a calibration gas shall be used.

Local regulations or standards may specify the frequency or nature of this check.

7 Specific requirements for locating portable leak detectors

7.1 General

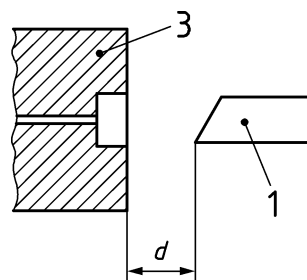
Locating leak detectors shall be able to indicate a halogen leak in two different situations: first, when the detector probe is stationary in front of a leak, second, when the detector probe is moving in front of a leak.



Key

- 1 sniffer probe
- 2 test object with leak
- d* sniffing distance

a) Sniffing distance *d* during leak search on a test object



Key

- 1 sniffer probe
- 3 calibration leak outlet
- d* sniffing distance

b) Sniffing distance *d* during calibration with a calibration leak

Figure 1 — Sniffing distance

7.2 Lowest detectable leakage rate threshold when the leak detector is stationary

The leak detector with the probe held stationary in front of a leak at a distance of 3 mm shall give a visual or acoustical alarm indicating that the threshold value set equal to the leakage rate value has been exceeded. Testing conditions are detailed in 11.1.

7.3 Lowest detectable leakage rate threshold value when the detector probe is moving

The detector probe, when moved across a leak passing at a speed of 2 cm/s and a distance of 3 mm in front of the leak exit, shall be able to repeatedly detect this leakage rate. Testing conditions are detailed in 11.1.

7.4 Leak detection in a contaminated environment

The leak detector shall be able to compensate for a slowly varying contaminating concentration of the halogen refrigerant and retain its detection ability for leak location.

8 Specific requirements for room monitors

8.1 General

Room monitors can be single-sensor or multi-sensor instruments. Requirements shall be verified for each sensor.

8.2 Lowest detectable concentration (lower detection limit)

The manufacturer shall specify the lowest detectable concentration in parts per million (ppm).

8.3 Highest tolerable concentration (upper detection limit)

The manufacturer shall specify the highest detectable concentration in parts per million (ppm) (this is the critical concentration which prevents the cell from recovering to its initial detection limit).

8.4 Upper and lower alarm thresholds

The manufacturer shall specify the method to set upper and lower alarm thresholds, and the way the user can check them.

8.5 Response time for alarm trigger

The manufacturer shall specify the response time.

9 Calibration leaks

9.1 General

Two types of calibration leaks exist and are commercially available: capillary calibration leaks and membrane calibration leaks (permeation membrane). Industrial calibration leaks permit to verify the correct operation of on-site leak detectors. Industrial membrane or capillary calibration leaks shall be re-calibrated after a time recommended by the manufacturer. The accuracy of calibration leaks shall be specified by the manufacturer by a statement of uncertainty of the nominal leakage rate.

Industrial calibration leaks shall be calibrated with reference to secondary standards, which can also be calibration leaks. These secondary standards are calibrated with reference to a primary standard made available by the respective national metrological institute.

Secondary standards: leaks calibrated with reference to the primary standard are used for the calibration of industrial calibration leaks and for the qualification of leak detectors in the test apparatus described in Clause 10.

9.2 Calibration gases

A calibration gas consists of the target gas at a specified concentration e.g. R404A at 1000 ppm, in a carrier gas such as air or nitrogen and at a specified concentration uncertainty.

Calibration gases are readily available in cylinders or may be produced in test chambers by injection of the target gas by syringe or by the use of calibrated mass flow controllers or equivalent.

10 Test apparatus

10.1 General

R-134a is the reference refrigerant for measurements described in the following procedures. R-25 and R-32 are used for selectivity tests.

10.2 Apparatus no. 1: detector probe stationary at the orifice of a calibration leak

The apparatus comprises a calibration leak that is a secondary standard with $\pm 15\%$ uncertainty of its value.

The apparatus is located in a room where ambient temperature is (20 to 25) °C and relative humidity (30 to 70) % at atmospheric pressure.

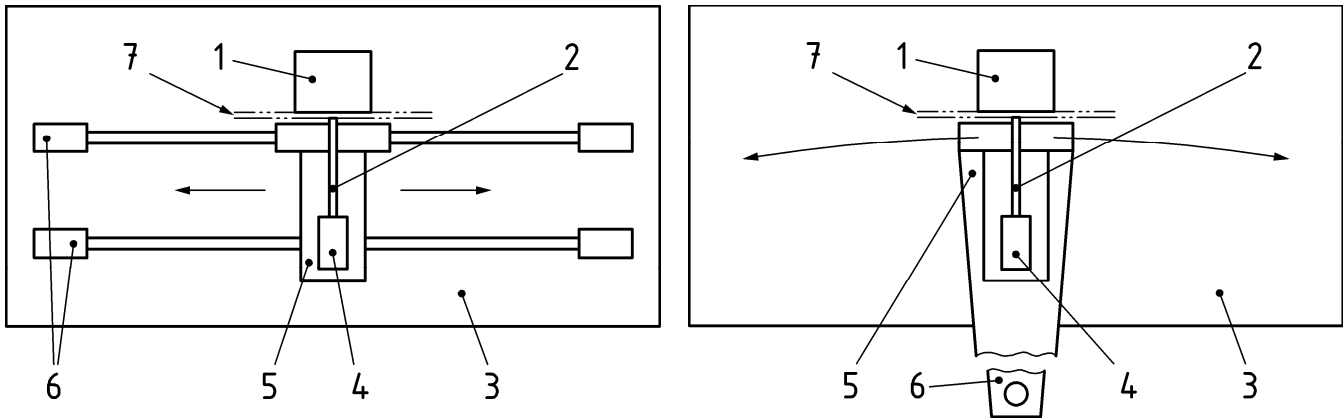
The alarm threshold of the leak detector is set to the nominal leakage rate value of the calibration leak in the test device.

10.3 Apparatus no. 2: detector probe moved with defined speed and distance in front of a calibration leak

The apparatus comprises a calibration leak that is a secondary standard with uncertainty of $\pm 15\%$ of its value.

The detector probe is located on a sliding carriage or pivoting arm which can be moved from left to right and vice-versa in front of the leak exit at a speed adjustable between 1 cm/s and 3 cm/s, the distance adjustable in the range of 1 mm to 5 mm with a minimum deflection of approximately 10 cm (the dwell time offside the leak shall at least be equal to the recovery time).

The apparatus, see Figure 2, is located in a room where ambient temperature is (20 to 25) °C and relative humidity (30 to 70) % at atmospheric pressure. The alarm threshold of the leak detector is set to the nominal leakage rate value of the calibration leak in the test device.



Key

- 1 calibration leak
- 2 leak detector probe
- 3 base plate
- 4 leak detector
- 5 sliding carriage with variable speed
- 6 driving system of the sliding carriage
- 7 minimum distance between the calibration leak exit and the sensor probe tip

a) — Apparatus no. 2: test stand with sliding leak detector probe

Key

- 1 calibration leak
- 2 leak detector probe
- 3 base plate
- 4 leak detector
- 5 pivoting arm with variable speed
- 6 driving system of the pivoting arm
- 7 minimum distance between the calibration leak exit and the sensor

b) — Apparatus no. 2: test stand with pivoting leak detector probe

Figure 2 — Apparatus no. 2

10.4 Apparatus no. 3: Chamber with monitored concentration

A definite concentration of R-134a vapour is generated by a gas mixing device or e.g. by injection of a definite volume of R-134a with a syringe into a tight chamber of known volume containing synthetic air. To obtain a uniform concentration in the chamber the gas is mixed with a fan, which is switched off before every measurement.

11 Performance tests

11.1 Performance test of locating leak detector

11.1.1 Test no. 1: Static detection

11.1.1.1 Detection limit

The locating leak detector probe is placed at a distance of $3 \text{ mm} \pm 0,5 \text{ mm}$ in front of the calibration leak of apparatus no. 1 during no longer than 10 s and the minimum leakage rate for triggering a respective alarm is determined. This test is repeated for various nominal values of leakage rates: 10 g/a, 5 g/a and 3 g/a until the detection limit is established. The leaks may have actual leakage rate values within $\pm 20 \%$ of the above nominal values.

11.1.1.2 Leak detector response time

After each test, the leak detector is placed in clean ambient air and the response time (see 6.4) is measured. The test is repeated 10 times for each value of calibration leakage rate, and the readings given by the leak detector are recorded. The indication can be either an audible or visual alarm or a reading if the system is a measuring leak detector.

11.1.1.3 Cross-sensitivity

The test for detection limit is repeated with the interfering gases R-125 and R-32 at the minimum leakage rate or concentration threshold measured previously. The leak detector's reading for the interfering gases is recorded.

11.1.2 Test no. 2: dynamic detection limit

The leak detector probe is placed on apparatus no. 2 at a distance of $3 \text{ mm} \pm 0,5 \text{ mm}$ moving at a speed of $(2 \pm 0,2) \text{ cm s}^{-1}$. The leak detector signal is recorded during each passage in front of the leak orifice. The dynamic detection limit test is repeated 10 times in a sequence and the output signal is recorded each time. This test is repeated for various nominal values of leakage rates: 10 g/a, 5 g/a and 3 g/a until the detection limit is established. The leaks used may have values within $\pm 20 \%$ of the above nominal values.

11.1.3 Test no. 3: detection limit in contaminated environment

The apparatus no. 2 is placed in a chamber (apparatus no. 3) where the concentration of halogen refrigerant is the maximum concentration in ppm as specified by the manufacturer.

In the absence of such a specification the maximum concentration shall be 1000 ppm. A tolerance of $\pm 10 \%$ of the concentration is acceptable.

The leak detector probe is located in the same chamber, the zeroing procedure of the leak detector as recommended by the manufacturer is applied and the dynamic detection limit is measured according to the same procedure as test no. 2.

11.1.4 Test no. 4: recovery time

The leak detector probe is placed in front of the largest leak as specified by the manufacturer for 10 s. If not specified by the manufacturer this leak shall be 50 g/a. The probe is then removed from the large leak and placed again in front of the apparatus no. 1 with the alarm trigger set to the detection limit. The recovery time is measured. This test is repeated five times.

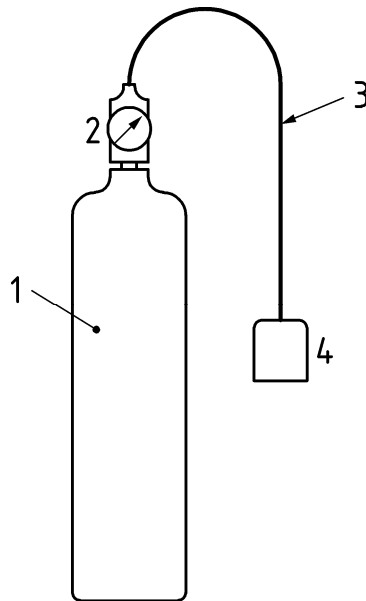
11.2 Performance tests of room monitor

11.2.1 General

These tests are carried out in a room at atmospheric pressure where ambient temperature is (20 to 25) °C and relative humidity (30 to 70) %.

11.2.2 Test a) to determine the upper and lower detection limits

Each sensor of the room monitor is located in the test chamber (apparatus no. 3) or alternatively, without a chamber, calibration gas ($\pm 5 \%$ concentration uncertainty) may be delivered directly to each sensor in turn using a typical calibration kit as shown in Figure 3.



Key

- 1 cylinder typically 44 cm high 110 l capacity of calibration gas
- 2 flow regulator typical flow 0,3 l/min
- 3 flexible non-absorbant tubing
- 4 vented calibration hood

Figure 3 — Calibration kit

Concentrations of 10 ppm, 20 ppm, 50 ppm, 100 ppm, 1000 ppm and intermediate or higher values if the manufacturer so requires, are generated successively in the test chamber (by injection of the required gas volume with a syringe or using a calibrated mass flow controller) or delivered to the sensor using calibration gases. The upper and lower detection limits shall be established and recorded.

11.2.3 Test b) to determine response time

The alarm set points, one or more e.g. 100 ppm or 500 ppm, are specified by the manufacturer.

Each sensor of the room monitor is located in the test apparatus chamber (apparatus no. 3) or alternatively, without a chamber, calibration gas may be delivered directly to each sensor in turn using a typical calibration kit.

The concentrations specified in turn (if more than one) are generated successively in the test chamber (by injection of the required gas volume with a syringe or using calibrated mass flow controllers) or delivered directly to the sensor using calibration gases.

The time to reach the alarm set point(s) or in the case of an indicating controller the time to display the specified values e.g. 50 % or 90 % of full scale is recorded.

11.2.4 Test c) to determine recovery time from exposure to a large concentration

The maximum concentration in ppm as specified by the manufacturer and established in 11.2.1 above is generated in the chamber of apparatus no. 3 or delivered directly to the sensor using a typical calibration kit.

In the absence of such a specification the maximum concentration shall be 1000 ppm. A tolerance of $\pm 10\%$ of the concentration is acceptable.

Each sensor of the room monitor is located in the test volume chamber of apparatus no. 3 and exposed to the maximum concentration or alternatively, without a chamber, exposed to calibration gas using a typical calibration kit. Then the recovery time of the room monitor sensor is measured by removing the sensor from the chamber or removing the calibration gas from the sensor and recording the time for the sensor to return to its lower detection limit as established in 11.2.1 above.

The above tests should be repeated a minimum of 10 times and the results averaged.

12 Instrument characteristics and reporting of test results

12.1 Characteristics of locating leak detector

- Static upper and lower detection limit for leakage rates:
Upper and lower detection limits are stated if all out of 10 measurements at these limits according to the test in 11.1.1.1 have been repeatable. The static detection limits are expressed in g/a.
- Dynamic detection limits:
Upper and lower detection limits are stated if all out of 10 measurements at these limits according to the test in 11.1.2 have been repeatable. The static detection limits are expressed in g/a.
- Detection limit in contaminated environment:
Upper and lower detection limits are stated if all out of 10 measurements at these limits according to the test in 11.1.3 have been repeatable. The static detection limits are expressed in g/a.
- Response time for leakage rates:
The response time is stated according to test no. 1 (see 11.1.1.2).
- Recovery time:
The recovery time of the leak detector is stated according to test no. 4 (see 11.1.4).

12.2 Characteristics of room monitors

- Upper and lower detection limits for concentrations:
Upper and lower detection limits are stated in the report according to the test a) in paragraph 11.2.2. The detection limits are expressed in ppm. The alarm set points, if any, are specified by the manufacturer in ppm.
- Response time for concentrations:
The response time is stated in the report according to test b) in paragraph 11.2.3 and is expressed in seconds.
- Recovery time:
The recovery time of the room monitor is stated in the report according to test c) (see 11.2.4) and is expressed in seconds.
- Lifetime of the cell:
The manufacturer's statement about the cell lifetime including both long exposures to low concentrations (in the range of 10 ppm) and unexpected exposures to high concentrations (in the range of 1000 ppm) is repeated in the report.

13 Technical data

13.1 Locating leak detectors

The product data sheet shall specify the following technical data:

- static upper and lower detection limits for the alarm triggers of locating leak detectors;
- dynamic upper and lower detection limits for the alarm triggers of locating leak detectors.

13.2 Measuring leak detectors

The product data sheet shall specify the following technical data:

- static upper and lower detection limits for the indication of concentrations or leakage rate values by measuring leak detectors;
- dynamic upper and lower detection limits for the indication of concentrations or leakage rate values by measuring leak detectors.

13.3 All portable leak detectors

The product data sheet shall specify the following technical data:

- response time;
- zeroing time;
- recovery time;
- lower detection limit in halogen gas contaminated environment;
- re-calibrating frequency;
- directions for use;
- safety instructions;
- leak detector weight.

13.4 Room monitor

The product data sheet shall specify the following technical data for concentration measurement:

- upper and lower detection limits;
- pre-set alarm point(s);
- response time to the lower alarm set point or measurement value specified e.g. 50 % full scale;
- response time to the upper alarm set point, if provided, or measurement value specified e.g. 90 % of full scale;
- recovery time;
- check/calibration frequency as specified in 6.7;

- installation instruction including guidelines for sensor locations in the room to be controlled;
- directions for use;
- safety instructions.

Annex A (informative)

Conversion factors of leakage rate units

Table A.1 — Most common units

y x	Pa · m ³ /s or W	Torr · l/s	atm · cm ³ /s	mbar · l/s
1 Pa · m ³ /s or W	1	7,5	9,87	10
1 Torr · l/s	0,133	1	1,32	1,33
1 atm · cm ³ /s	0,101 3	0,76	1	1,013
1 mbar · l/s	0,1	0,75	0,987	1

Table A.2 — Other units

Y X	Pa · m ³ /s	lusec (micron · 1/s)	m · ft ³ /s	std · cm ³ /s	atm · ft ³ /mn	mol/s
Pa · m ³ /s	1	$7,5 \times 10^3$	$2,65 \times 10^2$	9,87	$2,097 \times 10^{-2}$	$4,403 \times 10^{-4}$
lusec (micron 1/s)	$1,33 \cdot 10^{-4}$	1	$3,53 \times 10^{-2}$	$1,32 \times 10^{-3}$	$2,795 \times 10^{-6}$	$5,87 \times 10^{-8}$
m · ft ³ /s	$3,76 \times 10^{-3}$	$2,83 \times 10$	1	$3,71 \times 10^{-2}$	$7,92 \times 10^{-5}$	$1,662 \times 10^{-6}$
std · cm ³ /s	$1,013 \times 10^{-1}$	$7,6 \times 10^2$	$2,67 \times 10$	1	$2,12 \times 10^{-3}$	$4,461 \times 10^{-5}$
atm · ft ³ /mn	$4,78 \times 10$	$3,58 \times 10^5$	$1,264 \times 10^4$	$4,72 \times 10^2$	1	$2,105 \times 10^{-2}$
mol/s	$2,271 \times 10^3$	$1,703 \times 10^7$	$6,016 \times 10^5$	$2,24 \times 10^4$	47,49	1

Annex B (informative)

Correlation between test gas concentration and leakage rate

EXAMPLE 1a Conversion of a concentration increase in a hood to a total leakage volume flow rate (pV-throughput)

A test object pressurized with halogen gas should be tested for overall leakage. It is therefore placed in an envelope of given volume where the escaping halogen gas can accumulate for a definite period of time. After that time, the resulting concentration increase in the envelope measured with a leak detector probe (by puncturing the envelope with the probe tip).

The following assumptions are made:

- the envelope has a free volume (between test object and outer volume) $V = 0,2$ litre;
- the concentration increase is $\Delta c_{\text{halogen}} = 420$ ppm;
- the accumulation time is $\Delta t_{\text{acc}} = 1$ h;
- the pressure inside the envelope stays at atmospheric pressure $p_{\text{atm}} = 1\,000$ mbar during the accumulation time (this means a soft envelope with pressure contact to the ambient atmosphere).

The following equation yields the overall leakage rate as pV-throughput (volume flow rate):

$$q_{pV}^{\text{halogen}} = V \times \frac{\Delta c_{\text{halogen}} \times p_{\text{atm}}}{\Delta t} = 0,21 \times \frac{0,000\,42 \times 1\,000 \text{ mbar}}{3\,600 \text{ s}} = 2,3 \times 10^{-5} \text{ mbar l/s}$$

- **The test object has a leakage rate of $2,3 \times 10^{-5}$ mbar l/s R-134a.**

Conclusion:

To detect this leakage rate after 1 h accumulation time the leak detector has to be capable of measuring the assumed increase of refrigerant concentration of 420 ppm with good repeatability (its lower concentration detection limit should be better than 100 ppm).

(the conversion of this volume flow rate into a mass flow rate can be found in Example 2)

EXAMPLE 1b Concentration increase due to a small leak in a voluminous room

If measurement is carried out in a voluminous room and detection cells are placed at unknown positions relatively to potential emission sources, the time for the leakage gas concentration to reach the detection limit of a detection cell can be very long.

According to the equation from Example 1a the tracer gas escaping from a leak (the leakage rate q) generates an overall concentration increase (Δc) of the tracer gas within the room (volume V) within a time interval Δt according to the following equation:

$$q_{pV}^{\text{halogen}} = V_{\text{room}} \times \frac{\Delta c_{\text{halogen}} \times p_{\text{atm}}}{\Delta t}$$

for the elapsed time until the detection limit (Δc_{min}) is reached this yields:

$$\Delta t = V \times \frac{\Delta c_{\min} \times p_{\text{atm}}}{q_{pV}^{\text{halogen}}}$$

Assuming a room of dimensions 15 m × 10 m × 4 m, a detection cell with a concentration detection limit of 10 ppm and a leakage rate of $q_m = 5 \text{ g/a}$ (R-134a) equivalent to $q_{pV} = 3,8 \times 10^{-5} \text{ mbar} \cdot \text{l/s}$ this equation yields:

$$\Delta t = 15 \times 10 \times 4 \text{ m}^3 \times \frac{10^{-5} \times 1000 \text{ mbar}}{3,8 \cdot 10^{-5} \text{ mbar} \times 10^{-5} \text{ m}^3} \times \text{s} = 1,5 \times 10^8 \text{ s} = 5,0 \text{ a}$$

which means that the leak will never be detected.

Rearranging the above equation for the smallest detectable concentration and requiring a reasonable response time of e.g. 60 s, it turns out that the concentration is far below any feasible sensor detection limit.

All this means that it is essential to ventilate the room under control and place a room monitor in such a position that an air flow from the unit to be controlled is always directed across the sensor. In this case, the air flow acts as a so-called “carrier gas” in which the leaking gas is quickly carried to the sensor before it spreads throughout the whole room volume and becomes diluted to a concentration below the detection limit of the sensor.

In practice this means that several detectors will be needed combined with a carefully planned ventilation to make sure that no leakage gas escapes without any contact to a sensor and leaks could remain undetected.

Therefore, the smallest leak a room monitor can detect is strongly dependent on the position and air flow situation in the room under control: the leak detection limit of the method is mainly determined by the gas flow arrangement within the room.

The concentration detection limit of the room monitor determined by the tests in 11.2 is only a characteristic of the sensor and does not say anything about the detection limit in a specific situation.

Guidelines for monitoring a machinery room or space for gas leaks are given in Annex C (informative).

EXAMPLE 2 Conversion of a leakage rate (pV-throughput) into a mass flow rate

The leakage volume flow rate from Example 1 has to be converted into a mass flow rate to find the amount of lost refrigerant from the test object in grams per year (g/a).

For that purpose, the type of refrigerant and its molar mass have to be known. Let us assume R-134a with a molar mass of 102 g/mol.

As a starting point, one mole of every gas has a volume of approximately 24 l at room temperature and at atmospheric pressure.

With this data, the above calculated leakage rate firstly needs to be converted into “standard litres”, i.e. litres at 1 bar pressure or bar litres. $2,3\text{E-}05 \text{ mbar l/s}$ is found and since 1 bar is 1 000 mbar, the result is $2,3\text{E-}08 \text{ bar l/s}$.

In 1 h the following is then accumulated

$$3600\text{s} \times 2,3 \times 10^{-8} \text{ bar} \times \text{l/s} = 8,3 \times 10^{-5} \text{ l at atmospheric pressure.}$$

In 24 h this amounts to

$$24 \times \frac{8,3 \times 10^{-5} \text{ l}}{24 \text{ l/mol}} = 8,3 \times 10^{-5} \text{ mol of R134a or } 8,3 \times 10^{-5} \text{ mol} \times 102 \text{ g/mol} = 8,5 \times 10^{-3} \text{ g.}$$

This means a loss of $365 \times 8,5 \times 10^{-3} \text{ g}$ in one year = 3,1 g/a refrigerant R-134a.

The test object has a leakage rate of 3,1 g/a R-134a.

Conclusion:

This leak has been detected with a leak detector with a lower detection limit of 100 ppm.

To detect this leak by direct probing (without accumulation) the leak detector needs to have a much better performance. The respective concentration of halogen gas in front of a 3 g/a leak is calculated in Example 3.

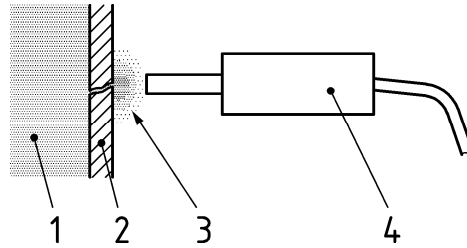
EXAMPLE 3 Calculation of the concentrations of tracer gas to be detected in front of a leak with specified leakage rate

To get an idea of what concentrations of refrigerant are found in front of a certain leak the following calculation of the diffusion cloud in front of a leak may be useful.

The refrigerant escaping from a leak does not flow away from the leak exit immediately diluting within the ambient air. In fact, there is a diffusion cloud in front of the leak which is formed because the gas diffusion is limited by the ambient air. This effect makes leak localization only possible since otherwise the leaking gas concentration in front of a small leak will be easily missed when scanning with a probe without knowing the leak location in advance.

Employing Fick's law for diffusion and integrating his differential equation over a semisphere in front of the leak one gets the following relation for the refrigerant concentration vs. radial distance from the leak exit:

$$c_{\text{ref}}(r) = \frac{q_{pV}^{\text{ref}}}{q_{pV}^{\text{ref}} + 2\pi \times D \times r \times p_{\text{atm}}}$$



Key

- 1 pressurized object
- 2 leak
- 3 cloud of refrigerants
- 4 sniffer probe

Figure B.1 — Concentration cloud of refrigerant gas in front of a leak

where q_{pV} is the volume flow rate of refrigerant from the leak, r is the radial distance from the leak, D is the diffusion coefficient of refrigerant in air and p_{atm} is the local atmospheric pressure.

With a plausible diffusion coefficient for refrigerants in air of $D = 1,5 \text{ E-}05 \text{ m}^2/\text{s}$ and the leakage rate from Example 1 of $2,3 \times 10^{-5} \text{ mbar l/s}$ the above equation yields a refrigerant concentration in 1 mm distance of 240 ppm.

Under steady state conditions, the indication of the leak detector is given by the ratio of the leakage rate and the gas aspiration rate of the sniffing line (under the assumption that all the gas escaping from the leak is taken up by the leak detector).

With a typical aspiration rate of 2,5 mbar l/s (150 sccm) and the leakage rate of $2,3 \text{ E-}05 \text{ mbar l/s}$ the concentration in the sniffing line is $(2,3 \text{ E-}5) / 2,5 = 9,2 \text{ ppm}$.

Conclusion:

This means that a measuring leak detector with a static lower leakage rate detection limit of 100 ppm can detect this leak after accumulation of the escaping halogen gas. A localizing leak detector of the same performance can only detect this leak if it comes as close as 1 mm to 2 mm to the leak exit and is kept there for some seconds.

In practice, this is not easy to achieve and in 5 mm of distance the concentration has already dropped to 50 ppm, in 10 mm down to 10 ppm.

To find such a leak one will have to scan and detect the refrigerant cloud concentration in some distance from the leak as shown in Figure B.1.

NOTE For a localizing leak detector to detect this leak when scanning across in 5 mm to 10 mm distance the detector should have a dynamic concentration detection limit of 10 ppm or better. To measure the above leakage rate correctly a measuring leak detector should have a static lower detection limit of 5 ppm or less.

Annex C (informative)

Guidelines for monitoring a machinery room or space for gas leaks

Sensors, which can also be used for occupant safety, monitor a point as opposed to an area. If a gas leak does not reach the sensor then an alarm will not be raised. Therefore, it is extremely important to carefully select the sensor location considering also ease of access for regular checks as required by standards and regulations.

There is no absolute rule or standard for determining the number of sensors and their location. However, a number of simple considerations will help to make a decision.

The size and nature of the site and the refrigerant in use will help to decide. With heavier than air gases, such as halocarbons, sensors should be placed down low. Locations requiring the most protection in a machinery room are around compressors, pressurised storage vessels, refrigerant cylinders or storage rooms or pipelines. Most vulnerable are valves, gauges, flanges, joints (brazed or mechanical), and pressure relief valve vent pipes, filling or draining connections.

When mechanical or natural ventilation is present sensors should be mounted in the airflow downstream of the equipment to be monitored. Depending on the site either of point detection, where sensors are located as near as possible to the most likely sources of leakage, such as the compressor, or perimeter detection, where sensors completely surround the area or equipment, will be more relevant. If in doubt, seek the manufacturer's guidance.

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