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Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods —

Part 8:
Diffusion method

Analyse des gaz — Préparation de mélanges de gaz pour étalonnage à l'aide de méthodes volumétriques —

Partie 8: Méthode par diffusion

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 6145-8 was prepared by Technical Committee ISO/TC 158, *Analysis of gases*.

ISO 6145 consists of the following parts, under the general title *Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods*:

- *Part 1: Methods of calibration*
- *Part 2: Volumetric pumps*
- *Part 4: Continuous syringe injection method*
- *Part 5: Capillary calibration devices*
- *Part 6: Critical orifices*
- *Part 7: Thermal mass-flow controllers*
- *Part 8: Diffusion method*
- *Part 9: Saturation method*
- *Part 10: Permeation method*
- *Part 11: Electrochemical generation*

Introduction

This part of ISO 6145 is one of a series of International Standards that present various dynamic volumetric methods used for the preparation of calibration gas mixtures. In the lower part of the mole fraction range considered, it is difficult to prepare and maintain gas mixtures – for example of certain organic or reactive components – in cylinders. This dynamic method has the advantage of a practically unlimited supply of calibration component, whereby adsorption effects can be reduced or even eliminated.

If the complementary gas flow is measured as a gas mass flow, the preparation of calibration gas mixtures using diffusion is a dynamic-gravimetric method which gives contents in mole fractions. Principles for the measurement of the complementary gas flow are given in ISO 6145-1.

Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods —

Part 8:
Diffusion method

1 Scope

This part of ISO 6145 specifies a dynamic method using diffusion for the preparation of calibration gas mixtures containing component mole fractions ranging from 10^{-9} to 10^{-3}. A relative expanded uncertainty of measurement, U, obtained by multiplying the relative combined standard uncertainty by a coverage factor $k = 2$, of not greater than ± 2 % can be achieved by using this method.

By keeping the path between the diffusion source and place of use as short as possible, the method can be applied for the generation of low-concentration calibration gases of organic components that are liquid at room temperature, with boiling points ranging from about 40 °C to 160 °C.

This part of ISO 6145 is applicable not only for the generation of calibration gas mixtures of a wide range of hydrocarbons at ambient and indoor air concentration levels, but also for the generation of low-concentration gas mixtures of water.

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 6145-7, *Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods — Part 7: Thermal mass-flow controllers*

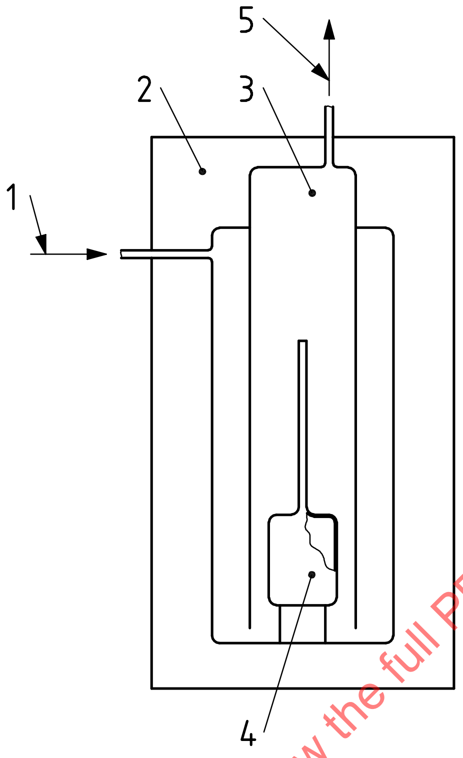
3 Principle

The calibration component migrates by diffusion through a diffusion tube of suitable dimensions (length, diameter) into a flow of a complementary gas, i.e. the complementary gas of the mixture prepared. The liquid calibration component, of a known high purity, is contained in a reservoir that acts as the source of the component vapour. The reservoir is provided with a vertically placed diffusion tube. This assembly (the diffusion cell) is placed in a temperature-controlled containment that is purged at a known and constant flow rate by a high-purity complementary gas (see Figure 1). The composition of the mixture is determined from the diffusion mass flow of the calibration component and the flow rate of the complementary gas.

The diffusion mass flow rate of the calibration component in principle depends on

- its diffusion coefficient in the complementary gas,
- its vapour pressure at the temperature of the containment,
- the dimensions of the diffusion tube.

Accurate determination of the mass flow rate is achieved by either continuous weighing, after mounting the tube in a suspension microbalance, or by periodic weighing. The method of determination affects the uncertainty of the (momentary) mass flow of the calibration component (see 7.2).



Key

1 complementary gas inlet
2 containment
3 diffusion tube
4 liquid reservoir
5 calibration gas outlet

Figure 1 — Schematic of diffusion apparatus

4 Reagents and materials

4.1 Liquid substances to be used as calibration component, of the highest possible purity so as to avoid any effects on the diffusion mass flow.

If possible, the nature and quantities of the impurities should be known and allowance made for their effects.

4.2 Complementary gas, of known purity, established by appropriate analytical techniques, e.g. Fourier-transform infrared spectrometry or gas chromatography.

The nature of the complementary gas shall be adapted to the substance to be used as the calibration component. For example, air shall not be used as complementary gas for the preparation by diffusion of calibration gas mixtures of oxidizable substances.

5 Apparatus

5.1 Diffusion apparatus

5.1.1 Materials

The materials of the diffusion apparatus shall be chosen so as to avoid effects of physical or chemical sorption or desorption on the content of the calibration component. The smaller the desired content, the greater the effect of sorption/desorption phenomena.

Diffusion reservoirs and tubes, as well as temperature containments and blending apparatus, should preferably be manufactured out of borosilicate glass. Choose chemically inert, flexible tube materials for the supply of complementary gas and transport of calibration gas mixture. Pay special attention to all junctions as possible sources of leaks.

5.1.2 Complementary gas flow configuration

Before the complementary gas reaches the diffusion cell, it is essential that its temperature be controlled to that of the diffusion cell containment. In order to achieve the uncertainty stated in Clause 1, the temperature in the containment should be controlled to within ± 0,15 K.

The minimum flow rate of the complementary gas should be sufficient to remove all component vapour without saturation. The maximum allowable rate should be low enough to avoid convective transport of the calibration component vapour inside the diffusion tube. This maximum flow rate is dependent upon the geometry of the diffusion apparatus. It is recommended to keep the Reynolds number of the complementary gas flow in the diffusion cell below 100. At a temperature of 25 °C, the following condition should approximately be fulfilled:

$$v \cdot d < 1{,}6 \times 10^{-3}$$

where

v is the average linear velocity of the complementary gas, in metres per second;

d is the diameter, in metres, of the tubing through which the complementary gas flows.

5.1.3 Choice of temperature

The choice of temperature depends on the diffusion cell characteristics and the diffusion mass flow rate required. To carry out temperature control, establish thermal equilibrium within the diffusion cell at a value close to ambient temperature or at a temperature sufficiently above ambient so as to avoid effects of ambient conditions on temperature control. The use of a temperature slightly above ambient has two advantages:

- accurate control of temperature can more easily be achieved near ambient temperature,
- the temperature of the complementary gas can more easily be controlled.

5.2 Diffusion cells, consisting of a borosilicate glass reservoir capable of holding a sufficiently large quantity of the liquid calibration component, fitted with a diffusion tube. Several design examples are given in Reference [1].

In principle, Equation (1) can be applied for the prediction of diffusion volume flow rates [1] and, conversely, for the calculation of approximate dimensions and temperatures of diffusion tubes and containments necessary for the generation of a given mass flow rate of the calibration component.

$$q_V(\text{A}) = \frac{A}{L} D \cdot \ln\left(\frac{p}{p - p_\text{V}}\right) \tag{1}$$

where

$q_V(\text{A})$ is the volume flow rate of component A, in cubic metres per second;

A is the cross-sectional area of the diffusion tube, in square metres;

L is the length of the diffusion tube, in metres;

D is the diffusion coefficient, in square metres per second;

p is the pressure in the diffusion cell, in pascals or kilopascals;

p_v is the partial pressure of the calibration component, in pascals or kilopascals.

If no data for the diffusion coefficients exist, methods for their calculation are given in the literature. The method of Fuller, Schettler and Giddings [2] is the most successful, but errors of up to 25 % can easily occur. Data for the atomic and structural volume increments applicable to calibration component and complementary gases and vapours are given in Reference [4].

To achieve the best performance, diffusion tubes should remain within the following dimensional ranges:

— $L > 0{,}03$ m;

— ratio of L to diameter of diffusion tube > 3;

— diameter: 0,001 m to 0,02 m.

NOTE Units which operate on the diffusion principle are commercially available and provide calibration gas mixtures containing highly adsorptive vapours. An example of one such unit for the preparation of reference standards of humidity in volume fractions of 10^{-9} and its performance details are given in Annex A.

6 Procedure

6.1 Preliminary checks and operating conditions

Before assembling or filling a diffusion cell, the purity of the substance to be used as calibration component is to be assessed using an appropriate analytical technique (e.g. Fourier-transform infrared spectrometry or gas chromatography) so as to quantify any likely major contaminants.

Periodically check the diffusion mass flow at a known, fixed temperature and complementary gas flow rate as an indication of stability of the calibration compound in the reservoir. If the diffusion mass flow drifts by more than 1 % per month, this may be an indication of the presence of impurities. In that case, the contents of the diffusion cell should be replaced.

When first placing the diffusion cell in its containment, allow the system to equilibrate before performing the first weighing so as to ensure constancy of the diffusion mass flow. Generally, a period of 24 h is sufficient.

To change the content of the calibration gas mixture, adjust the complementary gas flow rate. Alternatively, the calibration gas mixture can be further diluted, and its contents adjusted, by application of a secondary flow of a diluent gas. Changing the temperature of the diffusion-cell containment for adjustment of the content of the calibration gas mixture is not recommended.

During the period of use, maintain the diffusion cell at constant temperature in order to avoid delay due to the time needed to restore equilibrium.

6.2 Determination of mass loss

6.2.1 Handling the diffusion cell

Ensure that all weighing is performed with extreme cleanliness and avoid direct contact of the diffusion cell with hands. Use gloves and clean pliers or tweezers. If appropriate, depending on the type used, close the diffusion cell before weighing.

6.2.2 Periodic-weighing mode

The temperature and relative humidity in the weighing room should be controlled and kept constant during successive readings. The cell is periodically removed from the enclosure, weighed, and returned immediately to the enclosure. In a given time interval, the diffusion cell will decrease in mass. The measurement of this change in mass will have an associated measurement uncertainty. Therefore, the choice of the time interval over which the weighings are made depends on the required uncertainty. Choose the time interval such that the weighing uncertainty is a small fraction (e.g. $< 1\%$) of the mass loss of the diffusion cell during this interval. Determine the diffusion rate by calculation of the mass difference between the periodic weighings and the time interval between them.

Because of the dependence of the diffusion mass flow rate on ambient pressure, a correction to standard pressure (usually 101,325 kPa) may be applied as follows

$$\bar{q}_m(\mathrm{A}) = \frac{\Delta m}{\Delta t}\frac{\bar{p}}{p_0} \tag{2}$$

where

$\bar{q}_m(\mathrm{A})$ is the average mass flow rate of component A from the diffusion cell over time period Δt, in grams per minute;

Δm is the mass difference, in grams, between consecutive weighings;

Δt is the time interval, in minutes, between consecutive weighings;

$\bar{p}$ is the average air pressure, in kilopascals, over the interval between weighings;

p_0 is the standard pressure for correction (usually 101,325 kPa).

The actual momentary mass flow is then calculated from q_m(A) by applying a reverse correction for actual pressure

$$q_m(\mathrm{A}) = \bar{q}_m(\mathrm{A})\frac{p_0}{p} \tag{3}$$

where p is the actual air pressure, in kilopascals.

NOTE An example of the mass flows of diffusion cells for toluene and for trichloromethane as a function of time is given in Annex B.

6.2.3 Continuous-weighing mode

The diffusion cell is weighed continuously on a load cell that transmits its readings to a computer (acquisition analysis diagnostics). Choose the frequency at which weighings are to be recorded to be as close as possible to the value obtained by dividing the diffusion rate by the accuracy of the weighing system. This will indicate systematic deviations from a constant mass-loss rate.

EXAMPLE A diffusion rate of 2,0 × 10⁻⁶ g·min⁻¹ and a weighing system accuracy of 1 × 10⁻⁶ g would suggest a sampling rate of 2 min⁻¹.

7 Expression of results

7.1 Calculation

The mass concentration of the calibration component A in the resulting gas mixture, $\beta(\text{A})$, is given by:

$$\beta(\text{A}) = \frac{q_m(\text{A})}{q_V} \tag{4}$$

where

$q_m(\text{A})$ is the diffusion rate (mass flow) of the calibration component A having dimensions $\text{M}\cdot\text{T}^{-1}$ and, for example, expressed in micrograms per minute ($\mu\text{g}\cdot\text{min}^{-1}$);

q_V is the total volume flow rate of the complementary gas plus the flow rate of the component gas, having dimensions $\text{L}^3\cdot\text{T}^{-1}$ and expressed, for example, in litres per minute ($\text{l}\cdot\text{min}^{-1}$).

For practical purposes, the flow rate q_V of the component can be neglected. In the case of a two-stage dilution procedure the flow rate q_V is the sum of the flow rates of the complementary gas and the diluent gas.

The above calculation then gives the mass concentration of the gas mixture, $\beta(\text{A})$, in dimensions of $\text{M}\cdot\text{L}^{-3}$, in units for example of micrograms per cubic metre ($\mu\text{g}\cdot\text{m}^{-3}$). Note that in this case the concentration is dependent on the pressure and temperature conditions.

The calculated concentration can be converted into a mole fraction, $x(\text{A})$, by taking into account the molar mass, $M(\text{A})$, of the component gas and the molar mass, M_{tot}, of the sum of the gases under measurement conditions. The mass flow rate of the mixture can be calculated from the multiplication of volume flow rate, $q_{V,\text{tot}}$, and the density, ρ_{tot}, of the mixture under measurement conditions; the molar mass flow rate is then obtained by dividing ($q_{V,\text{tot}} \times \rho_{\text{tot}}$) by M_{tot}. For practical purposes the density and the molar mass of the complementary gas under measurement conditions can be used:

$$x(\text{A}) = \frac{q_m(\text{A})}{M(\text{A})} \times \frac{M_{\text{tot}}}{q_{V,\text{tot}} \cdot \rho_{\text{tot}}} \tag{5}$$

Combination of Equations (4) and (5) gives:

$$x(\text{A}) = \frac{\beta(\text{A})}{M(\text{A})} \times \frac{M_{\text{tot}}}{\rho_{\text{tot}}} \tag{6}$$

Alternatively, if the complementary gas flow is measured as a mass flow of gas, $q_{m,\text{cg}}$, the mole fraction of the resulting gas mixture can be calculated by taking into account the molar mass of the component gas, $M(\text{A})$, and that of the complementary gas, M_{cg}. The component gas flow can usually be neglected in the sum of the mass flow so that:

$$x(\text{A}) = \frac{q_m(\text{A})}{M(\text{A})} \times \frac{M_{\text{cg}}}{q_{m,\text{cg}}} \tag{7}$$

The results may be expressed in any appropriate units.

NOTE Equations (4), (6) and (7) are related by constants which have a negligible uncertainty associated with them (the typical relative uncertainty in a molar mass is ± 1 × 10^{-5}). Therefore, the relative uncertainty associated with the mole fraction is the same as that associated with the mass concentration.

7.2 Sources of uncertainty

7.2.1 General

There are several sources of uncertainty, the principal ones of which are identified below:

a) measurement of mass flow from diffusion cell:

- balance,
- buoyancy effects,
- purity of calibration component,
- stability of calibration component,
- effects of sorption or desorption;

b) short-term fluctuations in mass flow of the calibration component;

c) measurement of time;

d) measurement of flow rate of complementary gas and optional diluent gas:

- flow meter,
- purity of complementary gas and optional diluent gas;

e) short-term fluctuations in complementary and diluent gas flows.

An example of an uncertainty evaluation of the generation of a calibration gas mixture by diffusion, based on periodic weighing, is given in Annex C.

7.2.2 Measurement of the mass flow from the diffusion cell

7.2.2.1 Balance

Uncertainties in the mass measurement usually result from deficiencies in the calibration of the weighing device and/or from the limited sensitivity of the balance. Weighing devices shall be traceably calibrated. The intervals between subsequent weighings shall be sufficiently large so as to minimize the contribution of balance resolution to the combined uncertainty.

7.2.2.2 Buoyancy effects

The mass of air displaced by the diffusion cell during weighing affects the apparent mass. Compensation for this can be made by calculation of the magnitude of this buoyancy change. The true mass loss, Δm, of the diffusion cell is calculated according to Equation (8):

$$\Delta m = m_1 - m_2 + \left(\rho_1 - \rho_2\right)V \tag{8}$$

where

m_1 is the apparent mass of the diffusion cell at the time of the first weighing;

m_2 is the apparent mass of the diffusion cell at the time of the second weighing;

ρ_1 is the density of air at the time of the first weighing;

ρ_2 is the density of air at the time of the second weighing;

V is the volume of the diffusion cell.

In the case in which the atmospheric conditions (temperature, pressure and humidity) remain constant in the interval between the first and second weighings, the buoyancy will remain constant and the determination of mass loss, given by the difference between the initial and final weighings, will not be subject to a buoyancy correction.

If a two-pan balance configuration is used, this buoyancy effect can be eliminated by employing a tare mass having the same volume as the diffusion cell.

If a single-pan balance configuration is used, then the buoyancy effect can be eliminated by performing relative weighings against the same tare mass having a volume equal to that of the diffusion cell.

Alternatively, if no correction for buoyancy is applied, then the uncertainty due to buoyancy effects shall be fully taken into account.

7.2.2.3 Purity of the calibration component

As discussed above in 3.1, before using a diffusion cell for the preparation of gas mixtures, any impurities in the calibration component shall be identified and quantified, or upper limits placed on their relative concentrations. Appropriate analytical techniques shall be used for this purpose. Frequent (e.g. weekly) checks on the diffusion mass flow rate at a fixed temperature and complementary gas flow rate are a good means of verifying that a single component is diffusing (see 6.1).

7.2.2.4 Stability of calibration component

Some substances may undergo polymerization or may react, either with other compounds present or with diffusion cell materials. This will have the effect of reducing the true concentration of the final gas mixture, and account shall be taken of this effect in determination of the total uncertainty.

7.2.2.5 Effects of sorption or desorption

The apparatus shall be allowed to reach equilibrium before use. The establishment of equilibrium can be checked by measuring the calibration component content as a function of time.

7.2.3 Short-term fluctuations in calibration component mass flow

In addition to the uncertainty arising from the contributions described above, the momentary mass flow that is used for the calculation of actual concentration values is governed by short-term fluctuations. In general, the uncertainties related to these short-term fluctuations add to the average mass flow as

$$q_m(\mathrm{A}) = \overline{q}_m(\mathrm{A}) + \Sigma\delta q_m(\mathrm{A}) \tag{9}$$

in which $\Sigma\delta q_m(\mathrm{A})$ represents the sum of contributions of sources of short-term variation in $q_m(\mathrm{A})$.

Starting from Equation (2), applying Maxwell's and Antoine's equations to express D and p_V as functions of temperature and air pressure, $\Sigma\delta q_m(\mathrm{A})$ can be expressed as follows:

$$\Sigma\delta q_m(\mathrm{A}) = (c_1 + c_2)\delta p + c_3\delta T \tag{10}$$

where δp and δT represent short-term fluctuations in air pressure and diffusion cell temperature, and c_1, c_2 and c_3 are sensitivity coefficients derived from characteristics of the diffusion cell, the calibration component and external conditions.

Application of Equation (10) for the derivation of uncertainty contributions shows that, in practice, when diffusion cell temperature is controlled to within ± 0,15 K, normal fluctuations in air pressure will lead to relative uncertainties in q_m(A) of about 0,4 % to 0,6 %. These are due mainly to uncertainties of the components' vapour pressures due to temperature variations.

7.2.4 Measurement of time

The measurement of the time interval between weighings may be incorrect due to errors in the time measurement. This is minimized by regular traceable calibration of the measuring device. The calibration uncertainty shall be considered in the overall uncertainty analysis.

7.2.5 Measurement of the flow rate of the complementary and diluent gases

7.2.5.1 Flow meter

The measurement of the flow rate of the complementary and diluent gases contributes to the final uncertainty in the composition of the calibration gas mixture. This is minimized by regular traceable calibration of the flow meter. Uncertainties for various flow meters shall be estimated as specified in ISO 6145-1.

7.2.5.2 Impurities of complementary and diluent gases

Any impurities in the complementary gases shall be identified and quantified, or upper limits placed on their relative concentrations. Appropriate analytical techniques shall be used for this purpose.

7.2.6 Short-term fluctuations in complementary and diluent gas flow rates

Short-term variations in complementary and diluent gas flow rates shall be checked by repeated measurement of flow rates. In general, the relative uncertainty associated with these fluctuations is estimated to be < 0,4 %.

7.2.7 Possibility of leaks

The presence of a leak within the diffusion apparatus has an effect on the measurement uncertainty of the gas mixture. If there is a leak immediately after the complementary gas has swept over the diffusion cell then the concentration of the prepared gas mixture is lower than the value calculated using Equation (2). A thorough leak test of the diffusion apparatus should be conducted before measurements are made using the system, and an upper limit placed on the magnitude of leaks present.

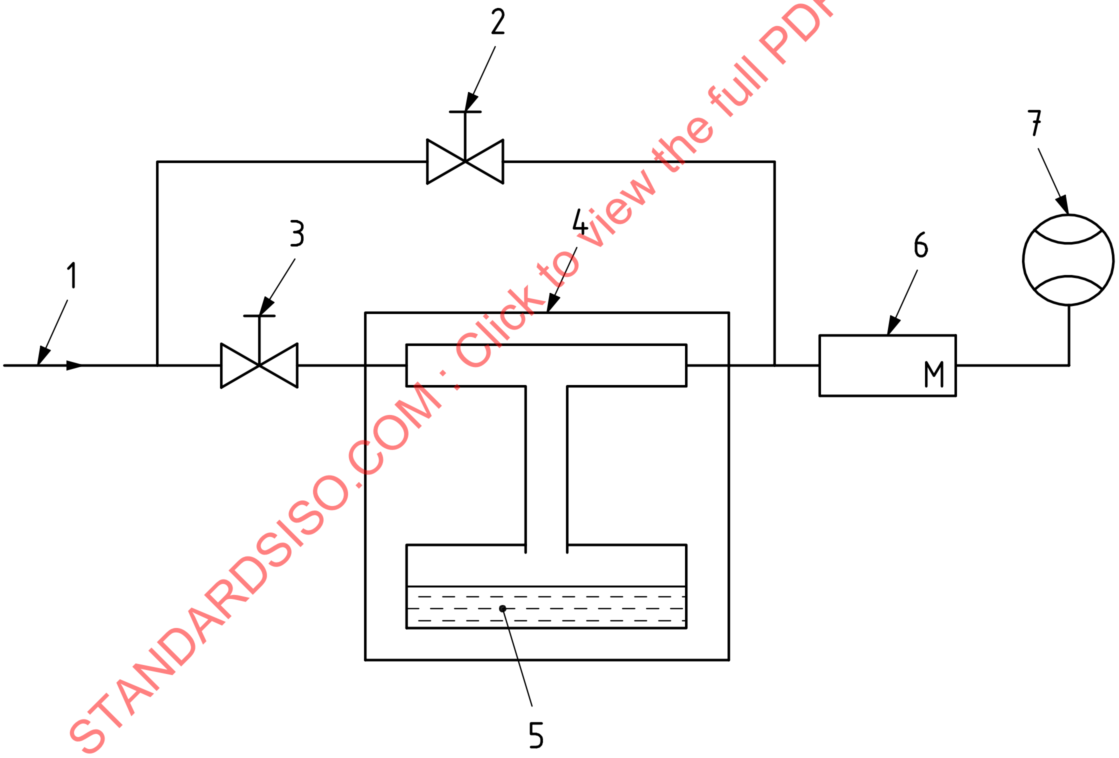
Annex A
(informative)

Practical example of a diffusion cell calibrator configured for evaluating speed of response in a hygrometer

A.1 General background

The diffusion method has been applied to moisture generation for a number of years and approved for use on non-reactive gases including methane. The schematic setup is essentially similar to that described in Clause 5 and given in Figure A.1, with adequate monitoring and/or control of the significant variables outlined under earlier sections.

The significance and convenience of this method is that it permits the fundamental performance assessment and intercomparison of different cells, engineered to produce the same results, using mass as the prime intercomparison unit. Concentration ranges from 5 × 10^{-9} to 10^{-3} have been achieved with good repeatability.



Key

1 dry air
2 flow control valve V2
3 flow control valve V1
4 temperature-controlled chamber
5 water
6 hygrometer
7 flow meter

Figure A.1 — Example of a diffusion cell calibrator

Data collected over several years showed that basic uncertainties increased to ± 2 % in the 10^{-9} region. Mass generation data is initially determined for each cell and then intercomparison studies are carried out between other cells. This methodology forms a convenient basis for an ongoing control in any particular location. The use of a fast responding moisture comparator can be used to indicate the short-term stability of moisture generation thus precluding time dependent averages.

The method is of particular relevance for the determination of time of response, and in the calibration of individual moisture sensors.

Historically, a statement of errors has usually been ascribed to a unit being calibrated once equilibrium conditions have been reached. This does take a variable amount of time, depending upon the response of the device itself and that of the calibration system. The device response can now be accurately assessed and a dynamic calibration carried out, with a statement of errors related to the lapsed time following any moisture change. This can be of particular value in enabling end users to modify their operational methods so as to obtain readings of significance related to the available sampling time within a process measurement.

A.2 Example

In the following example, the diffusion calibrator has been used to carry out comparative speed of response tests between several hygrometers undergoing evaluation. All the hygrometers were found to be accurate within their manufacturer's tolerance, but not all gave repeatable data after short exposure to high moisture levels within the sampling time required by the end user. Such a configuration as described below enabled the user to establish the performance characteristics of each hygrometer under dynamic and realistic operating conditions.

Air from heat-reactivated driers was considered adequately dry for the application, and fed into the calibrator (see Figure A.1). The flow control valve V1 is set to purge at a constant flow rate through the diffusion cell, raising the moisture content entering the hygrometer.

A typical diffusion cell used for calibration of commercial hygrometers may have a flow rate of 400 ml/min, generating a moisture content of 12 ml/m^3. Because variations in flow rate within the range 100 ml/min to 500 ml/min will not change the mass of water diffused per unit time into the dry air stream, constant flow rate monitoring through V1 is not required.

Flow control valve V2 determines the flow rate of dry air injected into the sample line. Altering the valve setting will instantly change the 10^{-9} level sampled by the hygrometer so that the true instrument response speed may be assessed. In the above example, the 10^{-9} level (L, expressed in millilitres per cubic metre) of the hygrometer sample gas may be determined by the following formula:

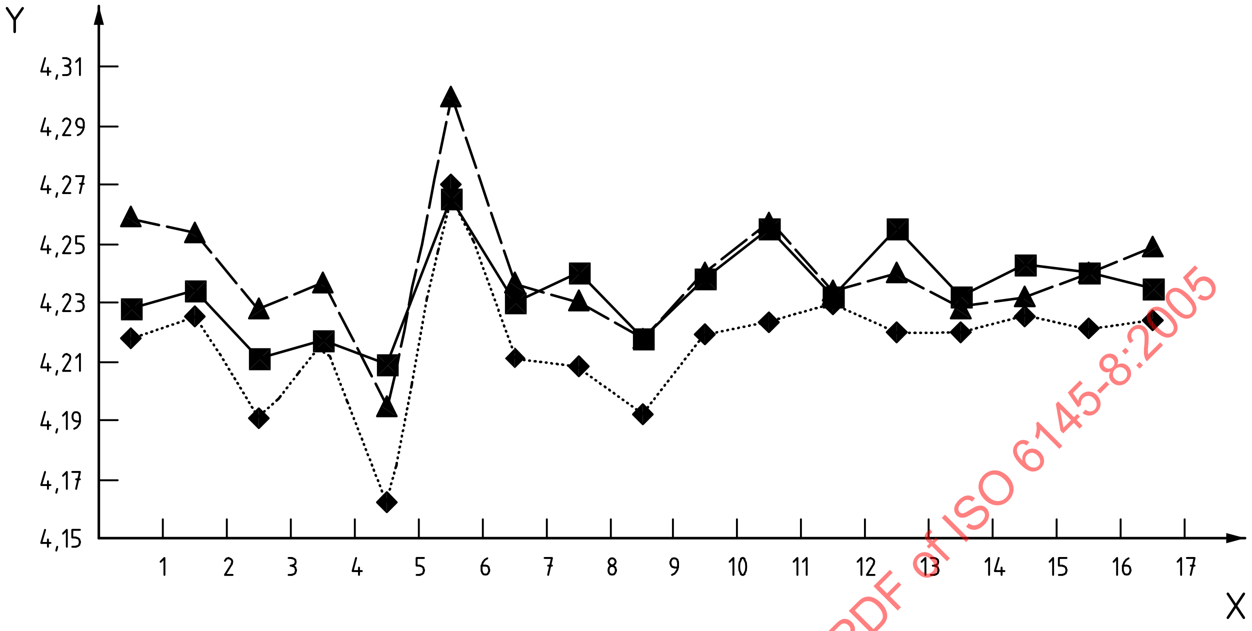
$$L = \frac{12 \times 400}{\sum q} \qquad \text{(B.1)}$$

Here Σq represents the total flow rate, in millilitres per minute, of the gas mixture to the hygrometer, and a volume fraction of 12 ml/m^3 at 400 ml/min provides a diffusion rate.

Cells with different values of diameter and length of diffusion tube can be supplied giving humidity ranges corresponding to frost points less than – 70 °C.

A.3 Stability of diffusion cell output

An example of the output from an accredited system is given in Figure A.2. It can be seen that the actual data derived from three such cells (indicated as TC 16, TC 17 and TC 18), under strictly controlled conditions, correlated with each other to within 0,5 %. This corresponds to a moisture variation of less than ± 0,05 ml/m^3 at the 10 ml/m^3 level. It therefore provides a low initial base of uncertainty to which any additional uncertainties, associated with individual configurations, would be added and still provide acceptable practical interchangeability of data around the world in various locations.



Key

X time, days
Y output, mg/day

⋯◆⋯ TC 16
—■— TC 17
–▲– TC 18

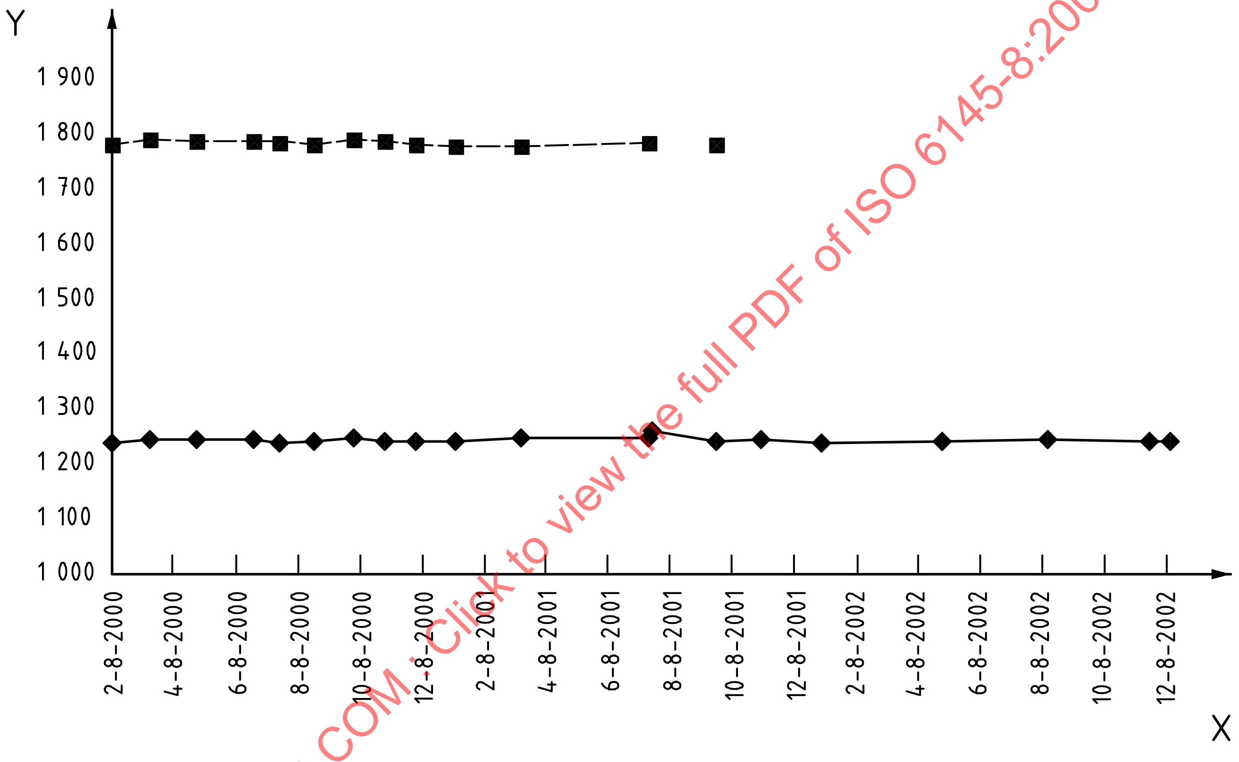
NOTE Data, corrected for pressure and time-lapse, provided by MCM Thorpe Arch, Budgate, UK.

Figure A.2 — Stability of moisture generation

Annex B
(informative)

Example of performances of diffusion cells for toluene and trichloromethane

In Figure B.1, an example of the output (in 10^{-9} g/min) of a diffusion cell for both toluene and trichloromethane is given. The data are listed in Table B.1.



Key

X date

Y mass flow rate, mg/min

—◆— toluene

--■-- trichloromethane

Figure B.1 — Examples of performance of diffusion cells

Table B.1 — Diffusion cell mass flow rate

Toluene 10^{-9} g/min		**Trichloromethane** 10^{-9} g/min	
1 237	1 249	1 782	1 777
1 244	1 259	1 790	1 779
1 244	1 242	1 788	1 785
1 245	1 244	1 786	1 782
1 237	1 238	1 784	
1 241	1 242	1 780	
1 249	1 244	1 791	
1 243	1 240	1 786	
1 243	1 243	1 780	
1 242	mean: 1 244		mean: 1 784
1 247	std: 5		std: 4