TECHNICAL
REPORT

ISO/TR
11150

First edition
2007-12-15

Natural gas — Hydrocarbon dew point and hydrocarbon content

Gaz naturel — Point de rosée d'hydrocarbure et teneur en hydrocarbure

Reference number
ISO/TR 11150:2007(E)

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Published in Switzerland

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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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 11150 was prepared by Technical Committee ISO/TC 193, *Natural gas*, Subcommittee SC 1, *Analysis of natural gas*.

Introduction

With Resolution 6 at its Prague meeting in 2004, ISO/TC 193/SC 1, *Analysis of natural gas*, decided to publish a Technical Report on guidance for various International Standards on hydrocarbon dew point and hydrocarbon content.

The main purpose of this Technical Report is to explain to the wider gas community the complex issues behind the natural gas property called hydrocarbon dew point on the application of various International Standards on these subjects.

Natural gas — Hydrocarbon dew point and hydrocarbon content

1 Scope

This Technical Report describes the various means of estimating hydrocarbon dew point and hydrocarbon content of natural gas.

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 6327, *Gas analysis — Determination of the water dew point of natural gas — Cooled surface condensation hygrometers*

ISO 6570:2001, *Natural gas — Determination of potential hydrocarbon liquid content — Gravimetric methods*

ISO 6974 (all parts), *Natural gas — Determination of composition with defined uncertainty by gas chromatography*

ISO 7504:2001, *Gas analysis — Vocabulary*

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

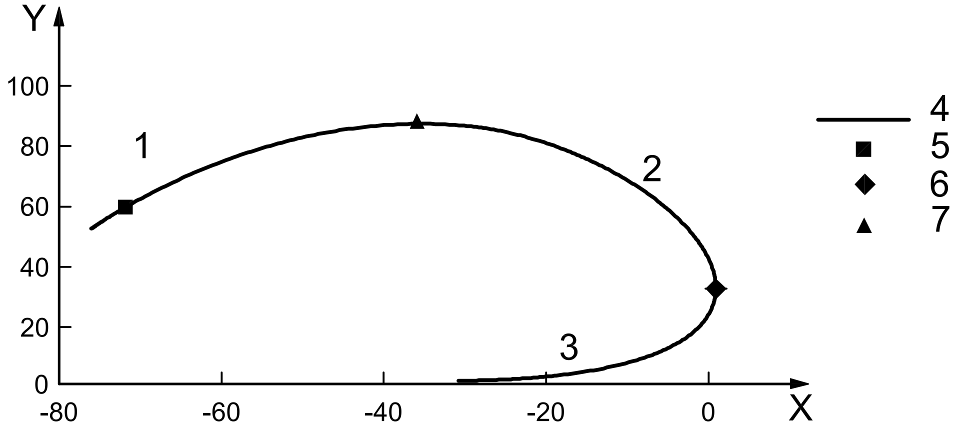
ISO 14532:2001, *Natural gas — Vocabulary*
Technical Corrigendum:2002

ISO 23874, *Natural gas — Gas chromatographic requirements for hydrocarbon dewpoint calculation*

3 Background

Hydrocarbon dew point is often a requirement of gas quality specifications in sales contracts where gas is traded or crosses international borders. It can also be quoted in health and safety legislation. It is usually specified as a temperature at a defined pressure or over a range of pressures above which no hydrocarbon condensation will occur. It may alternatively be expressed as a maximum amount of hydrocarbon liquid which may condense under specific pressure and temperature conditions.

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. Phase behaviour in hydrocarbon mixtures such as natural gas is highly non-ideal. More ideal behaviour, such as that of water in air, or, indeed, in natural gas, gives a dew point temperature which continually increases with pressure. Retrograde behaviour, which affects hydrocarbon mixtures, produces dew point temperatures which have a maximum value at an intermediate pressure. Figure 1 shows a typical phase diagram.



Key

X temperature in degrees centigrade
Y pressure in bar

1 dense phase
2 gas only
3 gas + liquid
4 dewline
5 critical point
6 cricondentherm
7 cricondenbar

Figure 1 — Natural gas phase diagram

In Figure 1 the dew line is the phase boundary. To the right of and above this line only single-phase gas exists. Within the curve of the dew line, both gas and liquid phases are present, in proportions which are governed by the pressure and temperature. The closer to the line, the smaller is the proportion of liquid. The cricondentherm is the point of maximum dew point temperature. Above this temperature only single-phase gas exists, whatever the pressure. Similarly, at pressures above the cricondenbar, only single phase or dense phase gas exists, whatever the temperature.

A gas with a dew line similar to that in Figure 1 would be stable single-phase at – 5 °C and 70 bar. If its pressure is reduced isothermally, it would remain single phase to about 55 bar, at which point it would encounter the phase boundary and condensate would start to separate. As pressure is further reduced, varying ratios of gas and condensate will be found until about 15 bar, when it returns to single phase for the remainder of its depressurization. In fact, once condensate has separated, it is unlikely that it will instantly return to the gas phase, and so liquids may continue to be present at lower pressures. Another consideration is that pressure reduction without the addition of heat is isenthalpic rather than isothermal, and Joule-Thomson cooling will cause the two-phase region to be encountered earlier, unless the gas has been pre-heated so that the cooling curve stays in the single phase region.

4 Why is hydrocarbon dew point important?

Avoidance of condensate formation is important for pipeline operations. The presence of condensate can cause problems with filters and with measurement and control instrumentation. There is also an issue with gas turbines in power plants – significant damage can be caused by the presence of condensate in the burners.

A measured dew point temperature which is lower than the specification limit should give assurance that condensation will not occur. For certain needs, such as plant design, or if it is known that a certain amount of condensable material can remain after treatment, knowledge of the quantity of condensable hydrocarbons produced at specified conditions is useful. This can be physically measured using ISO 6570.

Operators require confidence in the measured result. At present, there is little or no information on the maximum permissible error of measurement, from any type of measurement which is strongly dependent on the type and nature of the natural gas. The single determined value as measured is accepted as the basis for decision making. However, for some natural gases, even a small decrease in temperature can result in a large liquid drop out.

5 What is the definition of hydrocarbon dew point?

The following definitions can be found in various ISO documents, such as in ISO 14532.

2.6.5 Dew points

2.6.5.2 Hydrocarbon dew point

2.6.5.2.1 **Hydrocarbon dew point**
temperature above which no condensation of hydrocarbons occurs at a specified pressure

NOTE 1 At a given dew point temperature there is a pressure range within which retrograde condensation can occur.

The **cricondentherm** defines the maximum temperature at which this condensation can occur.

NOTE 2 The dew point line is the locus of points for pressure and temperature which separates the single phase gas from the biphasic gas-liquid region.

2.6.5.2.2 **Retrograde condensation**
phenomenon associated with the non-ideal behaviour of a hydrocarbon mixture in the critical region wherein, at constant temperature, the vapour phase in contact with the liquid may be condensed by a decrease in pressure; or at constant pressure, the vapour is condensed by an increase in temperature

NOTE Retrograde condensation of natural gas is the formation of liquid when gas is heated or pressure is reduced.

2.6.5.2.3 Potential hydrocarbon liquid content (PHLC)
amount of liquid potentially condensable per unit volume of gas at a given temperature and pressure

Or alternatively in ISO 7504.

3.5.2 **Dew point**
at a specified pressure, the temperature at, or below which, condensation from the gas phase will occur

3.1 **Equation of State**
mathematical relationship between the state variables (pressure and temperature) of a gas or gas mixture, and the volume occupied by a given amount of substance

3.5.1 **Critical point**
single point in pressure-temperature phase diagram at which the composition and properties of the gas and liquid phases in equilibrium are identical

NOTE 1 The pressure at this point is known as the “critical pressure” and the temperature as the “critical temperature”.

6 Specifications

Two examples from legislation and gas trading can be given.

6.1 EASEE-gas European association for the streamlining of energy exchange — Gas

Common business practice 2005-001/01 Harmonisation of natural gas quality 3/2/05. Hydrocarbon dew point shall be maximum of – 2 °C at 1 bar to 70 bar.

NOTE EASEE-gas has not observed any technical constraints in conflict with the proposed harmonized values, and such values were adopted by 1/10/06. This same published document also made the comment *"The need for introducing a harmonized measuring method has been identified"*.

6.2 United Kingdom Health and Safety Executive

A guide to the Gas Safety (Management) Regulations 1996.

Schedule 3 Content and other characteristics of gas.

Regulation 8 Part 1 Requirements under normal conditions.

Hydrocarbon dew point and water dew point shall be at such levels that they do not interfere with the integrity or operation of pipes or any appliance [within the meaning of regulation 2(1) of the 1994 Regulations] that a consumer could reasonably be expected to operate.

7 Hydrocarbon dew point measurement

7.1 General

The definition of the theoretical hydrocarbon dew point alone is not well understood by measurement technicians/scientists/engineers or those who draft sales gas contracts. At the most pedantic level, the dew point temperature is the minimum value at which no condensate is present, but only homogeneous gas phase. **However this cannot and will never be physically measured as the first molecule will not be detected because the available methods are not sensitive enough (theoretical hydrocarbon dew point temperature)**.

So the method of determination of hydrocarbon dew point is critical, as each approach is based on different measurement principles, the hydrocarbon dew point can only be estimated with an associated uncertainty, and the true value cannot be achieved.

7.2 General sampling

Before any instrument or method can be deployed, a sample of the gas to be measured, has to be taken from the flowing gas in the pipeline and transferred unaltered to the measuring device.

ISO 10715 states:

> **3 Principles of sampling**
>
> **3.1 Sampling methods**
>
> The main function of sampling is to take an adequate sample that is representative of the gas by direct sampling such that the sample is drawn from a stream and directly transferred to the analytical method. Care should be exercised to transfer a representative sample flowing in the pipeline unaltered and in a homogeneous single gas phase state to the analytical method. In general, turbulent flow is advantageous in a sampling system and in a gas line to be sampled because turbulence creates a well-mixed gas. Great care and consideration should be given for a gas near the dew point, as a reduction in line temperature will cause some condensation to occur, as will rapid reduction of pressure isothermally (adiabatic expansion causing cooling) resulting in two-phase sample gas flow.

7.3 Hydrocarbon dew point determination/estimation/monitoring

There are two principal methods: direct determination by physical observation of liquid condensation and calculation from detailed analysis. A third method measuring a similar/related property of potential hydrocarbon liquid formation (gravimetric method) is also discussed.

The first technique and apparatus for determining the dew point of gases under pressure was published by Deaton and Frost[1]. This manual method was widely adopted as it was the only method available and by default has become the *de facto* standard. However, there is currently no published ISO method with any performance characteristics. There is a method describing how manual cold mirrors operate in the ISO standard for water dew point. See ISO 6327. That International Standard also describes the procedures necessary for precautions against hydrocarbon or other liquid formation on the mirror prior to the water dew point determination (see Annex A for further information).

Similarly, the method for calculation from detailed analysis by gas chromatography is described in ISO 23874. That International Standard only deals with the chromatographic requirements and not with equation of state numerical methods. For the benefit of the user this draft is given in Annex B.

There is a published standard for potential hydrocarbon liquid content: ISO 6570. Explanation on the essentials is given in Annex C.

The real requirement is for an on-line automated method for the determination of the physical gas property of hydrocarbon dew point. The potential hydrocarbon liquid content method does not readily lend itself to automation.

7.4 Physical methods

7.4.1 General

Natural gas is passed through a cell at a defined pressure – typically in the range 25 bar to 35 bar. The cell contains a reflecting surface on to which light is directed and which can be observed. The surface is cooled and its temperature at the first appearance of liquid is recorded. This is regarded as the dew point temperature at the pressure of measurement. The operation can be controlled manually, in which case the appearance of liquid on the surface is usually detected by eye, or automatically, in which case the detection is by means of a photocell.

7.4.2 Physical methods — Advantages

- Condensation of liquid is clearly demonstrated.
- It is the *de facto* standard method, and experienced operators can achieve good agreement when using it.
- The manual equipment is portable, so sampling should not be a problem. The cooling can be done by expansion of carbon dioxide or air, avoiding the need for electrical power. Of the physical methods, it may be assumed that dew point temperature is a more rigorous specification than quantity of condensate (PHCL). It assumes, after all, “zero” condensate at the specified temperature rather than “not more than a defined amount”.
- The automatic equipment conforms to safety requirements for installation on process plant.

7.4.3 Physical methods — Disadvantages

- A small power source is needed to illuminate the cooled surface with the manual equipment, but it is regularly used under a permit to work scheme.
- A defined amount of liquid needs to condense before it becomes visible. This will occur at a temperature below the theoretical dew point temperature (the first molecule) and the extent of the difference varies between gases from different sources. The effect may be significant. The rate at which liquid condensate forms as a function of the temperature below the theoretical dew point depends upon the composition of the gas. Figures 2 to 4 show the dew lines and iso-vapour fraction lines for three gases. The iso-vapour fraction lines correspond to condensate quantities of 50 mg/m^3, 100 mg/m^3 and 200 mg/m^3 in each case.