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Zemeljski plin - Izraļ un kompresijskega faktorja - 3. del: Izraļ un na podlagi fizikalnih lastnosti (ISO 12213-3:2006)

Natural gas - Calculation of compression factor - Part 3: Calculation using physical properties (ISO 12213-3:2006)

Erdgas - Berechnung von Realgasfaktoren - Teil 3: Berechnungen basierend auf physikalischen Stoffeigenschaften als Eingangsgrößen (ISO 12213-3:2006)

Gaz naturel - Calcul du facteur de compression - Partie 3: Calcul à partir des caractéristiques physiques (ISO 12213-3:2006)

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Natural gas - Calculation of compression factor - Part 3: Calculation using physical properties (ISO 12213-3:2006)

Gaz naturel - Calcul du facteur de compression - Partie 3: Calcul à partir des caractéristiques physiques (ISO 12213-3:2006)

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Foreword

The text of ISO 12213-3:2006 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 12213-3:2009.

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of an identical text or by endorsement, at the latest by March 2010, and conflicting national standards shall be withdrawn at the latest by March 2010.

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.

This document supersedes EN ISO 12213-3:2005.

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

Endorsement notice

The text of ISO 12213-3:2006 has been approved by CEN as a EN ISO 12213-3:2009 without any modification.

INTERNATIONAL STANDARD

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Second edition
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Natural gas — Calculation of compression factor —

Part 3: Calculation using physical properties

Gaz naturel — Calcul du facteur de compression —

Partie 3: Calcul à partir des caractéristiques physiques

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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.

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.

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ISO 12213-3 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 12213-3:1997), which has been technically revised. The revision includes changes to Subclause 4.4.1 and the addition of a new annex, Annex E.

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*

Natural gas — Calculation of compression factor —

Part 3:
Calculation using physical properties

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.

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 F).

More detail concerning the scope and field of application of the method is given in ISO 12213-1.

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

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

ISO 80000-4, *Quantities and units — Part 4: Mechanics*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12213-1 apply.

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

$$Z = 1 + B\rho_m + C\rho_m^2 \tag{1}$$

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

$$\rho_m = p/(ZRT) \tag{2}$$

where

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

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

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

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 in 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 88 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 $MJ \cdot m^{-3}$	$\leqslant$	H_S	$\leqslant$	45 $MJ \cdot m^{-3}$
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 (the ratio of successive mole fractions in the alkane homologous series is typically 3:1 — see Annex E):

methane	0,7	$\leqslant$	x_{CH_4}	$\leqslant$	1,0
nitrogen	0	$\leqslant$	x_{N_2}	$\leqslant$	0,20