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Natural gas — Calculation of thermodynamic properties —

Part 2: Single-phase properties (gas, liquid, and dense fluid) for extended ranges of application

Gaz naturel — Calcul des propriétés thermodynamiques —

Partie 2: Propriétés des phases uniques (gaz, liquide, fluide dense) pour une gamme étendue d'applications

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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).

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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 WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

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

ISO 20765 consists of the following parts, under the general title *Natural gas — Calculation of thermodynamic properties*:

— *Part 1: Gas phase properties for transmission and distribution applications*

— *Part 2: Single-phase properties (gas, liquid, and dense fluid) for extended ranges of application*

— *Part 3: Two-phase properties (vapour-liquid equilibria)*

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Natural gas — Calculation of thermodynamic properties —

Part 2: Single-phase properties (gas, liquid, and dense fluid) for extended ranges of application

1 Scope

This part of ISO 20765 specifies a method to calculate volumetric and caloric properties of natural gases, manufactured fuel gases, and similar mixtures, at conditions where the mixture may be in either the homogeneous (single-phase) gas state, the homogeneous liquid state, or the homogeneous supercritical (dense-fluid) state.

NOTE 1 Although the primary application of this document is to natural gases, manufactured fuel gases, and similar mixtures, the method presented is also applicable with high accuracy (i.e., to within experimental uncertainty) to each of the (pure) natural gas components and to numerous binary and multi-component mixtures related to or not related to natural gas.

For mixtures in the gas phase and for both volumetric properties (compression factor and density) and caloric properties (for example, enthalpy, heat capacity, Joule-Thomson coefficient, and speed of sound), the method is at least equal in accuracy to the method described in Part 1 of this International Standard, over the full ranges of pressure p, temperature T, and composition to which Part 1 applies. In some regions, the performance is significantly better; for example, in the temperature range 250 K to 275 K (–10 °F to 35 °F). The method described here maintains an uncertainty of ≤ 0,1 % for volumetric properties, and generally within 0,1 % for speed of sound. It accurately describes volumetric and caloric properties of homogeneous gas, liquid, and supercritical fluids as well as those in vapour-liquid equilibrium. Therefore its structure is more complex than that in Part 1.

NOTE 2 All uncertainties in this document are expanded uncertainties given for a 95 % confidence level (coverage factor k = 2).

The method described here is also applicable with no increase in uncertainty to wider ranges of temperature, pressure, and composition for which the method of Part 1 is not applicable. For example, it is applicable to natural gases with lower content of methane (down to 0,30 mole fraction), higher content of nitrogen (up to 0,55 mole fraction), carbon dioxide (up to 0,30 mole fraction), ethane (up to 0,25 mole fraction), and propane (up to 0,14 mole fraction), and to hydrogen-rich natural gases. A practical usage is the calculation of properties of highly concentrated CO_2 mixtures found in carbon dioxide sequestration applications.

The mixture model presented here is valid by design over the entire fluid region. In the liquid and dense-fluid regions the paucity of high quality test data does not in general allow definitive statements of uncertainty for all sorts of multi-component natural gas mixtures. For saturated liquid densities of LNG-type fluids in the temperature range from 100 K to 140 K (–280 °F to –208 °F), the uncertainty is ≤(0,1 – 0,3) %, which is in agreement with the estimated experimental uncertainty of available test data. The model represents experimental data for compressed liquid densities of various binary mixtures to within ±(0,1 – 0,2) % at pressures up to 40 MPa (5800 psia), which is also in agreement with the estimated experimental uncertainty. Due to the high accuracy of the equations developed for the binary subsystems, the mixture model can predict the thermodynamic properties for the liquid and dense-fluid regions with the best accuracy presently possible for multi-component natural gas fluids.

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2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7504, *Gas Analysis — Vocabulary*

ISO 14532, *Natural gas — Vocabulary*

ISO 20765-1, *Natural gas — Calculation of thermodynamic properties — Part 1: Gas phase properties for transmission and distribution applications*

ISO 80000-5:2007, *Quantities and units — Part 5: Thermodynamics*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 80000-5:2007 and/or ISO 20765-1, ISO 7504, ISO 14532, and the following apply.

NOTE 1 See Annex A for the list of symbols and units used in this part of ISO 20765.

NOTE 2 Figure 1 is a schematic representation of the phase behaviour of a typical natural gas as a function of pressure and temperature. The positions of the bubble and dew lines depend upon the composition. This phase diagram may be useful in understanding the definitions below.

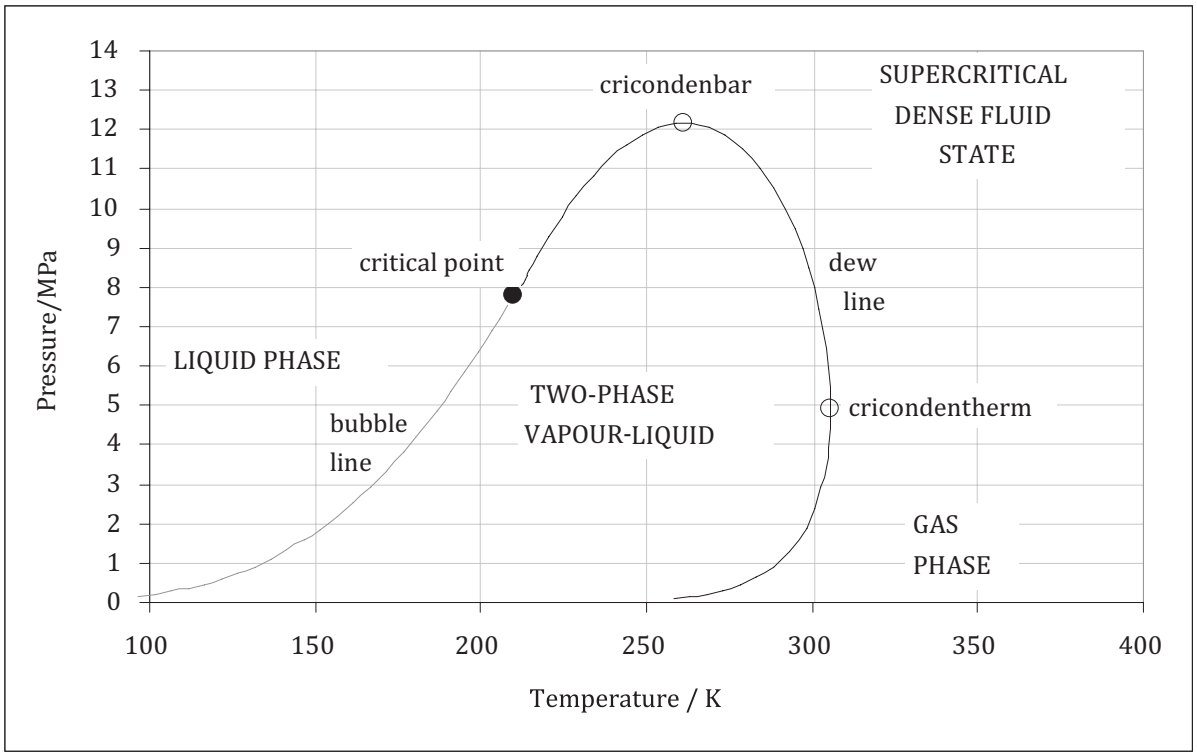


Figure 1 — Phase diagram for a typical natural gas

3.1
bubble pressure
pressure at which an infinitesimal amount of vapour is in equilibrium with a bulk liquid for a specified temperature

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