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Natural gas — Determination of potential hydrocarbon liquid content — Gravimetric methods

Gaz naturel — Détermination de la teneur en hydrocarbures liquides potentiels — Méthodes gravimétriques

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Tel. + 41 22 749 01 11
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Contents

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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 6570 was prepared by Technical Committee ISO/TC 193, *Natural gas*, Subcommittee SC 1, *Analysis of natural gas*.

This first edition cancels and replaces ISO 6570-1:1983 and ISO 6570-2:1984, which have been technically revised.

Annexes A to D of this International Standard are given for information only.

Introduction

Under certain conditions, higher hydrocarbons present in natural gas or similar gases may condense and the condensate formed can cause difficulties in the operation of gas transport and distribution systems.

Dew-point measurements, by condensation on a mirror, may give an indication of the conditions under which condensation starts. However, these measurements give no further information about the amount of liquid to be expected under operating conditions.

For proper operation of transport and distribution systems, a knowledge of the quantities of condensate formed as a function of temperature and pressure is required. This knowledge is also required for the design of production and treatment systems as well as for subsequent handling and disposal of the liquid.

The methods described in this International Standard are intended for the determination of the quantity of hydrocarbon condensate formed from a natural gas or similar gas as a function of the temperature and pressure of the gas.

Instruments based on different measurement principles can give a figure related to potential condensate content or dew point. The dew point can only be determined by performing measurements at different temperatures followed by extrapolation of the measurements to a potential hydrocarbon liquid content (ρ_{PHLC}) value of zero. The methods described in this International Standard can be used to calibrate such instruments.

Natural gas — Determination of potential hydrocarbon liquid content — Gravimetric methods

WARNING — The use of this International Standard may involve hazardous materials, operations and equipment. This International Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this International Standard to establish appropriate safety and health practices and to determine the applicability or regulatory limitations prior to use.

1 Scope

This International Standard describes the principles of, and general requirements for, two gravimetric methods for the determination of the potential hydrocarbon liquid content of natural gas, or similar gas, at a given pressure and temperature. Two methods are specified in this International Standard to determine the amount of condensate in a sample gas:

- Method A: a manual weighing method;
- Method B: an indirect automatic weighing method based on the indication of the pressure difference caused by the accumulation of condensate in a vertical tube.

The manual weighing method is a reference method for the indirect automatic method (Method B). The indirect automatic method (Method B) is suitable for semi-continuous control.

NOTE Unless otherwise specified, gas volumes are in cubic metres at 273,15 K and 101,325 kPa.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 6976:1995, *Natural gas — Calculation of calorific values, density, relative density and Wobbe index from composition*

ISO 10715:1997, *Natural gas — Sampling guidelines*

ISO 12213-1:1997, *Natural gas — Calculation of compression factor — Part 1: Introduction and guidelines*

ISO 12213-2:1997, *Natural gas — Calculation of compression factor — Part 2: Calculation using molar-composition analysis*

ISO 12213-3:1997, *Natural gas — Calculation of compression factor — Part 3: Calculation using physical properties*

3 Principle

Determination of the quantity of hydrocarbon condensate which can be formed at a pressure (p) and a temperature (T) by passing a representative sample of the gas through an apparatus where it is first brought to the pressure (p) and then cooled to the temperature (T).

The temperature and pressure are selected according to the specific application (see annex A).

Prior to reducing the pressure of the sample of gas to that required for the determination, the gas is heated, so that, after pressure reduction, the temperature is well above the dew-point temperature of the gas. Downstream of the reducer, the sample is cooled isobarically in a cooling bath to the required measurement temperature.

The quantity of liquid accumulated during the measurement period is determined by either direct manual weighing of the collected liquid or weighing of the condensate cyclone separator at the start and at the end of a measurement period (Method A).

Alternatively, the quantity of liquid accumulated in a vertical measuring tube may be determined automatically (indirect automatic weighing) by indication of the pressure difference caused by the liquid accumulated in a vertical measuring tube.

4 Apparatus requirements

WARNING — The instrumentation used for this method shall comply with local legal regulations for application in hazardous areas.

4.1 Measurement installation

The general arrangement is shown in Figure 1. Examples of the line-up of the apparatus are given in annex B.

4.1.1 Gas-line connecting tubes, made of stainless steel with an internal diameter ranging between 2 mm and 4 mm.

If mist is present in the gas, all tubing up to the point where the mist is evaporated or separated shall have an internal diameter compatible with that of the sample line (4.1.2).

4.1.2 Sample line, the length of which is kept to a minimum and temperature-controlled along its length to at least the point where it enters the part of the installation where the measurement is made.

An example of a sample line is given in Figure 2.

The sample line can be heated by fitting a plastic hose concentrically around the line through which water flows at the desired temperature. For this purpose, a temperature-controlled bath can be used from which the water to be circulated is drawn and to which it returns after circulation. The minimum temperature of the sample line can be checked easily by measuring the return temperature. The sample valve and its vicinity shall be heated or at least thermally insulated.

4.1.3 Drying tube (optional), for eliminating water vapour present in sufficiently large quantities in the gas.

Care shall be taken to avoid interferences with the determination of potential hydrocarbon liquid content.

Under certain conditions, the presence of water vapour can lead to the formation of hydrate which is detrimental to the determination. It is, therefore, necessary that the water dew point of the sample be lowered by passing it through a drying tube packed with anhydrous calcium sulfate or a similar water absorption agent which does not absorb hydrocarbons. In such cases, it is necessary to monitor the water dew point downstream to the drying tube so as to check the degree of saturation of the absorption agent. Install the drying tube upstream of a dust filter in order to prevent particles of the drying agent from entering the measurement installation.

If the presence of water vapour does not lead to hydrate formation, the drying tube may be omitted and the amount of water formed under the measurement conditions determined.

If hydrocarbon mist is present in the sample, and a drying tube is used, ensure that the mist is evaporated by heating before allowing the sample to pass through the drying tube.

4.1.4 Dust filter, preferably of a 5 µm pore size, which does not adsorb hydrocarbons.

4.1.5 Heat exchangers, pressure regulators and controllers, installed on the gas line with the heat exchanger immediately upstream to each pressure regulator so as to ensure that the gas temperature after pressure reduction remains at least 5 K above the dew point.

The pressure controller can be placed upstream or downstream from the cooling bath in the measurement installation (see annex B).

4.1.5.1 Heat exchanger (see example in Figure 3), through which water, maintained at the required temperature, is circulated from a thermostatically controlled bath so as to maintain the temperature constant in the gas line.

4.1.5.2 Pressure regulator and **pressure controller**, to ensure the maximum variation from its set-point with the pressure measurement in the gas/liquid cyclone separator is ± 10 kPa.

4.1.6 Measurement instruments for temperature and pressure, capable of recording or monitoring the following:

a) gas temperature and pressure in the gas/liquid cyclone separator;

b) ambient temperature and pressure;

c) gas temperature in the gas transmission line, or in the cylinder from which the sample is taken (optional);

d) gas temperature after pressure reduction (optional);

e) temperature of the bath (optional);

f) gas pressure before pressure reduction (optional);

g) gas pressure after pressure reduction (optional).

If proven experimentally that the difference between the temperature of the gas in the cyclone separator and the temperature of the cooling bath is less than 0,1 K, the temperature of the cooling bath may be measured instead. The pressure can be measured in the sample line just before or just after the cyclone separator.

4.1.7 Gas flow meter, capable of making either mass or volumetric measurements for either wet or dry gas. If a mass flow meter is used, it is necessary that the density of the gas be known.

The flow rate of the gas passing through the installation is limited by the cooling capacity of the bath, the heat transmission between the cooling coil and bath and the temperature drop to which the sample is subjected. The flow rate shall, therefore, be limited to a value that will ensure that the gas is cooled to the bath temperature (see 4.1.9.3).

Check the accuracy of the meter at regular intervals. The choice of gas meter shall be made taking into account the required accuracy, flow rate and the nature of the natural gas. The maximum permissible error in the flow meter shall be ± 1 % of the measured value.

The measured values shall be corrected for temperature and pressure if the values vary during the course of the period of measurement from reference conditions (273,15 K and 101,325 kPa).

4.1.8 Heated cabinet, used in the case of indirect sampling, of the appropriate shape to contain the sample cylinder and capable of heating to at least 10 K above the temperature at the sampling point (see 5.5).

4.1.9 Condenser/separator apparatus, consisting of a cooling coil connected at the end to a cyclone separator where condensates are collected (see Figure 4).

The cooling coil and cyclone separator are completely immersed in the cooling bath. The difference in temperature between the cooling bath and the gas/liquid cyclone separator shall not exceed 0,1 K.

4.1.9.1 Cooling coil, possibly in the form of a coil of stainless steel tubing and meeting the following design characteristics:

a) capable of providing turbulent flow throughout the measurements;

b) capable of maintaining the temperature difference between the gas leaving the cooling coil and the temperature of cooling bath to less than 0,25 K;

c) capable of maintaining pressure difference over the cooling coil not exceeding 1 kPa so as to ensure isobaric conditions;

d) having an internal diameter between 2 mm and 4 mm.

NOTE These specifications can be met for example with a cooling coil of 2,5 m length and a gas flow of 1 m^3/h.

4.1.9.2 Cyclone separator, permanently connected to the cooling coil, with a specific inlet diameter enabling sufficient centrifugal action to be obtained as the sample gas enters the cyclone separator barrel.

EXAMPLE A cyclone separator having an inlet diameter of 1 mm can meet these requirements. A provision can be made for measuring or recording the gas temperature in the barrel.

For the indirect automatic condensate measurement (Method B) a vertical measuring tube is mounted at the bottom of the cyclone separator. A weighing device (4.1.10.2) is connected to the bottom of the measuring device. This differential pressure transducer is connected to one side at the bottom of the measuring tube and to the other side at the lower part of the cyclone separator. Thus, the pressure difference between both sides of the transducer is a measure for the mass of the liquid in the measuring tube. At the bottom of the measuring tube there is also a drain line connected. This drain is opened at regular time intervals to release the collected condensate from the measuring tube.

NOTE For the weighing device an accurate differential pressure gauge should be used (see 4.1.10.2).

4.1.9.3 Cooling bath, well stirred, capable of completely immersing the cooling coil (4.1.9.1) and cyclone separator (4.1.9.2) as well as maintaining the temperature at any point of the bath by less than 0,25 K.

Proper operation of the cooling bath should be checked as follows.

a) Use a sensitive dew-point meter to verify that the measured dew point of the outgoing gas is equal to the temperature of the cooling bath within 0,25 K. This gives information on the performance of the gas cooler as well as on the efficiency of the gas/liquid cyclone separator.

b) Measure the temperature of the outgoing gas to verify that its temperature is equal to the bath temperature within 0,25 K. This procedure gives only information on the performance of the cooling coil and bath.

4.1.10 Measurement devices, consisting of one of the following:

4.1.10.1 Balance (Method A), capable of weighing to the nearest 0,01 g for masses of at least 2 kg.

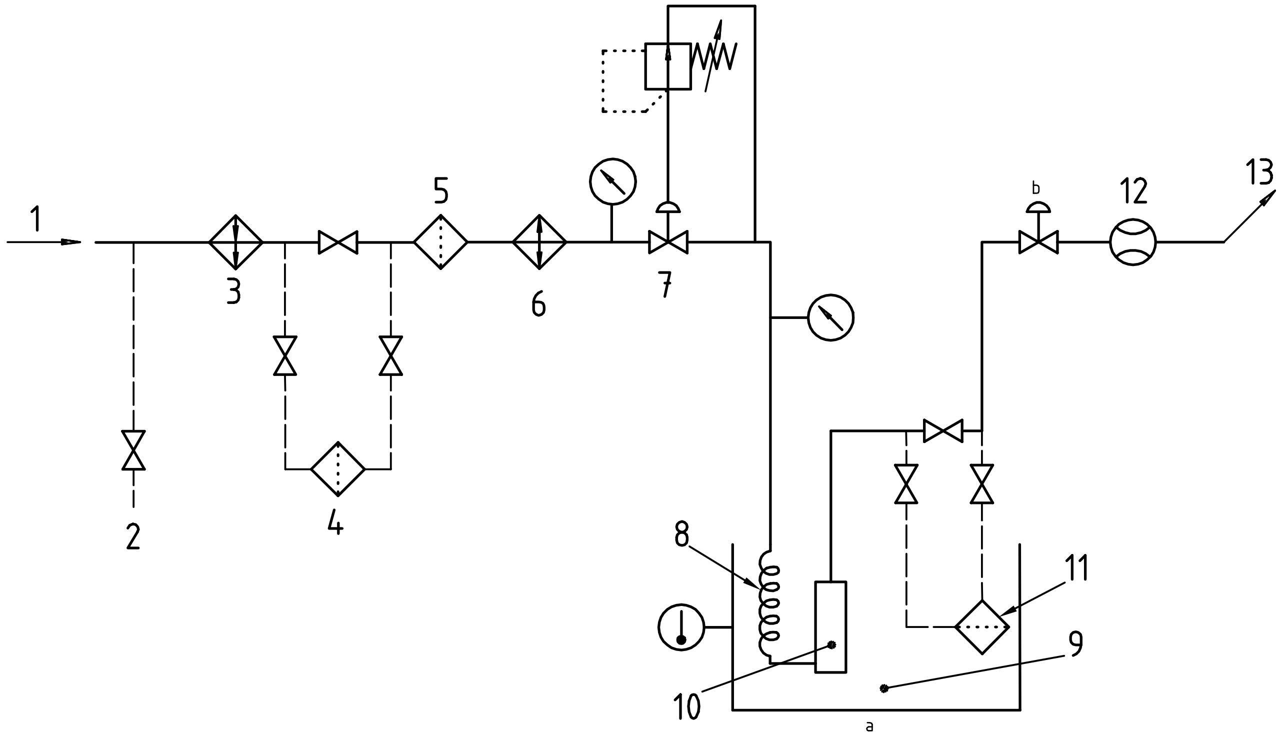
4.1.10.2 Differential pressure gauge (Method B), capable of measuring pressure differences to the nearest 1 mg/m^3 (normalized) and having a lower detection limit of 5 mg/m^3 (normalized).

4.1.11 Isokinetic sampling probe (optional), capable of being installed in the transmission pipeline of the measurement arrangement (4.1) and having a probe inlet with dimensions such that the gas velocities in the pipeline and in the probe inlet do not differ by more than 30 %.

An example of an isokinetic sampling probe is shown in Figure 5.

4.2 Check for correct installation operation

The proper operation of the measurement installation can be checked by periodically carrying out measurements at the same temperature and pressure. In order to obtain an insight into the fluctuations of a process, the measurement temperature chosen should be below the lowest dew point expected of the gas to be measured.



Key

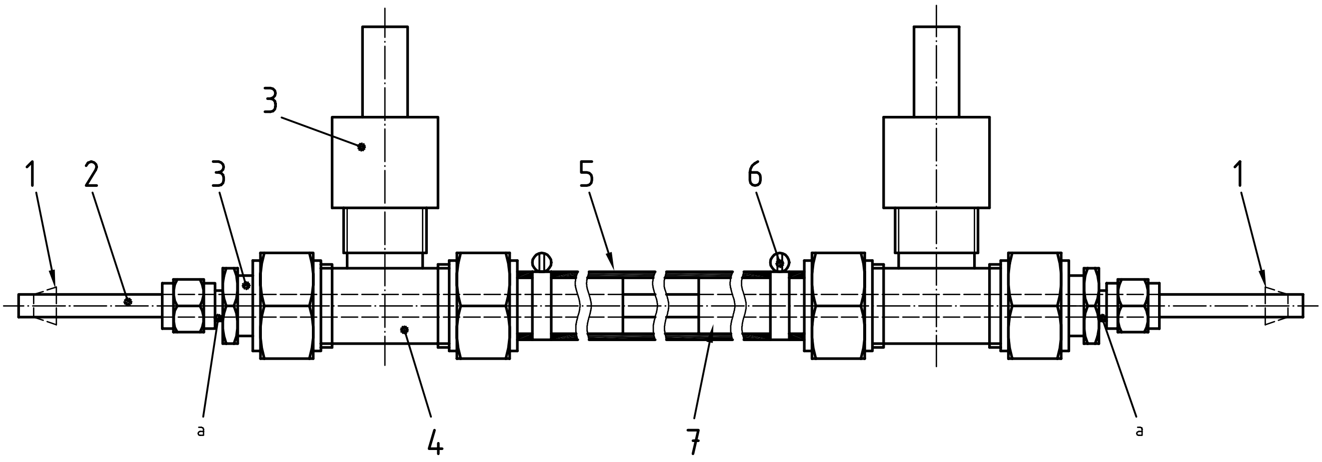
1	Gas from pipeline or sample cylinder
2	Nitrogen supply (optional)
3	Temperature-controlled sample line
4	Drying tube for removal of water vapour (optional)
5	Dust filter
6	Heat exchanger
7	Pressure reducer
8	Cooling coil
9	Cooling bath
10	Main cyclone separator
11	Mist filter (optional)
12	Gas flow meter
13	Vent

[a] Measurement of condensable vapour and mist (if present).

[b] To atmospheric pressure.

Figure 1 — General arrangement of measurement installation

Dimensions in millimetres



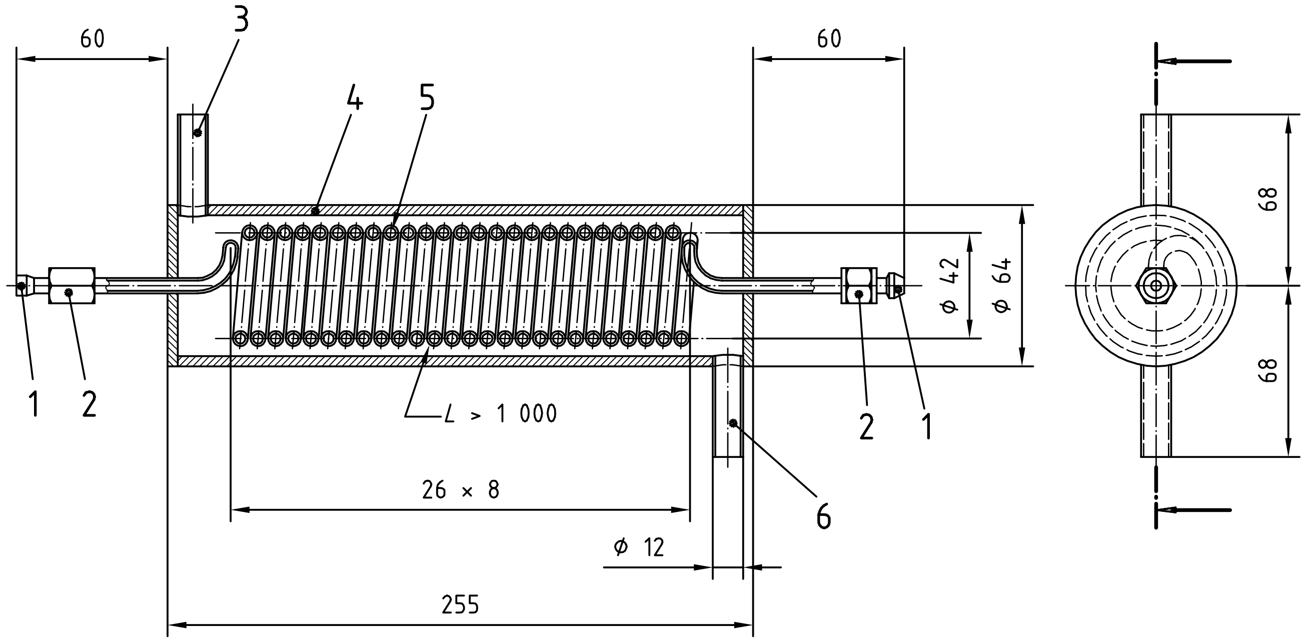
Key

1	Ferrule	5	Plastic hose
2	Copper tube	6	Hose clamp
3	Reducer gyrolock	7	Copper tube [∅ 16/13 (outer diameter/inner diameter), length 50]
4	Tee gyrolock		

a To be drilled through.

Figure 2 — Example of temperature-controlled sampling line

Dimensions in millimetres



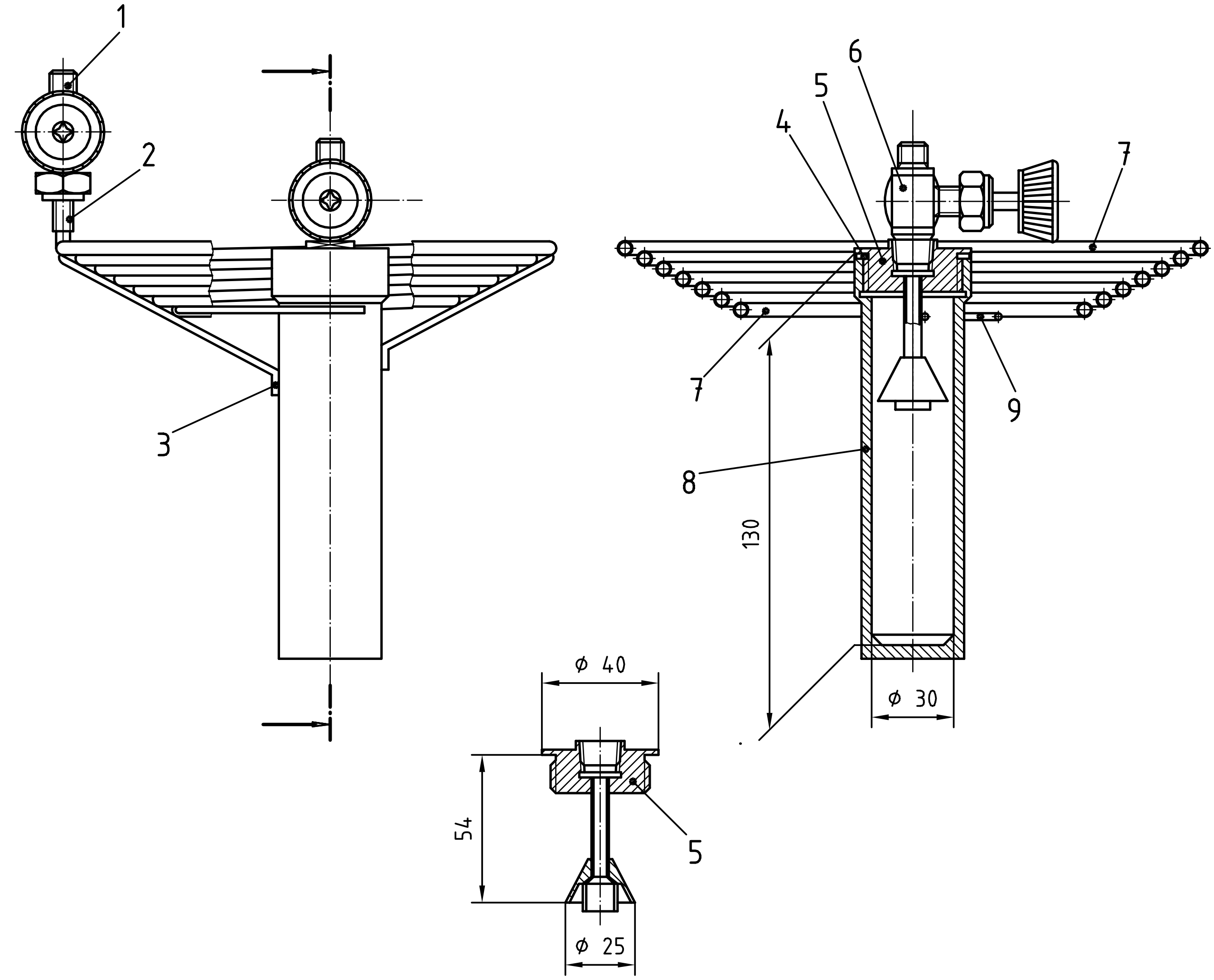
Key

1 Ferrule	4 Shell
2 Nut	5 Gas line
3 Liquid inlet	6 Liquid outlet

L = length and $L > 1\ 000$

Figure 3 — Example of heat exchanger

Dimensions in millimetres
(unless otherwise stated)



Key

1 High-pressure needle valve, stainless steel (1/4 in × 1/4 in)
2 Stainless steel tube (∅ 1/4 in × 0,028 in, length 20)
3 Stainless steel strip (6 × 2)
4 O-ring: hydrocarbon-resistant elastomeric toroidal sealing ring (∅ 34,65 × 1,78)
5 Stainless steel plug
6 High-pressure needle valve, stainless steel [1/4 in × 1/4 in NPT*)]
7 Cooling coil made of stainless steel tubes (∅ 3/16 in × 0,02 in) or copper tubes (∅ 3/16 in × 0,049 in) (length 2 500)
8 Stainless steel barrel
9 Stainless steel tube or copper tube [∅ 2/1 (outer diameter/inner diameter), length 60]

NOTE 1 When a sulfurous gas is tested, the cooling coil should be made of stainless steel.

NOTE 2 Maximum mass 1 100 g.

Figure 4 — Example of condenser/separator apparatus

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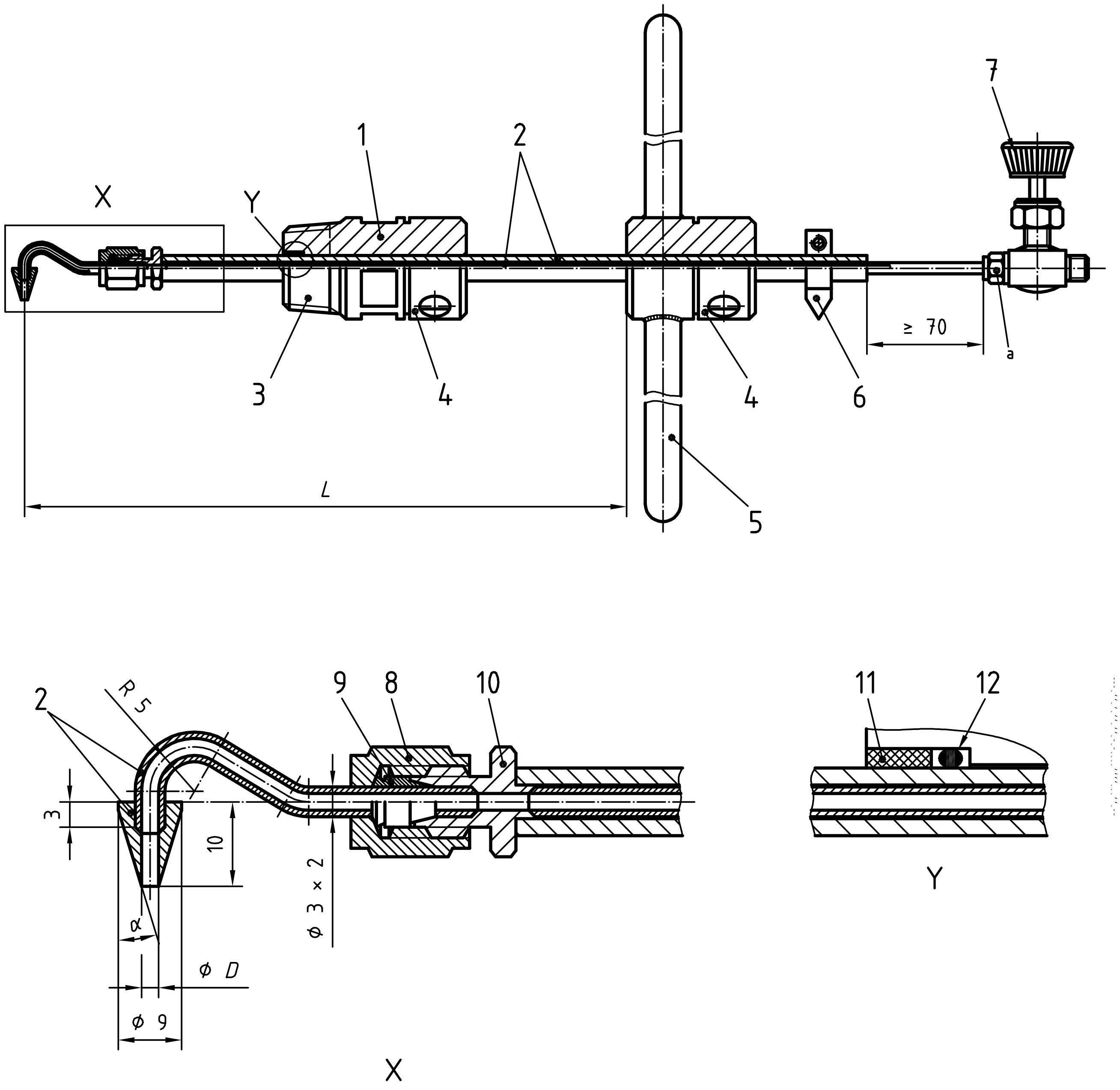
*) National Pipe Thread Taper.

Dimensions in millimetres



Key

1	Sampling plug	7	Needle valve
2	Stainless steel	8	Nut
3	Thread	9	Ferrules
4	Clamp	10	Valve
5	Handle	11	Delrin® (wear-resistant technical polyoxymethylene)
6	Indication of nozzle position	12	O-ring

L = variable length

D = various diameters for isokinetic sampling

α = angle dependent on bore

[a] To change the O-ring, the ferrule should be removed by cutting the tube about 10 mm.

Figure 5 — Example of isokinetic sampling probe

5 Sampling

5.1 General

In addition to ISO 10715, the guidelines outlined in this clause shall be followed in order to obtain reliable results.

Transfer the gas directly to the measurement installation through a sample line from the transmission line or other system. The gas reaching the installation shall be representative of the one to be tested. Although an indirect sampling method, by use of sample cylinders, to transport gas to the measurement installation is permitted, the preferred method is to directly transfer the sample through a pipe from the transmission line or other system.

5.2 Sampling conditions

If hydrocarbon mist is present in the pipeline system, the result of the measurements will strongly depend on the distance between the probe and the point where the mist is formed. In this case, sample the gas isokinetically, using an isokinetic sampling probe (4.1.11) placed in the transmission pipeline.

If it is required to measure the quantity of mist separately, use direct sampling.

5.3 Sample line

Heat the whole sample line (4.1.2) to at least 5 K above the dew point of the sampled gas in order to avoid condensation.

Pass the gaseous sample through a dust filter (4.1.4). If mist is present in the gas, the velocity of the gas should be sufficiently high so as to avoid accumulation in the sample line. In this case, no dust filter should be installed.

5.4 Direct sampling

For direct sampling, connect the sampling line directly to the measurement installation.

5.5 Indirect sampling

It is possible to take a sample in a cylinder and transport it to the laboratory. However, the limited volume of the sample affects the sensitivity and accuracy of the method. In order to ensure that the contents of the cylinder are representative, clean, dry and check the cylinder for hydrocarbon content. Prior to filling, evacuate the cylinder to a pressure below 100 Pa absolute.

Taking samples from a relatively hot system into a cold cylinder causes the gas to contract and may cause condensation. Both factors increase the mass of gas sampled on filling the cylinder to system pressure when compared with the mass of a similar volume of gas taken under the conditions of sampling. Consequently, in the laboratory, before any gas is removed, heat the cylinder for at least 24 h to a temperature of at least 10 K above the temperature of the gas at the sampling point. Heating is necessary in order to re-evaporate any condensed liquid in the cylinder. It also increases the pressure to above that of the system from which the sample was taken; this excess pressure provides enough gas for measurements to be made at the sampling pressure. Monitor the pressure in the cylinder so as to remain within the safe working pressure range of the cylinder.

If hydrocarbon mist is present in the pipeline system, the indirect sampling method shall not be used.

6 Procedure

6.1 Determination of potential hydrocarbon liquid content

6.1.1 Method A — Manual weighing method

6.1.1.1 Cleaning of the gas condenser/separator apparatus

Clean and dry the total condenser/separator system (4.1.9) before starting a test.

To clean the interior of the cyclone separators which already have been used, it is suitable to wash them with a solvent (pentane or any other solvent harmless to the O-ring joints). Hot air or gas may be used to evaporate the residual cleaning solvents. It may require 30 min to dry the cyclone separator (4.1.9.2). Water with added antifreeze may be used as the cooling liquid in the temperature-controlled bath (4.1.9.3). Monoethylene glycol is a suitable antifreeze agent and is easily removed from the external surfaces of the cyclone separator prior to weighing.

6.1.1.2 Determination using the sample gas

After cleaning and drying, place the cooling coil and cyclone separator in the cooling bath and connect them to the measurement installation. Considerations for the selection of the desired measurement temperature and pressure of the measurement installation are given in annex A. When they have reached the temperature of the bath, bring the pressure of the gas in the cyclone separator to the measurement pressure. This can be done very accurately by initially applying a slightly higher pressure and then venting as much gas as required via the gas meter until the pressure gauge shows the desired measurement pressure.

When no excess pressure is available, determine the mass of sampled gas by weighing the cooling coil and cyclone separator on the balance (4.1.10.1) at a pressure slightly lower than the measurement pressure. Close the inlet and outlet valves of the cooling coil and cyclone separator. Disconnect the cyclone separator and cooling coil, including the valves, remove them from the cooling bath and immerse them in a tank containing clean water, in order to wash off the antifreeze and also to check for gas leakage. Once the outer surface is clean, remove the cooling coil and cyclone separator from the tank and dry them. Weigh the cooling coil and cyclone separator to determine their initial mass. Place the cooling coil and cyclone separator back in the cooling bath and connect them to the measurement installation. Allow the gas to flow through the measurement installation at a flow rate in accordance with design specifications.

In practice, a gas flow between 0,5 m^3/h and 1,5 m^3/h gives good results when using a cooling coil and a cyclone separator according to 4.1.9.

When sufficient gas has been passed, stop the flow and ensure that the static gas pressure in the installation is equal to the pressure at which the mass of the cooling coil and cyclone separator was first determined.

It is preferable to pass at least 10 m^3 (standard reference conditions) of gas through the installation or collect at least 1 g of liquid.

Close the valves. Disconnect the cooling coil and cyclone separator, wash them in water, clean and dry the outer surfaces. Determine the mass of the cooling coil and cyclone separator containing the liquid sample.

6.1.1.3 Determination using ambient air (alternative method)

Alternatively after cleaning and drying (see 6.1.1.1), determine the initial mass of the cooling coil and cyclone separator filled with air at ambient conditions by weighing (see 4.1.10.1). Then place the cooling coil and cyclone separator in the cooling bath and connect them to the measurement installation. When they have reached the temperature of the bath, bring the pressure of the gas in the cyclone separator to the measurement pressure. Allow the gas to flow through the measurement installation at a flow rate in accordance with the design specifications (6.1.1.2). When sufficient gas has been passed, stop the flow and close the valves. Disconnect the cooling coil and cyclone separator, wash them with water and clean and dry the outer surfaces. Determine the mass of the cooling coil and cyclone separator containing the liquid sample. Make sure that a compositional analysis of the sample gas is available at the moment of sampling so as to calculate the mass of the gas in the measurement system according to 7.1.2.

6.1.2 Method B — Indirect automatic method

6.1.2.1 Calibration of the weighing device

Calibrate the differential pressure gauge (differential pressure transducer) of the automatic condensate measurement apparatus using a pseudo-condensate of known density comparable to the density of the condensate under investigation such as *n*-decane or a 1:1 mixture by volume of *n*-decane and trimethylbenzene (the density of the condensate under investigations may be determined at regular intervals on samples collected from the drain). Place the cooling coil and cyclone separator in the cooling bath. Set the temperature of the cooling bath to a sufficiently low temperature so as to prevent any condensate from evaporating during the calibration. Set the pressure at the desired measurement pressure. Determine the mass of the different amounts of the pseudo-condensate by weighing or by making a volume measurement. Inject these amounts in the vertical measuring tube at the bottom of the cyclone separator.

Inject the pseudo condensate with a liquid pump or with a syringe. For injection with a syringe, first release the pressure to atmospheric pressure, then open the cyclone separator. After injection, increase the pressure to the desired measurement pressure immediately. The reading of the weighing device will correspond to the mass of condensate.

6.1.2.2 Determination

According to the calibration, an increase in the indication of the differential pressure gauge corresponds to a well-defined amount of condensate in the measuring tube. The amount of condensate per cubic metre can be obtained by dividing the amount of condensate formed during a certain period of time by the gas amount that has passed through the apparatus during the same period of time.

6.2 Determination of water formation

If the amount of water formed under the measurement conditions is such that no hydrate formation occurs, the amount of water can be determined using the manual weighing method as follows.

Carry out two determinations in parallel, using a drying tube (4.1.3) in one and not in the other.

If the gas composition is sufficiently stable, the determination may be carried out consecutively instead of in parallel.

7 Expression of results

7.1 Method A — Manual weighing method

7.1.1 Use of sample gas

The potential hydrocarbon liquid content, ρ_{PHLC}, expressed in grams per cubic metre, at the measured pressure and temperature is given by the equation:

$$\rho_{\mathrm{PHLC}} = \frac{m_{\mathrm{c}}}{V^*} \tag{1}$$

where

m_{c} is the mass, expressed in grams, of liquid formed during the determination;

V^* is the volume, expressed in cubic metres, at 273,15 K and 101,325 kPa, of the sample gas passed through the apparatus during the measurement period.

At the end of the measurement, less gas is contained by the cooling coil and cyclone separator than at the beginning, since part of the gas has been displaced by liquid. This should be taken into account by calculating the actual mass, m_c, expressed in grams, of condensate collected using equation (2):

$$m_c = \frac{m_2 - m_1}{1 - \frac{\rho_g}{\rho_c}} \tag{2}$$

where

m_1 is the mass, expressed in grams, of the cooling coil and cyclone separator containing sample gas at measurement conditions before the determination;

m_2 is the mass, expressed in grams, of the cooling coil and cyclone separator after the determination;

ρ_g is the density, expressed in grams per cubic centimetre, of the sample gas at measurement conditions;

ρ_c is the density, expressed in grams per cubic centimetre, of the condensate.

The correction has only a limited influence on the final result. Therefore, for calculating the correction, approximate values of the densities of the gas and condensate may be used.

7.1.2 Use of ambient air — alternative method

If the alternative method as mentioned in 6.1.1.3 is used, it is essential that the physical properties of the sample gas be available. Based on a compositional analysis of the sample gas and the calculation methods for physical properties of the gas specified in ISO 6976, ISO 12213-1, ISO 12213-2 and ISO 12213-3, it is possible to calculate the necessary physical properties of the gas.

The potential hydrocarbon liquid content, ρ_{PHLC}, expressed in grams per cubic metre, at the measured pressure and temperature is given by the equation:

$$\rho_{PHLC} = \frac{m_2 - m_3 - \left[(1-\alpha)\cdot \rho_g V_i\right]}{V^*} \tag{3}$$

where

m_3 is the mass, expressed in grams, of the cooling coil and cyclone separator filled with air at ambient conditions;

m_2 is the mass, expressed in grams, of the cooling coil and cyclone separator after the determination;

ρ_g is the density, expressed in grams per cubic centimetre, of the sample gas at measurement conditions;

V_i is the internal volume, expressed in cubic centimetres, of the cooling coil and cyclone separator;

V^* is the volume, expressed in cubic metres, at 273,15 K and 101,325 kPa of the sample gas passed through the apparatus during the measurement period;

and α is determined as follows:

$$\alpha = \frac{\rho_{\mathrm{air}}^{*}}{\rho_{\mathrm{g}}^{*}} \cdot \frac{T}{T_{\mathrm{amb}}} \cdot \frac{p_{\mathrm{amb}}}{p} \cdot \frac{Z_{\mathrm{g}}}{Z_{\mathrm{g}}^{*}} \tag{4}$$

where

ρ_{air}^{*}	is the density of air, expressed in grams per cubic centimetre, at 273,15 K and 101,325 kPa;
ρ_{g}^{*}	is the density of gas, expressed in grams per cubic centimetre, at 273,15 K and 101,325 kPa;
T	is the measurement temperature, expressed in kelvins;
T_{amb}	is the ambient temperature, expressed in kelvins;
p_{amb}	is the ambient pressure, expressed in kilopascals;
p	is the measurement pressure, expressed in kilopascals;
Z_{g}	is the compressibility of the sample gas at measurement conditions;
Z_{g}^{*}	is the compressibility of the sample gas at 273,15 K and 101,325 kPa.

7.2 Method B — Indirect automatic method

7.2.1 Calibration

After the calibration of the differential pressure gauge (differential pressure transducer) is completed, the readings of the differential pressure gauge (differential pressure transducer) can be plotted against the mass of condensate in a graph. Depending on the response function of the differential pressure gauge (differential pressure transducer) used, the curve can have different appearances. In general, the response function is defined as follows:

$$m_{\mathrm{cond}} = f(I_{\Delta p}) \tag{5}$$

where

m_{cond}	is the actual mass, expressed in grams, of pseudo-condensate collected in the measuring tube;
$I_{\Delta p}$	is the actual value, expressed in weighing units, of the differential pressure gauge (differential pressure transducer).

See annex C for a detailed example.

7.2.2 Measurements

The potential hydrocarbon liquid content, ρ_{PHLC}, expressed in grams per cubic metre, at the measurement pressure and temperature is given by the equation:

$$\rho_{\mathrm{PHLC}} = \frac{f(I_{p,2}) - f(I_{p,1})}{V^*} \tag{6}$$

where

$I_{p,1}$, $I_{p,2}$ is the indication of the weighing device at times t_1 and t_2 respectively;

$f()$ is the calibration function;

V^* is the volume, expressed in cubic metres, at 273,15 K and 101,325 kPa of the sample gas passed through the apparatus during the measurement period.

NOTE A differential pressure gauge can be used as a weighing device.

For the differential pressure transducer with linear characteristics, equation (6) can be simplified to:

$$\rho_{\mathrm{PHLC}} = \frac{a_{\mathrm{cal}} \cdot (I_{p,2} - I_{p,1})}{V^*} \tag{7}$$

where

$I_{p,1}$, $I_{p,2}$ is the indication of the differential pressure transducer at times t_1 and t_2 respectively;

a_{cal} is the slope, expressed in grams per weighing unit of the differential pressure transducer, of the calibration line;

V^* is the volume, expressed in cubic metres, at 273,15 K and 101,325 kPa of the sample gas passed through the apparatus during the measurement period.

See annex D for a detailed example.

8 Uncertainty of measurement

8.1 Achievable uncertainty

The achievable uncertainty of the total measurement system is about 1 %.

The principal sources of error to which the weighing method is subject are listed in 8.2 to 8.7. Those presented in 8.2 and 8.3 are applicable to the manual method only, whereas the source of error presented in 8.5 applies to the automatic method only.

8.2 Gas leakage

Gas leakage may occur in the gas/liquid cyclone separator during the time lapse between disconnecting and weighing. This leakage may sometimes become noticeable by a continuous decrease in mass during weighing or during immersing of the cooling coil and cyclone separator in the tank with water (6.1.1.2 or 6.1.1.3).

8.3 Bath liquid

Insufficient drying or cleaning are sources of errors because the bath liquid can adhere to the cooling coil and cyclone separator and cause errors in weighing.

8.4 Wet gas

Unexpected condensation of water vapour in the measurement system leads to erroneous results. If necessary, a drying tube shall be installed as described in 4.1.3.

8.5 Condensate leakage

Condensate leakage from the measuring tube or overflowing of the measuring tube during the measurement, results in a (significant) measurement error.

8.6 Variations in bath temperature and pressure in the gas/liquid cyclone separator

If the temperature and pressure in the gas/liquid cyclone separator vary during the measurement, the quantity of condensate will not be correct. To be aware of this problem, it is essential to record or monitor both the temperature and pressure.

8.7 Premature condensation

Premature condensation can be caused by the gas temperature being too low after having lowered the pressure to the measurement pressure.

9 Test report

The test report shall include the following information:

a) a reference to this International Standard, i.e. ISO 6570:2001;

b) all information necessary for the complete identification of the sample;

c) the results obtained;

d) details of any operations not specified in this International Standard or regarded as optional, together with details of any incidents likely to have affected the results.

Annex A
(informative)

Selection of measurement temperature and pressure

A.1 General considerations

The temperature and pressure to which the sample is to be brought in the measurement installation depends on the purpose for which the measurements are made. In general, these conditions are chosen according to the temperature and pressure to which the gas is subjected in the pipeline or processing plant under investigation. Some applications are given below.

A.2 Applications

A.2.1 Pipelines

In order to determine the possible condensate formation in a pipeline system, the temperature and pressure in the measurement installation have to correspond to those conditions in the pipeline system at which maximum condensate formation occurs.

In the case of a single supply source situation, measurements can be made over a period of time at the inlet station of a pipeline grid and at some representative outlet station at the same reference pressure and temperature. The difference between the inlet and the outlet stations gives the quantity of condensate formed in that grid.

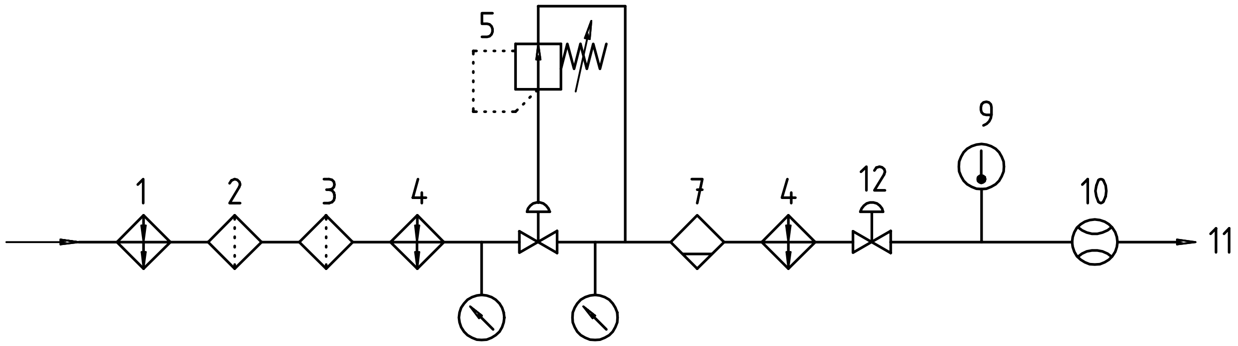
A.2.2 Gas delivery contracts

If the method of measurement is used for checking whether a gas meets a contract specification with respect to condensate formation at a delivery point, the pressure and temperature in the measurement system shall be those specified by the contract.

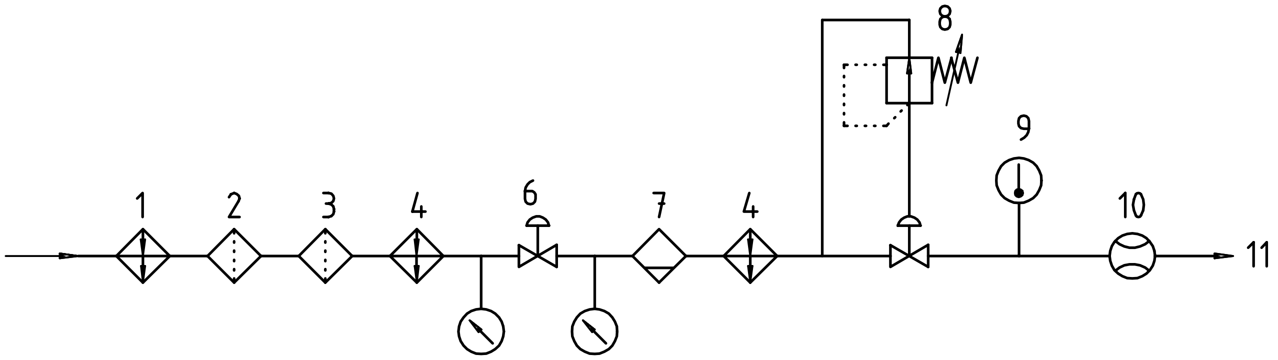
Annex B
(informative)

Examples of the line-up of the apparatus

The general arrangement of the measurement installation is shown in Figure B.1 which shows two systems of flow and pressure regulation and control. All points of the installation between the end of the sample line and the point where the gas is cooled for condensation shall be maintained at a temperature at least 5 K higher than the local dew point.



a) Pressure controller located upstream to cooling bath



b) Pressure controller located downstream to cooling bath

Key

1 Temperature-controlled sample line
2 Drying tube (optional)
3 Dust filter
4 Heat exchanger
5 Pressure reducer (heated or insulated housing)
6 Pressure reducer (hand-operated, heated or insulated needle valve)
7 Isobaric cooling and gas-liquid separator
8 Back-pressure reducer
9 Temperature indicator for measurement
10 Gas flow meter
11 Vent
12 Pressure reducer to reduce pressure to atmospheric pressure (hand-operated needle valve)

Figure B.1 — Typical measurement installation line-up

Annex C
(informative)

Example of calibration of the differential pressure gauge for the indirect automatic method — Method B

Several amounts of pseudo-condensate (1:1 mixture of *n*-decade and trimethylbenzene) are injected with a syringe. The mass of the injected condensate is obtained by weighing the syringe before and after injection. The indication of the differential pressure gauge is given in volts. Both values are given in Table C.1 and also have been plotted in Figure C.1. The response function obtained is:

$$m_{\text{cond}} = 157{,}11 \times I_{\Delta p} - 74{,}88$$

Table C.1 — Calibration of the weighing device

No.	Injection mg	Cumulative injection m_{cond} mg	Differential pressure gauge reading $I_{\Delta p}$ V
1	0	0	0,477
2	111	111	1,181
3	110	221	1,882
4	136	357	2,749
5	105	462	3,423
6	133	595	4,264
7	104	699	4,922

For a differential pressure transducer with linear characteristics the outcome of the plot will for example be a straight line:

$$m_{\text{cond}} = a_{\text{cal}} \cdot I_{\Delta p} + b_{\text{cal}}$$

where

m_{cond} is the actual mass, expressed in grams, of condensate collected in the measuring tube;

$I_{\Delta p}$ is the actual value, expressed in weighing units, of the differential pressure gauge (differential pressure transducer);

a_{cal} is the slope, expressed in grams per weighing unit of the differential pressure gauge, of the calibration line;

b_{cal} is the intercept, expressed in grams, of the calibration line.

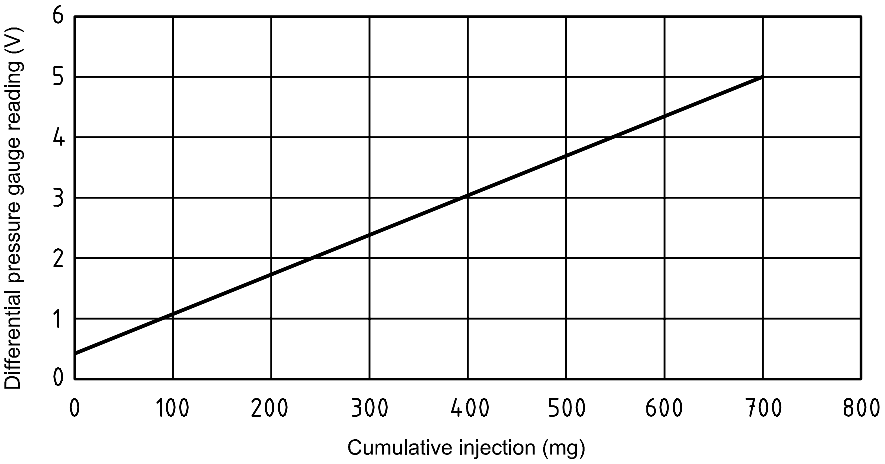


Figure C.1 — Calibration of the weighing device

Annex D
(informative)

Example of an indirect automatic measurement — Method B

Condensate is separated by the cyclone separator which is connected to the vertical measuring tube equipped with a differential pressure gauge. During a period of time the separated condensate causes a constant increase of the differential pressure gauge. From time to time some condensate is drained. This results in a sudden drop of the signal as shown in Figure D.1. The slope of the linear part of the response function (Figure D.1) gives the rate of condensate collection over a certain period. Dividing this result by the gas amount over the same period gives the amount of condensate per cubic metre (Figure D.2).

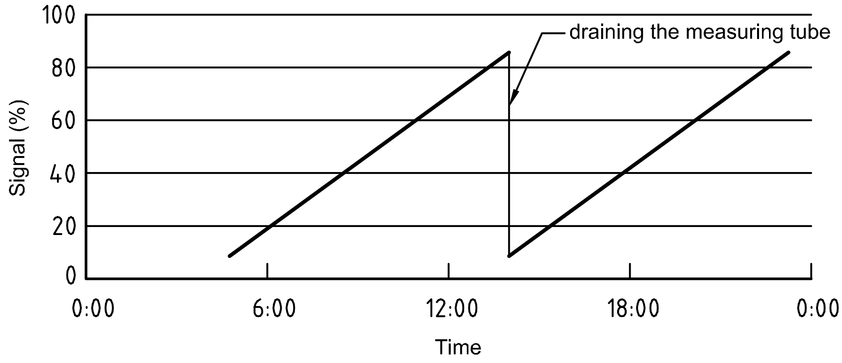
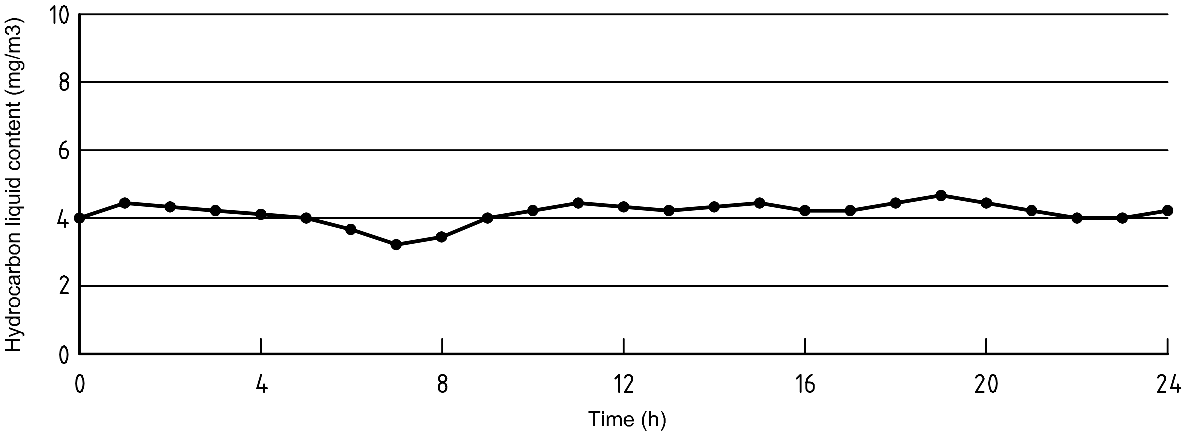


Figure D.1 — Example of the output pattern of the differential pressure transmitter — Method B



Measurement conditions:

p = 3,0 MPa (30 bar)

T = 0 °C

Figure D.2 — Example of the measurement results — Method B

ICS 75.060

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