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**Natural gas — Determination of water  
content at high pressure**

*Gaz naturel — Dosage de l'eau à haute pression*

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## Foreword

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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.

International Standard ISO 11541 was prepared by Technical Committee ISO/TC 193, *Natural gas*, Subcommittee SC 1, *Analysis of natural gas*.

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# Natural gas — Determination of water content at high pressure

## 1 Scope

Water vapour may be present in natural gas due to, for example, natural occurrence in the well production stream, the storage of gas in underground reservoirs, transmission or distribution through mains containing moisture or other reasons.

This International Standard specifies a method of determining the water content of natural gas under pressures of more than 1 MPa, the upper pressure limit being determined by the maximum pressure that the apparatus can withstand. It is applicable to sweet natural gas and sour natural gas, containing hydrogen sulfide, with a water concentration of 10 mg/m<sup>3</sup> or more.<sup>1)</sup>

NOTE — Test data may be affected by alcohols, mercaptans, hydrogen sulfide and glycol contained in the sample gas, as these compounds react with the phosphorus pentoxide (P<sub>2</sub>O<sub>5</sub>) used to absorb the water vapour in the gas.

## 2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 10715:—<sup>2)</sup>, *Natural gas — Sampling guidelines*.

## 3 Principle

A measured volume of gas is passed through an absorption tube filled with phosphorus pentoxide. Water contained in the gas is absorbed by the phosphorus pentoxide and phosphoric acid is formed. The increase in the mass of the tube is deemed to be the mass of water present in the gas. The absorption of water vapour at pipeline pressure is favoured over absorption at ambient pressure for the following reasons:

- the water vapour partial pressure is high;
- the necessary amount of gas is transmitted in a shorter time.

1) In this International Standard, all volumes are expressed at 288,15 K and 101,325 kPa.

2) To be published.

## 4 Reagents and materials

**4.1 Granulated phosphorus pentoxide**, on a solid support with a moisture indicator (commercially available).

**WARNING — Observe all safety precautions for phosphorus pentoxide. Any contact with skin or eyes and inhalation of vapours shall be avoided. Appropriate protective clothing shall be worn while working with phosphorous pentoxide.**

**4.2 Silica wool.**

**WARNING — If not handled properly, silica wool can cause silicosis. A respirator is recommended for safe handling.**

## 5 Apparatus

**5.1** The test apparatus consists of the following components (see figures 1, 2 and 3):

**5.1.1 Pressure vessel body.**

**5.1.2 End piece for pressure vessel.**

**5.1.3 Filter tube**, made of glass, with an outside diameter of 20 mm and a length of 32 mm, filled with silica wool.

**5.1.4 Coupling between filter tube and absorption tube**, made of stainless steel.

**5.1.5 Absorption tube**, made of glass, with an outside diameter of 20 mm and a length of 140 mm.

**5.1.6 End piece for absorption tube**, made of stainless steel.

**5.1.7 Plugs for absorption tube**, made of stainless steel or acrylic plastic.

**5.1.8 Needle valve**, designed as a shut-off valve which will produce a slow pressure increase in the absorption tube, with a transfer line linking it to the sample probe and connector linking it to the pressure vessel inlet.

**5.1.9 Pressure vessel**, capable of accommodating the filter tube and the absorption tube.

**WARNING — The pressure vessel shall be designed and have been tested for the pressure for which it will be used. Appropriate national safety regulations for pressure vessels and other equipment shall be observed.**

**5.1.10 Connector**, for the pressure vessel outlet.

**5.1.11 Manometer**, for the appropriate pressure range.

**5.1.12 Outlet needle valve**, for venting, made of stainless steel.

**5.1.13 Gas flow meter**, for a maximum flow rate of 10 m<sup>3</sup>/h.

**5.1.14 Thermometer**, incorporated in the flow meter outlet.

**5.1.15 Barometer.**

**5.1.16 Vent line.**

**5.1.17 Heater.**

**5.1.18 Sample probe valve.**

**5.1.19 Manifold.**

**5.2** The pressure vessel, the two needle valves, the manometer and all piping and fittings shall be designed for the maximum test pressure. If sour gas is measured, the material used shall be suitable for sour-gas service. The inside length of the pressure vessel shall be such that the filter tube, the coupling and the absorption tube will not be separated by a sudden pressure increase.

**5.3** The connectors at the inlet and the outlet of the pressure vessel shall be easy to attach and to release.

## 6 Procedure

### 6.1 Preparation of the absorption tube

Fill the absorption tube (5.1.5) with granulated phosphorus pentoxide (4.1). The ends of the tube shall be flocked with silica wool (approx. 2 cm) such that no cavities remain. Close the absorption tube with marked plugs (5.1.7).

### 6.2 Preparation of the filter tube

Fill the filter tube (5.1.3) with silica wool.

### 6.3 Preparation of the test apparatus

#### 6.3.1 Initial weighing of the tubes

Weigh the absorption tube with the marked plugs ( $= m_1$ ) and also weigh the filter tube together with the coupling (5.1.4) immediately before assembly.

#### 6.3.2 Assembly of the pressure vessel

Remove the marked plugs from the absorption tube and set them aside. Mount the end piece (5.1.6) on one end of the absorption tube. Join the other end of the absorption tube to the filter tube by means of the coupling.

Insert the tube assembly into the pressure vessel body (5.1.1) with the open end of the filter tube at the inlet side. Then close the pressure vessel.

Keep the marked plugs in a dessicator when not in use.

#### 6.3.3 Preparation of the sample probe

The sample probe shall be clean and dry. The inlet needle valve with the connector for the pressure vessel inlet shall be mounted.

#### 6.3.4 Installation of the gas flow meter

Join the connector for the pressure vessel outlet (5.1.10), the manometer (5.1.11) and the inlet needle valve (5.1.8) by high-pressure tubing. Join the flow meter (5.1.13) and the thermometer (5.1.14) to the outlet needle valve (5.1.12) and the vent line (5.1.16).

#### 6.3.5 Installation of the test apparatus

Connect the pressure vessel (5.1.9) to the sample probe valve (5.1.18) and the flow meter using the connectors (5.1.8, 5.1.10). Purge the sample probe upstream of the pressure vessel with sample gas.

## 6.4 Sampling

See ISO 10715 for general guidelines on sampling.

Make sure that the inlet and outlet valves (5.1.8, 5.1.12) are closed and the sample probe valve (5.1.18) is opened. Open the inlet needle valve (5.1.8) carefully and pressurize the test apparatus. Inspect the test apparatus for leaks.

Open the outlet needle valve (5.1.12) carefully and adjust the flow to 2 m<sup>3</sup>/h to 3 m<sup>3</sup>/h. During sampling, record the atmospheric pressure and gas temperature and monitor the gas flow rate. After a sample of 1,5 m<sup>3</sup> to 3 m<sup>3</sup> has been passed through the apparatus, close the inlet needle valve (5.1.8) and depressurize the test apparatus. Record the quantity of gas which has passed through the apparatus (=  $V_0$ ), as measured by the flow meter (5.1.13). Do not exceed one-half of absorption tube capacity or the test may be invalidated.

When sampling in a humid environment, special care shall be taken to avoid condensation on the tubes.

The maximum water concentration will depend on the actual pressure and temperature of the gas. The temperature of the sampling equipment and the test apparatus needs to be higher than the water dew point at the sampling pressure. If condensation should occur, thus invalidating the test data, heat the test apparatus to a temperature above the hydrocarbon dew point before making additional measurements.

## 6.5 Second weighing of the tubes

Remove the pressure vessel from the test apparatus and open it. Seal the absorption tube immediately after opening the pressure vessel, using the two marked plugs utilized for the initial weighing, and weigh again the absorption tube (=  $m_2$ ). Weigh again the filter tube together with the coupling.

If the mass of the filter tube has increased by more than 5 mg/m<sup>3</sup>, determine visually or by chemical analysis whether impurities have penetrated to the absorption tube. If penetration has occurred, the measurement is invalid.

Verify that the P<sub>2</sub>O<sub>5</sub> packing in the absorption tube is still complete and that the P<sub>2</sub>O<sub>5</sub> moisture indicator indicates that water has entered only the first half of the tube.

## 6.6 Parallel sampling

Simultaneous parallel sampling is recommended, especially if impurities are present. For parallel sampling, mount an asymmetric manifold (5.1.19) on the sample probe and attach two test apparatuses, as shown in figure 3. Since condensate or other impurities are not distributed equally to the two apparatuses, agreement between the two results will confirm the correctness of the test. If the difference in the water concentration calculated for the two apparatuses is greater than twice the uncertainty of measurement ( $\pm 5\%$  of the measured value), a repetition of the test is necessary.

# 7 Expression of results

## 7.1 Calculation

Calculate the water content,  $\rho_{H_2O}$ , expressed in milligrams per cubic metre, of the gas as follows:

$$\rho_{H_2O} = \frac{m_2 - m_1}{V_1} \times 10^3$$

where

- $m_1$  is the mass of the absorption tube, in grams, before sampling;
- $m_2$  is the mass of the absorption tube, in grams, after sampling;
- $V_1$  is the volume of the gas sample, in cubic metres (converted to normal conditions: 288,15 K, 101,325 kPa).

The conversion of the sample gas volume to normal conditions shall be made using the following equation:

$$V_1 = V_0 \frac{288,15 \times p_{\text{atm}}}{T \times 101,325}$$

where

$V_0$  is the gas sample volume, in cubic metres, as read from the flow meter;

$T$  is the mean gas temperature, in kelvins, at the flow meter outlet;

$p_{\text{atm}}$  is the atmospheric pressure during sampling, in kilopascals.

## 7.2 Uncertainty, detection limit

Under the conditions of a flow rate of 2 m<sup>3</sup>/h to 3 m<sup>3</sup>/h and a total transmitted gas volume of 1,5 m<sup>3</sup> to 3 m<sup>3</sup>, the uncertainty is estimated to be  $\pm 5\%$  of the measured value (but not better than 5 mg/m<sup>3</sup>) and the detection limit is estimated to be 10 mg/m<sup>3</sup>.

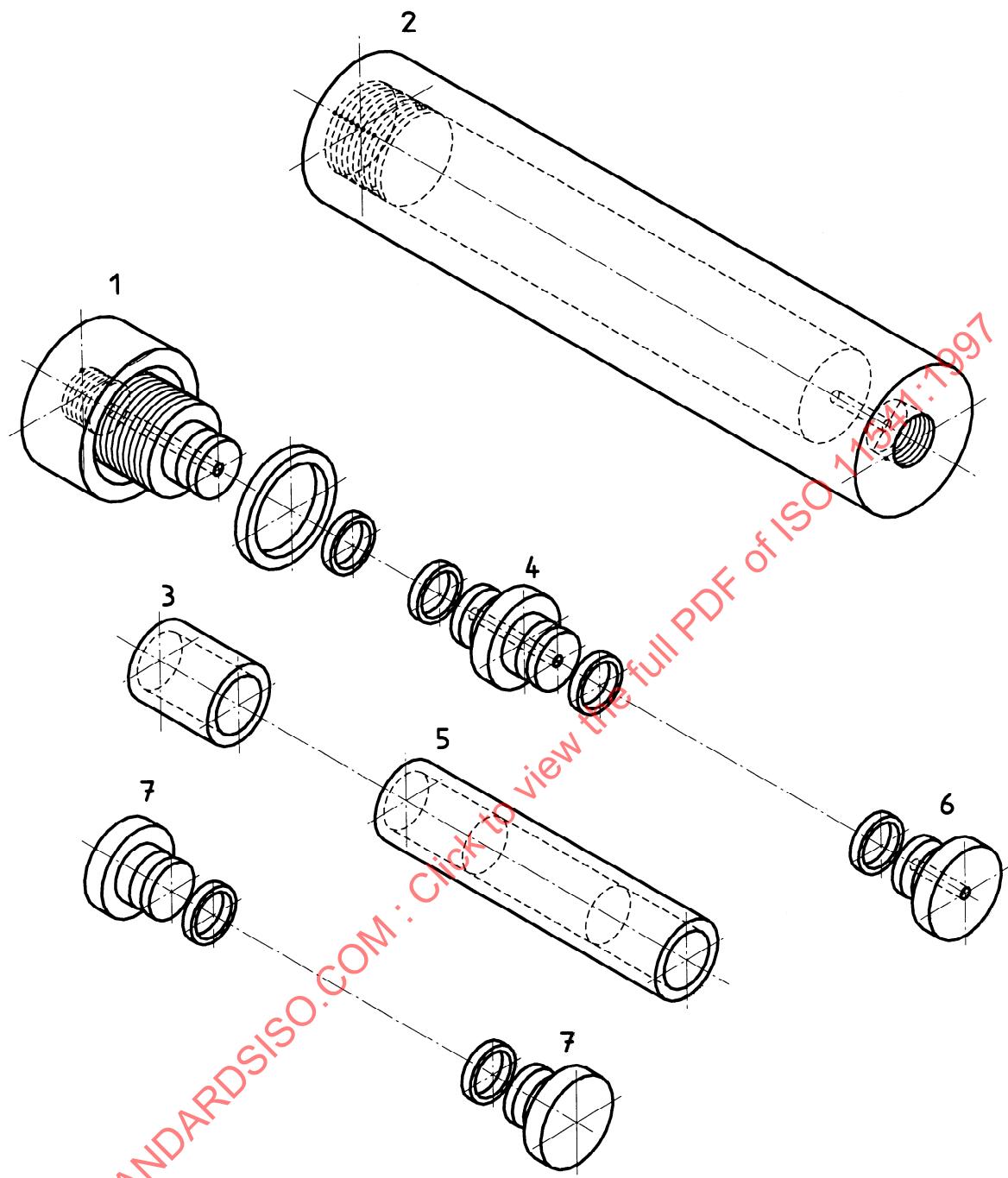
The uncertainty and the detection limit may be improved by increasing the transmitted gas volume without increasing the rate.

This method is applicable even at a pressure below 1 MPa if the flow rate is reduced.

## 8 Test report

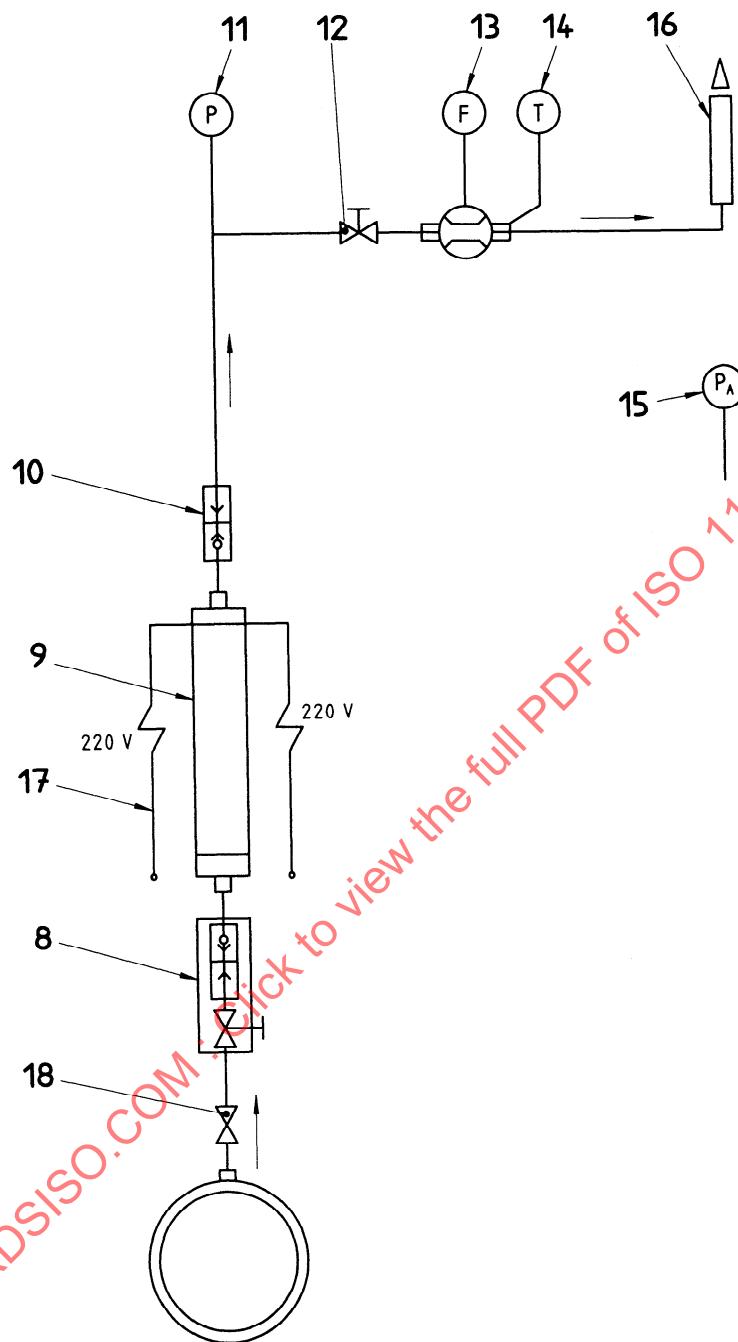
The test report shall include the following information:

- a) a reference to this International Standard;
- b) the place in the pipeline system at which the sample was taken;
- c) the sampling method used;
- d) the water content of the sample, reported to the nearest 1 mg/m<sup>3</sup> at 288,15 K and 101,325 kPa;
- e) the actual gas pressure and the actual temperature at the sample probe for calculation of the actual water dew point;
- f) any deviation from the procedure specified.



- 1 Pressure vessel body
- 2 End piece for pressure vessel
- 3 Filter tube
- 4 Coupling between filter tube and absorption tube
- 5 Absorption tube
- 6 End piece for absorption tube (stainless steel)
- 7 Plugs for absorption tube (stainless steel or acrylic plastic) (used during weighing)

**Figure 1 — Pressure vessel with filter and absorption tube**



- 8 Inlet needle valve, check valve and connector
- 9 Pressure vessel accommodating filter tube and absorption tube
- 10 Connector for pressure vessel outlet
- 11 Manometer
- 12 Outlet needle valve
- 13 Gas flow meter
- 14 Thermometer (incorporated in flow meter outlet)
- 15 Barometer
- 16 Vent line
- 17 Heater
- 18 Sample probe valve

Figure 2 — Schematic diagram of test apparatus