SIST

SLOVENSKI STANDARD
SIST EN ISO 12213-2:2005

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Zemeljski plin ï Izraļ un kompresijskega faktorja ï 2. del: Izraļ un na podlagi molarnih-kompozicijskih analiz (ISO 12213-2:1997)

Natural gas - Calculation of compression factor - Part 2: Calculation using molar-composition analysis (ISO 12213-2:1997)

Erdgas - Berechnung von Realgasfaktoren - Teil 2: Berechnungen basierend auf einer molaren Gasanalyse als Eingangsgröße (ISO 12213-2:1997)

Gaz naturel - Calcul du facteur de compression - Partie 2: Calcul a partir de l'analyse de la composition molaire (ISO 12213-2:1997)

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ICS:

75.060	Zemeljski plin	Natural gas

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English version

Natural gas - Calculation of compression factor - Part 2: Calculation using molar-composition analysis (ISO 12213-2:1997)

Gaz naturel - Calcul du facteur de compression - Partie 2: Calcul à partir de l'analyse de la composition molaire (ISO 12213-2:1997)

Erdgas - Berechnung von Realgasfaktoren - Teil 2: Berechnungen basierend auf einer molaren Gasanalyse als Eingangsgröße (ISO 12213-2:1997)

This European Standard was approved by CEN on 17 April 2005.

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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 Central Secretariat has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

The text of ISO 12213-2:1997 has been prepared by Technical Committee ISO/TC 193 "Natural gas" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 12213-2:2005 by CMC.

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of an identical text or by endorsement, at the latest by November 2005, and conflicting national standards shall be withdrawn at the latest by November 2005.

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

Endorsement notice

The text of ISO 12213-2:1997 has been approved by CEN as EN ISO 12213-2:2005 without any modifications.

INTERNATIONAL STANDARD

ISO 12213-2

First edition
1997-12-01

Natural gas — Calculation of compression factor —

Part 2:
Calculation using molar-composition analysis

Gaz naturel — Calcul du facteur de compression —

Partie 2: Calcul par analyse de la composition molaire

Reference number
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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.

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 12213-2 was prepared by Technical Committee ISO/TC 193, *Natural gas*, Subcommittee SC 1, *Analysis of natural gas.*

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*

Annexes A to D form an integral part of this part of ISO 12213. Annexes E to G are for information only.

Natural gas — Calculation of compression factor —

Part 2:
Calculation using molar-composition analysis

1 Scope

This International Standard 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.

This part of ISO 12213 specifies a method for the calculation of compression factors when the detailed composition of the gas by mole fractions is known, together with the relevant pressures and temperatures.

The method is applicable to pipeline quality gases within the ranges of pressure p and temperature T at which transmission and distribution operations normally take place, with an uncertainty of about ± 0,1 %. It can be applied, with greater uncertainty, to wider ranges of gas composition, pressure and temperature (see annex E).

More detail concerning the scope and field of application of the method is given in part 1 of this International Standard.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 12213. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 12213 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 31-3:1992, *Quantities and units — Part 3: Mechanics*.

ISO 31-4:1992, *Quantities and units — Part 4: Heat*.

ISO 6976:1995, *Natural gas — Calculation of calorific values, density, relative density and Wobbe index from composition*.

ISO 12213-1:1997, *Natural gas — Calculation of compression factor — Part 1: Introduction and guidelines*.

3 Definitions

All definitions relevant to the use of this part of ISO 12213 are given in part 1.

4 Method of calculation

4.1 Principle

The method recommended uses an equation based on the concept that pipeline quality natural gas may be uniquely characterized for calculation of its volumetric properties by component analysis. This analysis, together with the pressure and temperature, are used as input data for the method.

The method uses a detailed molar-composition analysis in which all constituents present in amounts exceeding a mole fraction of 0,000 05 should be represented. Typically, this includes all alkane hydrocarbons up to about C_7 or C_8 together with nitrogen, carbon dioxide and helium.

For other gases, additional components such as water vapour, hydrogen sulfide and ethylene need to be taken into consideration (see reference [1] in annex G).

For manufactured gases, hydrogen and carbon monoxide are also likely to be significant components.

4.2 The AGA8-92DC equation

The compression factor is determined using the AGA8 detailed characterization equation (denoted hereafter as the AGA8-92DC equation). This is an extended virial-type equation. The equation is described in AGA Report No. 8[1]. It may be written as

$$Z = 1 + B\rho_m - \rho_r \sum_{n=13}^{18} C_n^* + \sum_{n=13}^{58} C_n^* \left(b_n - c_n k_n \rho_r^{k_n} \right) \rho_r^{b_n} \exp\left(-c_n \rho_r^{k_n} \right) \qquad \text{. . . (1)}$$

where

- Z is the compression factor;
- B is the second virial coefficient;
- ρ_m is the molar density (moles per unit volume);
- ρ_r is the reduced density;
- b_n, c_n, k_n are constants (see table B.1);
- C_n^* are coefficients which are functions of temperature and composition.

The reduced density ρ_r is related to the molar density ρ_m by the equation

$$\rho_r = K^3 \rho_m \qquad \text{. . . (2)}$$

where K is a mixture size parameter.

The molar density can be written as

$$\rho_m = p/(ZRT) \qquad \text{. . . (3)}$$

where

- p is the absolute pressure;
- R is the universal gas constant;
- T is the absolute temperature.

Z is calculated as follows: first the values of B and C_n^* (n = 13 to 58) are calculated, using relationships given in annex B. Equations (1) and (3) are then solved simultaneously for ρ_m and Z by a suitable numerical method (see figure B.1).

4.3 Input variables

The input variables required for use with the AGA8-92DC equation are the absolute pressure, absolute temperature and molar composition.

The composition is required, by mole fraction, of the following components: nitrogen, carbon dioxide, argon, methane, ethane, propane, *n*-butane, methyl-2-propane (iso-butane), *n*-pentane, methyl-2-butane (iso-pentane), hexanes, heptanes, octanes, nonanes, decanes, hydrogen, carbon monoxide, hydrogen sulfide, helium, oxygen and water.

NOTE — If the mole fractions of the heptanes, octanes, nonanes and decanes are unknown, then use of a composite C_{6+} fraction may be acceptable. The user should carry out a sensitivity analysis in order to test whether a particular approximation of this type degrades the result.

All components with mole fractions greater than 0,000 05 shall be accounted for. Trace components (such as ethylene) shall be treated as given in table 1.

If the composition is known by volume fractions, these shall be converted to mole fractions using the method given in ISO 6976. The sum of all mole fractions shall be unity to within 0,000 1.

4.4 Ranges of application

4.4.1 Pipeline quality gas

The ranges of application for pipeline quality gas are as defined below:

absolute pressure	$0\ \text{MPa} \leq p \leq 12\ \text{MPa}$
temperature	$263\ \text{K} \leq T \leq 338\ \text{K}$
superior calorific value	$30\ \text{MJ}\cdot\text{m}^3 \leq H_S \leq 45\ \text{MJ}\cdot\text{m}^3$
relative density	$0{,}55 \leq d \leq 0{,}80$

The mole fractions of the natural-gas components shall be within the following ranges:

methane	$0{,}7 \leq x_{CH_4} \leq 1{,}00$
nitrogen	$0 \leq x_{N_2} \leq 0{,}20$
carbon dioxide	$0 \leq x_{CO_2} \leq 0{,}20$
ethane	$0 \leq x_{C_2H_6} \leq 0{,}10$
propane	$0 \leq x_{C_3H_8} \leq 0{,}035$
butanes	$0 \leq x_{C_4H_{10}} \leq 0{,}015$
pentanes	$0 \leq x_{C_5H_{12}} \leq 0{,}005$
hexanes	$0 \leq x_{C_6} \leq 0{,}001$
heptanes	$0 \leq x_{C_7} \leq 0{,}000\,5$
octanes plus higher hydrocarbons	$0 \leq x_{C_{8+}} \leq 0{,}000\,5$
hydrogen	$0 \leq x_{H_2} \leq 0{,}10$
carbon monoxide	$0 \leq x_{CO} \leq 0{,}03$
helium	$0 \leq x_{He} \leq 0{,}005$
water	$0 \leq x_{H_2O} \leq 0{,}000\,15$

Any component for which x_i is less than 0,000 05 can be neglected.

Minor and trace components are listed in table 1.

Table 1 — Minor and trace components

Minor or trace component	Assigned component
Oxygen	oxygen
Argon	argon
Hydrogen sulfide	hydrogen sulfide
Ethylene, acetylene	carbon dioxide
Propylene, propadiene	propane
Butenes, butadienes	*n*-butane
Neo-pentane, pentenes, benzene, cyclopentane	*n*-pentane
All C_6-isomers, cyclohexane, ethylbenzene, xylenes	*n*-hexane
All C_7-isomers, cycloheptane, toluene	*n*-heptane
All C_8-isomers	*n*-octane
All C_9-isomers	*n*-nonane
All C_{10}-isomers and all higher hydrocarbons	*n*-decane

The method applies only to mixtures in the single-phase gaseous state (above the dew point) at the conditions of temperature and pressure of interest.

4.4.2 Wider ranges of application

The ranges of application tested beyond the limits given in 4.4.1 are:

absolute pressure	$0 \text{ MPa} \leqslant p \leqslant 65 \text{ MPa}$
temperature	$225 \text{ K} \leqslant T \leqslant 350 \text{ K}$
relative density	$0{,}55 \leqslant d \leqslant 0{,}90$
superior calorific value	$20 \text{ MJ·m}^{-3} \leqslant H_S \leqslant 48 \text{ MJ·m}^{-3}$

The allowable mole fractions of the major natural gas components are:

methane	$0{,}50 \leqslant x_{CH_4} \leqslant 1{,}00$
nitrogen	$0 \leqslant x_{N_2} \leqslant 0{,}50$
carbon dioxide	$0 \leqslant x_{CO_2} \leqslant 0{,}30$
ethane	$0 \leqslant x_{C_2H_6} \leqslant 0{,}20$
propane	$0 \leqslant x_{C_3H_8} \leqslant 0{,}05$
hydrogen	$0 \leqslant x_{H_2} \leqslant 0{,}10$

The limits for minor and trace gas components are as given in 4.4.1 for pipeline quality gas. For use of the method outside these ranges, see annex E.

4.5 Uncertainty

4.5.1 Uncertainty for pipeline quality gas

The uncertainty of results for use on all pipeline quality gas within the limits described in 4.4.1 is ± 0,1 % (for the temperature range 263 K to 350 K and pressures up to 12 MPa) (see figure 1). For temperatures above 290 K and at pressures up to 30 MPa the uncertainty of the result is also ± 0,1 %.

For lower temperatures, the uncertainty of ± 0,1 % is at least maintained for pressures up to about 10 MPa.