SLOVENSKI STANDARD
SIST EN ISO 12213-3:2005

01-julij-2005

Zemeljski plin ï Izraļ un kompresijskega faktorja ï 3. del: Izraļ un na podlagi fizikalnih lastnosti (ISO 12213-3:1997)

Natural gas - Calculation of compression factor - Part 3: Calculation using physical properties (ISO 12213-3:1997)

Erdgas - Berechnung von Realgasfaktoren - Teil 3: Berechnungen basierend auf physikalischen Stoffeigenschaften als Eingangsgrößen (ISO 12213-3:1997)

Gaz naturel - Calcul du facteur de compression - Partie 3: Calcul a partir des caractéristiques physiques (ISO 12213-3:1997)

Ta slovenski standard je istoveten z: EN ISO 12213-3:2005

ICS:

75.060	Zemeljski plin	Natural gas

SIST EN ISO 12213-3:2005 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 12213-3

May 2005

ICS 75.060

English version

Natural gas - Calculation of compression factor - Part 3: Calculation using physical properties (ISO 12213-3:1997)

Gaz naturel - Calcul du facteur de compression - Partie 3: Calcul à partir des caractéristiques physiques (ISO 12213-3:1997)

Erdgas - Berechnung von Realgasfaktoren - Teil 3: Berechnungen basierend auf physikalischen Stoffeigenschaften als Eingangsgrößen (ISO 12213-3:1997)

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

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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.

CEN members are the national standards bodies of 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.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN ISO 12213-3:2005: E

Foreword

The text of ISO 12213-3:1997 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 12213-3:2005 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 12213-3:1997 has been approved by CEN as EN ISO 12213-3:2005 without any modifications.

INTERNATIONAL STANDARD

ISO 12213-3

First edition
1997-12-01

Natural gas — Calculation of compression factor —

Part 3:
Calculation using physical properties

Gaz naturel — Calcul du facteur de compression —

Partie 3: Calcul au moyen des caractéristiques physiques

Reference number
ISO 12213-3:1997(E)

Contents

Page

1	Scope	**1**
2	Normative references	**1**
3	Definitions	**2**
4	Method of calculation	**2**
	4.1 Principle	**2**
	4.2 The SGERG-88 equation	**2**
	4.3 Input variables	**3**
	4.4 Ranges of application	**3**
	4.5 Uncertainty	**4**
5	Suppliers of computer programmes	**6**

Annexes

A	Symbols and units	**7**
B	Description of the SGERG-88 method	**9**
C	Example calculations	**18**
D	Conversion factors	**19**
E	Performance over wider ranges of application	**22**
F	Subroutine SGERG.FOR in Fortran	**26**
G	Bibliography	**30**

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

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 12213-3 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 3:
Calculation using physical properties

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 superior calorific value, relative density and carbon dioxide content are known, together with the relevant pressures and temperatures. If hydrogen is present, as is often the case for gases with a synthetic admixture, the hydrogen content also needs to be known.

NOTE — In principle, it is possible to calculate the compression factor when any three of the parameters superior calorific value, relative density, carbon dioxide content (the usual three) and nitrogen content are known, but subsets including nitrogen content are not recommended.

The method is primarily 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 %. For wider-ranging applications the uncertainty of the results increases (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 equations which are based on the concept that pipeline quality natural gas may be uniquely characterized for calculation of its volumetric properties 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 method.

The method uses the following physical properties: superior calorific value, relative density and carbon dioxide content. The 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 with a synthetic admixture, the hydrogen content needs to be known.

4.2 The SGERG-88 equation

The calculation method using physical properties is based on the standard GERG 88 (SGERG-88) virial equation for natural gases [1], [2], [3]. The standard GERG 88 virial equation is derived from the master GERG 88 (MGERG-88) virial equation, which is a method of calculation based on a molar-composition analysis [4].

The SGERG-88 virial equation from which the compression factor Z is calculated may be written as

$$Z = 1 + B\rho_m + C\rho_m^2 \qquad \text{. . . (1)}$$

where

B and C are functions of the input data comprising the superior calorific value H_S, the relative density d, the contents of both inert and combustible non-hydrocarbon components of the gas mixture (CO_2 and H_2) and the temperature T;

ρ_m is the molar density given by

$$\rho_m = p/(ZRT) \qquad \text{. . . (2)}$$

where

$$Z = f_1\,(p, T, H_S, d, x_{CO_2}, x_{H_2}) \qquad \text{. . . (3)}$$

However, the SGERG-88 method treats the natural-gas mixture internally as a five-component mixture consisting of an equivalent hydrocarbon gas (with the same thermodynamic properties as the sum of the hydrocarbons present), nitrogen, carbon dioxide, hydrogen and carbon monoxide. To characterize the thermodynamic properties of the hydrocarbon gas adequately, the hydrocarbon heating value H_{CH} is also needed. Therefore, the calculation of Z uses

$$Z = f_2\,(p, T, H_{CH}, x_{CH}, x_{N_2}, x_{CO_2}, x_{H_2}, x_{CO}) \qquad \text{. . . (4)}$$

In order to be able to model coke oven gas mixtures, the mole fraction of carbon monoxide is taken to have a fixed relation to the hydrogen content. If hydrogen is not present ($x_{H_2} < 0{,}001$), then set $x_{H_2} = 0$. The natural-gas mixture is then treated in the calculation method as a three-component mixture (see annex B).

The calculation is performed in three steps.

First, the five-component composition from which both the known superior calorific value and the known relative density can be calculated satisfactorily may be found from the input data by an iterative procedure described in detail in annex B.

Secondly, once this composition is known, B and C may be found using relationships also given in annex B.

In the third step, equations (1) and (2) are solved simultaneously for ρ_m and Z by a suitable numerical method.

A flow diagram of the procedure for calculating Z from the input data is shown in figure B.1.

4.3 Input variables

4.3.1 Preferred input data set

The input variables required for use with the SGERG-88 equation are the absolute pressure, temperature and superior calorific value (volumetric basis), the relative density, the carbon dioxide content and the hydrogen content. Thus the physical properties used the input data set (set A) are

H_S, d, x_{CO_2} and x_{H_2}

Relative density is referred to normal conditions (101,325 kPa and 0 °C) and superior calorific value is referred to normal conditions (101,325 kPa and 0 °C) and a combustion temperature of 25 °C.

4.3.2 Alternative input data sets

Three alternatives to the preferred input data set (see 4.3.1) may be used with the standard GERG virial equation:

x_{N_2}, H_S, d and x_{H_2} (set B)

x_{N_2}, x_{CO_2}, d and x_{H_2} (set C)

x_{N_2}, x_{CO_2}, H_S and x_{H_2} (set D)

The alternative input data sets are considered fully in GERG Technical Monograph TM5 [3]. Use of the alternative input data sets gives results which may differ at the fourth decimal place. This part of ISO 12213 recommends the use of input data set A.

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 MPa	$\leqslant p$	$\leqslant$ 12 MPa
temperature	263 K	$\leqslant T$	$\leqslant$ 338 K
mole fraction of carbon dioxide	0	$\leqslant x_{CO_2}$	$\leqslant$ 0,20
mole fraction of hydrogen	0	$\leqslant x_{H_2}$	$\leqslant$ 0,10
superior calorific value	30 MJ·m^{-3}	$\leqslant H_S$	$\leqslant$ 45 MJ·m^{-3}
relative density	0,55	$\leqslant d$	$\leqslant$ 0,80

The mole fractions of other natural-gas components are not required as input. These mole fractions shall, however, lie within the following ranges:

methane	0,7	$\leqslant x_{CH_4}$	$\leqslant$ 1,0
nitrogen	0	$\leqslant x_{N_2}$	$\leqslant$ 0,20
ethane	0	$\leqslant x_{C_2H_6}$	$\leqslant$ 0,10
propane	0	$\leqslant x_{C_3H_8}$	$\leqslant$ 0,035
butanes	0	$\leqslant x_{C_4H_{10}}$	$\leqslant$ 0,015

pentanes	0	$\leqslant$	$x_{C_5H_{12}}$	$\leqslant$ 0,005
hexanes	0	$\leqslant$	x_{C_6}	$\leqslant$ 0,001
heptanes	0	$\leqslant$	x_{C_7}	$\leqslant$ 0,000 5
octanes plus higher hydrocarbons	0	$\leqslant$	$x_{C_{8+}}$	$\leqslant$ 0,000 5
carbon monoxide	0	$\leqslant$	x_{CO}	$\leqslant$ 0,03
helium	0	$\leqslant$	x_{He}	$\leqslant$ 0,005
water	0	$\leqslant$	x_{H_2O}	$\leqslant$ 0,000 15

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. For pipeline quality, the method is applicable over wider ranges of temperature and pressure but with increased uncertainty (see figure 1). In the computer implementation, the lower temperature limit is set at 250 K.

4.4.2 Wider ranges of application

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

absolute pressure	0 MPa	$\leqslant p$	$\leqslant$ 12 MPa
temperature	263 K	$\leqslant T$	$\leqslant$ 338 K
mole fraction of carbon dioxide	0	$\leqslant x_{CO_2}$	$\leqslant$ 0,30
mole fraction of hydrogen	0	$\leqslant x_{H_2}$	$\leqslant$ 0,10
superior calorific value	20 MJ·m^{-3}	$\leqslant H_S$	$\leqslant$ 48 MJ·m^{-3}
relative density	0,55	$\leqslant d$	$\leqslant$ 0,90

The allowable mole fractions of other major natural-gas components are extended to:

methane	0,5	$\leqslant x_{CH_4}$	$\leqslant$ 1,0
nitrogen	0	$\leqslant x_{N_2}$	$\leqslant$ 0,50
ethane	0	$\leqslant x_{C_2H_6}$	$\leqslant$ 0,20
propane	0	$\leqslant x_{C_3H_8}$	$\leqslant$ 0,05

The limits for other minor natural-gas components remain as given in 4.4.1 for pipeline quality gas.

The method is not applicable outside these ranges; the computer implementation described in annex B will not allow violation of the limits of composition quoted here.

4.5 Uncertainty

4.5.1 Uncertainty for pipeline quality gas

The uncertainty in the prediction of the compression factor ΔZ (for the temperature range 263 K to 338 K) is $\pm$ 0,1 % at pressures up to 10 MPa and $\pm$ 0,2 % between 10 MPa and 12 MPa for natural gases with $x_{N_2} \leqslant 0,20$, $x_{CO_2} \leqslant 0,09$, $x_{C_2H_6} \leqslant 0,10$ and $x_{H_2} \leqslant 0,10$, and for 30 MJ·m^{-3} $\leqslant H_S \leqslant$ 45 MJ·m^{-3} and $0,55 \leqslant d \leqslant 0,80$, (see figure 1).

For gases with a CO_2 content exceeding 0,09, the uncertainty of $\pm$ 0,1 % is maintained for pressures up to 6 MPa and for temperatures between 263 K and 338 K. This uncertainty level is determined by comparison with the GERG databank on measurements of the compression factor for natural gases [5], [6] and with the Gas Research Institute data [9].