
**Natural gas — Calculation of
compression factor —**

**Part 1:
Introduction and guidelines**

*Gaz naturel — Calcul du facteur de compression —
Partie 1: Introduction et lignes directrices*

**iTeh STANDARD PREVIEW
(standards.iteh.ai)**

ISO 12213-1:2006

<https://standards.iteh.ai/catalog/standards/sist/68c84847-49d8-4c4a-8a62-b1049eaa1457/iso-12213-1-2006>



PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 12213-1:2006

<https://standards.iteh.ai/catalog/standards/sist/68c84847-49d8-4c4a-8a62-b1049eaa1457/iso-12213-1-2006>

© ISO 2006

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
1 Scope	1
2 Normative references	2
3 Terms and definitions	2
4 General principles	4
5 Guidelines	5
5.1 Pipeline quality natural gases	5
5.2 Other gases and other applications	8
Annex A (normative) Symbols and units	11
Annex B (informative) Computer program	12
Bibliography	13

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 12213-1:2006

<https://standards.iteh.ai/catalog/standards/sist/68c84847-49d8-4c4a-8a62-b1049eaa1457/iso-12213-1-2006>

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.

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 12213-1 was prepared by Technical Committee ISO/TC 193, *Natural gas*, Subcommittee SC 1, *Analysis of natural gas*.

This second edition cancels and replaces the first edition (ISO 12213-1:1997), of which it constitutes a minor revision (the year of publication of Reference [5] in the Bibliography has been corrected).

ISO 12213 consists of the following parts, under the general title *Natural gas — Calculation of compression factor*:

- *Part 1: Introduction and guidelines*
- *Part 2: Calculation using molar-composition analysis*
- *Part 3: Calculation using physical properties*

<https://standards.iteh.ai/catalog/standards/sist/68c84847-49d8-4c4a-8a62-b1049eaa1457/iso-12213-1-2006>

Natural gas — Calculation of compression factor —

Part 1: Introduction and guidelines

1 Scope

ISO 12213 specifies methods for the calculation of compression factors of natural gases, natural gases containing a synthetic admixture and similar mixtures at conditions under which the mixture can exist only as a gas.

It is divided into three parts: this part of ISO 12213 gives an introduction and provides guidelines for the methods of calculation described in ISO 12213-2 and ISO 12213-3.

Part 2 gives a method for use where the detailed molar composition of the gas is known. Part 3 gives a method for use where a less detailed analysis, comprising superior calorific value (volumetric basis), relative density, carbon dioxide content and (if non-zero) hydrogen content, is available.

Both methods are applicable to dry gases of pipeline quality within the range of conditions under which transmission and distribution, including metering for custody transfer or other accounting purposes, are normally carried out. In general, such operations take place at temperatures between about 263 K and 338 K (approximately $-10\text{ }^{\circ}\text{C}$ to $65\text{ }^{\circ}\text{C}$) and pressures not exceeding 12 MPa (120 bar). Within this range, the uncertainty of prediction of both methods is about $\pm 0,1\%$ provided that the input data, including the relevant pressure and temperature, have no uncertainty.

NOTE Pipeline quality gas is used in this International Standard as a concise term for gas which has been processed so as to be suitable for use as industrial, commercial or domestic fuel. Although there is no formal international agreement upon the composition and properties of a gas which complies with this concept, some quantitative guidance is provided in 5.1.1. A detailed gas quality specification is usually a matter for contractual arrangements between buyer and seller.

The method given in Part 2 is also applicable (with increased uncertainty) to broader categories of natural gas, including wet or sour gases, within a wider range of temperatures and to higher pressures, for example for reservoir or underground storage conditions or for vehicular (NGV) applications.

The method given in Part 3 is applicable to gases with a higher content of nitrogen, carbon dioxide or ethane than normally found in pipeline quality gas. The method may also be applied over wider ranges of temperature and pressure but with increased uncertainty.

For the calculation methods described to be valid, the gas must be above its water and hydrocarbon dewpoints at the prescribed conditions.

This International Standard gives all of the equations and numerical values needed to implement both methods. It is planned to make verified computer programs available (see Annex B).

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

ISO 13443, *Natural gas — Standard reference conditions*

3 Terms and definitions

For the purposes of the various parts of this International Standard, the following terms and definitions apply.

3.1 compression factor

Z

ratio of the volume of an arbitrary mass of gas, at a specified pressure and temperature, to the volume of the same mass of gas under the same conditions as calculated from the ideal-gas law, as follows:

$$Z = V_{m(\text{real})}/V_{m(\text{ideal})} \quad (1)$$

where

$$V_{m(\text{ideal})} = RT/p \quad (2)$$

NOTE 1 Thus

$$Z(p, T, y) = pV_m(p, T, y)/(RT) \quad (3)$$

where

p is the absolute pressure;

T is the thermodynamic temperature;

y is a set of parameters which uniquely characterizes the gas (in principle, the latter may be the complete molar composition or a distinctive set of dependent physico-chemical properties, or a mixture of both);

V_m is the molar volume of the gas;

R is the molar gas constant, in coherent units.

NOTE 2 The compression factor is a dimensionless quantity usually close to unity.

NOTE 3 The terms “compressibility factor” and “Z-factor” are synonymous with compression factor.

3.2 density

ρ

mass of a given quantity of gas divided by its volume at specified conditions of pressure and temperature

3.3 molar composition

term used when the proportion of each component in a homogeneous mixture is expressed as a mole (or molar) fraction, or mole (molar) percentage, of the whole

NOTE 1 Thus the mole fraction x_i of component i is the ratio of the number of moles of component i in a given volume of a mixture to the total number of moles of all the components in the same volume of the mixture. One mole of any chemical species is the amount of substance which contains the relative molecular mass in grams. A table of recommended values of relative molecular masses is given in ISO 6976.

NOTE 2 For an ideal gas, the mole fraction (or percentage) is identical to the volume fraction (or percentage), but this is not in general a sufficiently accurate approximation to real-gas behaviour for the purposes of this International Standard.

3.4

molar calorific value

H

amount of heat which would be released by the complete combustion in air of the hydrocarbons in one mole of natural gas in such a way that the pressure at which the reaction takes place remains constant and all the products of combustion are returned to the same specified temperature as that of the reactants, all of these products being in the gaseous state except for water formed by combustion, which is condensed to the liquid state at the specified temperature

NOTE 1 The molar calorific value only includes the hydrocarbons in the natural gas, i.e. inert components (primarily nitrogen, carbon dioxide and helium) and other combustible components (such as hydrogen and carbon monoxide) are excluded.

NOTE 2 The specified temperature is 298,15 K (25 °C) and the reference pressure is 101,325 kPa.

NOTE 3 The term “molar heating value” is synonymous with “molar calorific value”.

3.5

superior calorific value (volumetric basis)

H_S

amount of heat which would be released by the complete combustion in air of all the combustible components in unit volume of natural gas in such a way that the pressure at which the reaction takes place remains constant and all the products of combustion are returned to the same specified temperature as that of the reactants, all of these products being in the gaseous state except for water formed by combustion, which is condensed to the liquid state at the specified temperature

NOTE 1 The superior calorific value includes all the combustible components in the natural gas.

NOTE 2 The reference temperature at which the volume is measured is 273,15 K (0 °C) and the specified temperature at which combustion takes place is 298,15 K (25 °C). The reference pressure is 101,325 kPa.

NOTE 3 Annex D of ISO 12213-3:2006 gives conversion factors which enable superior calorific values and relative densities determined at other reference or specified temperatures, and other reference pressures, including the ISO standard reference conditions (see ISO 13443), to be used as input data for the calculation method described.

NOTE 4 The terms “gross”, “higher”, “upper” and “total calorific value” and “heating value” are synonymous with “superior calorific value”.

3.6

relative density

d

ratio of the mass of a given volume of natural gas to the mass of dry air of standard composition which would be contained in the same volume at the same reference conditions of pressure and temperature

NOTE 1 The relative density includes all the components of the natural gas.

NOTE 2 The standard composition of dry air is given in ISO 6976.

NOTE 3 In this International Standard, the reference temperature is 273,15 K (0 °C) and the reference pressure is 101,325 kPa (see Note 3 to 3.5).

NOTE 4 The term “specific gravity” is synonymous with “relative density”.

3.7

uncertainty of a predicted compression factor

$\pm \Delta Z$

range of values $Z - \Delta Z$ to $Z + \Delta Z$ within which the (unknown) true value is expected to lie with a confidence level of 95 %

NOTE 1 This uncertainty may be expressed either as an absolute value or as a percentage.

NOTE 2 Estimates of the 95 % confidence limits are, to the extent that this is practicable, established by comparison of test data of low uncertainty with calculated values of Z .

4 General principles

The methods recommended use equations which are based on the concept that any natural gas may be uniquely characterized for calculation of its volumetric properties either by component analysis or by an appropriate and distinctive set of measurable physical properties. These characteristics, together with the pressure and temperature, are used as input data for the methods.

In the sense that the volumetric behaviour of a gas mixture derives directly from the numbers and types of molecular interactions (collisions) which take place, a method which explicitly recognizes each molecular constituent of the mixture, and its proportion of the whole, is to some degree more fundamental than alternatives.

The method given in Part 2 of this International Standard uses a detailed molar-composition analysis in which all constituents present in amounts exceeding a mole fraction of 0,000 05 should be represented. The sum of the mole fractions used should be unity to within 0,000 1. For a typical distributed (pipeline quality) gas, this includes all alkane hydrocarbons up to about C₇ or C₈ together with nitrogen, carbon dioxide and helium. For gases containing a synthetic admixture, hydrogen, carbon monoxide and ethylene are also likely to be significant components. For broader categories of gas, other components such as water vapour and hydrogen sulfide need to be taken into consideration.

The equation recommended is known as the AGA8 detailed characterization equation, and will be referred to hereafter as the AGA8-92DC equation ^[1] (see Bibliography). It is a revision of the equation described in AGA Report No. 8 ^[2].

The method given in Part 3 of this International Standard uses two distinct physical properties, namely superior calorific value and relative density, together with the carbon dioxide content.

NOTE In principle, any three from superior calorific value, relative density, carbon dioxide content and nitrogen content may be used, the calculation methods being essentially equivalent. However, the set comprising the first three is preferred for this International Standard. The reader interested in the use of alternative input variables is referred to the GERG TM5 documentation ^[3].

This method is particularly useful in the common situation where a complete molar composition is not available, but may also be preferred for its relative simplicity. For gases containing a synthetic admixture, the amount of hydrogen needs to be known.

The equation recommended is known as the SGERG-88 equation ^[3]. This equation is derived from the MGERG-88 equation ^[4], which uses a detailed molar analysis to characterize the gas.

The evaluation of both the AGA8-92DC and the SGERG-88 equations has been carried out using a large databank of high-accuracy ($\pm 0,1$ %) compression factor measurements (most of which are traceable to the relevant international metrological standards), compiled for the purpose by the Groupe Européen de Recherches Gazières ^[5] and the Gas Research Institute ^[6], ^[7]. Within the transmission and distribution pressure and temperature ranges, the equations are of essentially identical performance.

5 Guidelines

5.1 Pipeline quality natural gases

5.1.1 Pipeline quality gas

To make a definitive quantitative specification of what does or does not represent pipeline quality natural gas is, for several reasons, an elusive and contentious objective. Nevertheless, most transmission and distribution engineers are familiar with the general concept and will normally know whether any particular natural gas falls within the scope of this term. The following is therefore intended simply to provide summary guidance for any other users, rather than to formalize criteria for pipeline quality gas.

Pipeline quality gas is taken to consist predominantly (mole fraction greater than 0,70) of methane and to have a superior calorific value normally within the range $30 \text{ MJ}\cdot\text{m}^{-3}$ to $45 \text{ MJ}\cdot\text{m}^{-3}$ (see Table 1). Nitrogen and carbon dioxide are the main diluents (each up to a mole fraction of about 0,20).

Ethane (up to a mole fraction of about 0,10), propane, butanes, pentanes and higher alkanes will usually be present in steadily decreasing amounts. Minor amounts of helium, benzene and toluene may be present at mole fractions of less than 0,001. For natural gases with a synthetic admixture, hydrogen and carbon monoxide may be present in mole fractions of up to about 0,10 and 0,03, respectively, and there may be small amounts of ethylene. No other component, such as those found in wet and sour gases (for example water vapour, hydrogen sulfide or oxygen), is normally present in greater than trace amounts, and there should be no aerosol, liquid or particulate matter present. Minor and trace components should be treated as specified in Part 2 of this International Standard.

This way of defining pipeline quality gas is not intended to exclude natural gases of other compositions from being transported through pipelines.

The limits allowable for the purpose of this International Standard are given in Table 1.

Table 1 — Allowable limits for mole fractions of components

Component	Mole fraction
<u>Main components</u>	
Methane	$\geq 0,70$
Nitrogen	$\leq 0,20$
Carbon dioxide	$\leq 0,20$
Ethane	$\leq 0,10$
Propane	$\leq 0,035$
Butanes	$\leq 0,015$
Pentanes	$\leq 0,005$
Hexanes	$\leq 0,001$
Heptanes	$\leq 0,000 5$
Octanes and above	$\leq 0,000 5$
Hydrogen	$\leq 0,10$
Carbon monoxide	$\leq 0,03$
Helium	$\leq 0,005$
Water	$\leq 0,000 15$
<u>Minor and trace components</u>	
Ethylene	$\leq 0,001$
Benzene	$\leq 0,000 5$
Toluene	$\leq 0,000 2$
Argon	$\leq 0,000 2$
Hydrogen sulfide	$\leq 0,000 2$
Oxygen	$\leq 0,000 2$
Total unspecified components	$\leq 0,000 1$