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EUROPEAN STANDARD
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August 2016

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Supersedes EN ISO 6976:2005

English Version

**Natural gas - Calculation of calorific values, density,
relative density and Wobbe indices from composition (ISO
6976:2016)**

Gaz naturel - Calcul des pouvoirs calorifiques, de la masse volumique, de la densité relative et des indices de Wobbe à partir de la composition (ISO 6976:2016)

Erdgas - Berechnung von Brenn- und Heizwert, Dichte, relativer Dichte und Wobbeindex aus der Zusammensetzung (ISO 6976:2016)

This European Standard was approved by CEN on 24 August 2016.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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European foreword

This document (EN ISO 6976:2016) has been prepared by Technical Committee ISO/TC 193 “Natural gas” in collaboration with Technical Committee CEN/TC 278 “Test gases, test pressures, appliance categories and gas appliance types” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2017, and conflicting national standards shall be withdrawn at the latest by February 2017.

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

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

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INTERNATIONAL
STANDARD

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6976

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2016-08-15

Natural gas — Calculation of calorific values, density, relative density and Wobbe indices from composition

Gaz naturel — Calcul des pouvoirs calorifiques, de la masse volumique, de la densité relative et des indices de Wobbe à partir de la composition

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 193, *Natural gas*, Subcommittee SC 1, *Analysis of natural gas*.

This third edition ~~cancels and replaces the second edition (ISO 6976:1995)~~, which has been technically revised.

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Introduction

Both international and intra-national custody transfer of natural gas usually require precise determination of both the quantity and the quality of the gas to be traded. This document specifies methods for the calculation of key properties that describe gas quality, namely gross and net calorific value, density, relative density, and gross and net Wobbe index. The methods provide the means of calculating these properties and their uncertainties for any natural gas, natural gas substitute or similar combustible gaseous fuel of known composition at commonly used reference conditions.

Values of the various properties calculated in accordance with this document will, in general, differ only by very small amounts from those calculated using the second (1995) edition of this document. In this context, it is recognized that:

- a) adoption of the revisions detailed in this document will not be without cost, since instrumental software will need updating;
- b) recorded energy content and hence billed energy will, in consequence of these revisions, change by small amounts;
- c) unintended impacts could occur if the revisions are implemented uncritically; for instance, if the revisions are implemented at input points to a pipeline system but not at exit points, then a costly accountancy imbalance may result;
- d) commercial, contractual, regulatory and legislative obligations will need to be taken into account.

For these reasons, and depending upon the user's application, it may be appropriate to undertake an impact assessment in order to determine an agreed timing and procedure for implementation of the provisions of this document.

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Natural gas — Calculation of calorific values, density, relative density and Wobbe indices from composition

1 Scope

This document specifies methods for the calculation of gross calorific value, net calorific value, density, relative density, gross Wobbe index and net Wobbe index of natural gases, natural gas substitutes and other combustible gaseous fuels, when the composition of the gas by mole fraction is known. The methods specified provide the means of calculating the properties of the gas mixture at commonly used reference conditions.

Mole fractions by definition sum to unity. Guidance on the achievement of this requirement by chromatographic analysis is available in ISO 6974-1 and ISO 6974-2.

The methods of calculation require values for various physical properties of the pure components; these values, together with associated uncertainties, are provided in tables and their sources are identified.

Methods are given for estimating the standard uncertainties of calculated properties.

The methods of calculation of the values of properties on either a molar, mass or volume basis are applicable to any natural gas, natural gas substitute or other combustible fuel that is normally gaseous, except that for properties on the volume basis the method is restricted to mixtures for which the compression factor at reference conditions is greater than 0,9.

Example calculations are given in [Annex D](#) for the recommended methods of calculation.

NOTE 1 The qualifiers “superior”, “higher”, “upper” and “total” are, for the purposes of this document, synonymous with “gross”; likewise, “inferior” and “lower” are synonymous with “net”. The term “heating value” is synonymous with “calorific value”; “mass density” and “specific density” are synonymous with “density”; “specific gravity” is synonymous with “relative density”; “Wobbe number” is synonymous with “Wobbe index”; “compressibility factor” is synonymous with “compression factor”. The dimensionless quantity molecular weight is numerically equal to the molar mass in $\text{kg}\cdot\text{kmol}^{-1}$.

NOTE 2 There are no explicit limits of composition to which the methods described in this document are applicable. However, the restriction of volume-basis calculations to mixtures with a compression factor greater than 0,9 at reference conditions sets implicit limits on composition.

NOTE 3 Because the mole fraction of any water present is not normally available from chromatographic analysis, it is common practice to calculate the physical properties on a dry gas basis and to allow for the effects of water vapour in a separate procedure. However, if the mole fraction of water vapour is known then the property calculations can be carried out completely in accordance with the procedures described herein. The effects of water vapour on calorific value, whether the latter is directly measured or calculated, are discussed in ISO/TR 29922.

NOTE 4 For aliphatic hydrocarbons of carbon number 7 or above, any isomer present is included with the normal isomer of the same carbon number.

NOTE 5 If the user’s requirement includes the replacement of, for example, a C6+ or C7+ grouping of analytically unresolved components by a single pseudo-component, then it is the user’s own task to set the mole fraction composition, and hence properties, of this pseudo-component so as to be fit for purpose in the particular application. Any so-called “spectator water” and “non-combustible hydrogen sulfide” are treated as pseudo-components by setting the appropriate enthalpy of combustion values to zero.

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2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 6974-1, *Natural gas — Determination of composition and associated uncertainty by gas chromatography — Part 1: General guidelines and calculation of composition*

ISO 6974-2, *Natural gas — Determination of composition and associated uncertainty by gas chromatography — Part 2: Uncertainty calculations*

ISO 14912:2003, *Gas analysis — Conversion of gas mixture composition data*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 gross calorific value
 amount of heat that would be released by the complete combustion with oxygen of a specified quantity of gas, in such a way that the pressure, p_1 , at which the reaction takes place remains constant, and all the products of combustion are returned to the same specified temperature, t_1 , as that of the reactants, all of these products being in the gaseous state except for water, which is condensed to the liquid state at t_1

Note 1 to entry: Where the quantity of gas is specified on a molar basis, the gross calorific value is designated as $(Hc)_G(t_1, p_1)$; on a mass basis, the gross calorific value is designated as $(Hm)_G(t_1, p_1)$. Where the quantity of gas is specified on a volume basis, the gross calorific value is designated as $(Hv)_G(t_1, p_1; t_2, p_2)$, where t_2 and p_2 are the gas volume (metering) reference conditions (see [Figure 1](#)).

3.2 net calorific value
 amount of heat that would be released by the complete combustion with oxygen of a specified quantity of gas, in such a way that the pressure, p_1 , at which the reaction takes place remains constant, and all the products of combustion are returned to the same specified temperature, t_1 , as that of the reactants, all of these products being in the gaseous state

Note 1 to entry: On molar, mass and volume bases, the net calorific value is designated respectively as $(Hc)_N(t_1, p_1)$, $(Hm)_N(t_1, p_1)$ and $(Hv)_N(t_1, p_1; t_2, p_2)$.

3.3 density
 mass of a gas sample divided by its volume at specified conditions of pressure and temperature

3.4 relative density
 density of a gas divided by the density of dry air of reference composition at the same specified conditions of pressure and temperature

Note 1 to entry: The term ideal relative density applies when both gas and air are considered as gases that obey the *ideal gas law* ([3.8](#)). The term real relative density applies when both gas and air are considered as real fluids ([3.9](#)). For the fixed reference composition of dry air, see ISO/TR 29922.

3.5**gross Wobbe index**

volume-basis gross calorific value, at specified reference conditions, divided by the square root of the relative density at the same specified metering reference conditions

Note 1 to entry: In common usage, and in the absence of any other qualifier, the term Wobbe index is taken to mean the quantity that is here identified as gross Wobbe index.

3.6**net Wobbe index**

volume-basis net calorific value, at specified reference conditions, divided by the square root of the relative density at the same specified metering reference conditions

3.7**enthalpy of transformation**

amount of heat release that accompanies the change in condition (transformation) of a substance or system from one (initial) condition to another (final) condition

Note 1 to entry: A *positive* heat release is represented by thermodynamic convention as a numerically equal *negative* increment of enthalpy.

Note 2 to entry: In the context of this document, the following can be identified:

- **enthalpy of combustion:** the initial condition is that of an unburned stoichiometric mixture of reactants and the final condition is that of the products of combustion at the same pressure and temperature;
- **standard enthalpy of vaporization:** the initial condition is that of a substance in the liquid state at saturation and the final condition is that of the same substance in the hypothetical state of the ideal gas at the same temperature;
- **enthalpy (or enthalpic) difference:** the initial condition is that of a gas or gas mixture at temperature T_1 and the final condition is that of the same gas or gas mixture at the same pressure but at a different temperature T_2 ;
- **enthalpy (or enthalpic) correction (residual enthalpy):** the initial condition is that of a gas or gas mixture in the hypothetical state of an ideal gas and the final condition is that of the same gas or gas mixture at the same pressure and temperature in the state of the real gas.

3.8**ideal gas**

gas that obeys the ideal gas law

Note 1 to entry: The ideal gas law can be expressed as

$$p \cdot V^0 = R \cdot T$$

where

p is the absolute pressure;

T is the thermodynamic temperature;

V^0 is the volume occupied by one mole of ideal gas (ideal molar volume);

R is the gas constant in coherent units.

3.9**real gas**

gas that deviates from volumetric ideality

Note 1 to entry: No real gas obeys the ideal gas law. Deviations from volumetric ideality can be written in terms of the equation of state

$$p \cdot V = Z(p,T) \cdot R \cdot T$$