SLOVENSKI STANDARD
SIST EN ISO 14912:2006
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Analiza plinov – Pretvorba podatkov sestave plinskih zmesi (ISO 14912:2003)

Gas analysis - Conversion of gas mixture composition data (ISO 14912:2003)

Gasanalyse - Umrechnung von Zusammensetzungsangaben für Gasgemische (ISO 14912:2003)

Analyse des gaz - Conversion des données de composition de mélanges gazeux (ISO 14912:2003)

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Gas analysis - Conversion of gas mixture composition data (ISO 14912:2003)

Analyse des gaz - Conversion des données de composition de mélanges gazeux (ISO 14912:2003)

Gasanalyse - Umrechnung von Zusammensetzungsangaben für Gasgemische (ISO 14912:2003)

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Foreword

The text of ISO 14912:2003 has been prepared by Technical Committee ISO/TC 158 "Analysis of gases" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 14912:2006 by Technical Committee CEN/SS N21 "Gaseous fuels and combustible gas", the secretariat of which is held 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of an identical text or by endorsement, at the latest by February 2007, and conflicting national standards shall be withdrawn at the latest by February 2007.

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Endorsement notice

The text of ISO 14912:2003 has been approved by CEN as EN ISO 14912:2006 without any modifications.

INTERNATIONAL STANDARD

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Gas analysis — Conversion of gas mixture composition data

Analyse des gaz — Conversion des données de composition de mélanges gazeux

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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.

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 14912 was prepared by Technical Committee ISO/TC 158, *Analysis of gases*.

Introduction

The objective of gas analysis is to determine the composition of gas mixtures. Gas mixture composition is expressed qualitatively in terms of specified mixture components of interest, called analytes, and the complementary gas. Gas mixture composition is expressed quantitatively by specifying the amount of every analyte in the mixture and the composition of the complementary gas.

For the purpose of specifying the amount of an analyte in a gas mixture, different quantities are in use. This diversity is due to the fact that in different applications different quantities have decisive advantages. Therefore procedures for conversion between different quantities are required.

In cases where these quantities involve the volumes of the analytes or the gas mixture or both, they depend on the state conditions, i.e. pressure and temperature, of the gas mixture. For each of these quantities, procedures for conversion between different state conditions are required.

As a crude approximation, all of the conversions referred to above can be performed on the basis of the Ideal Gas Law. In most cases, however, an accurate conversion has to take into account the real gas volumetric behaviour of the analyte and of the gas mixture. In particular, many conversions require values of the compression factor (or of the density) of the gas mixture.

This International Standard provides formally exact conversion procedures, based on fundamental principles, which fully account for real gas behaviour of pure gases and gas mixtures. In addition to these, approximate procedures for practical applications are described, designed for different levels of accuracy and available data. These approximations are necessary because measured gas mixture compression factors (or densities) are rarely available and therefore have to be estimated from component data. Uncertainty estimates are given which result from combining approximations in the conversion procedures with the uncertainties of the input data. Where conversions require real-gas volumetric data of pure gases or gas mixtures, these are expressed by compression factors. As equivalents, density data could be converted into compression factor data.

Gas analysis — Conversion of gas mixture composition data

1 Scope

This International Standard defines the following quantities commonly used to express the composition of gas mixtures:

— mole fraction,

— mass fraction,

— volume fraction,

and

— mole concentration,

— mass concentration,

— volume concentration.

For these quantities of composition, this International Standard provides methods for

— conversion between different quantities, and

— conversion between different state conditions.

Conversion between different quantities means calculating the numerical value of an analyte content in terms of one of the quantities listed above from the numerical value of the same analyte content, at the same pressure and temperature of the gas mixture, given in terms of another of these quantities. Conversion between different state conditions means calculating the numerical value of an analyte content, in terms of one of the quantities listed above, under one set of state conditions from the numerical value of the same quantity under another set of state conditions, i.e. pressure and temperature, of the gas mixture. Gas mixture composition can be converted simultaneously between different quantities of composition and different state conditions by combination of the two types of conversion.

This International Standard is applicable only to homogeneous and stable gas mixtures. Therefore any state conditions (pressure and temperature) considered need to be well outside the condensation region of the gas mixture and that of each of the specified analytes (see Annex A).

2 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

NOTE See also References [1] and [2] in the Bibliography.

2.1 Quantities for the expression of gas mixture composition

NOTE Further information concerning the terms defined in this subclause is given in 4.1.

2.1.1
mole fraction
amount-of-substance fraction
x
quotient of the amount of substance of a specified component and the sum of the amounts of substance of all components of a gas mixture

NOTE The mole fraction is independent of the pressure and the temperature of the gas mixture.

2.1.2
mass fraction
w
quotient of the mass of a specified component and the sum of the masses of all components of a gas mixture

NOTE The mass fraction is independent of the pressure and the temperature of the gas mixture.

2.1.3
volume fraction
ϕ
quotient of the volume of a specified component and the sum of the volumes of all components of a gas mixture before mixing, all volumes referring to the pressure and the temperature of the gas mixture

NOTE The volume fraction is not independent of the pressure and the temperature of the gas mixture. Therefore the pressure and the temperature have to be specified.

2.1.4
mole concentration
amount-of-substance concentration
c
quotient of the amount of substance of a specified component and the volume of a gas mixture

NOTE The mole concentration is not independent of the pressure and the temperature of the gas mixture. Therefore the pressure and the temperature have to be specified.

2.1.5
mass concentration
β
quotient of the mass of a specified component and the volume of a gas mixture

NOTE The mass concentration is not independent of the pressure and the temperature of the gas mixture. Therefore the pressure and the temperature have to be specified.

2.1.6
volume concentration
σ
quotient of the volume of a specified component before mixing and the volume of a gas mixture, both volumes referring to the same pressure and the same temperature

NOTE 1 The volume concentration is not independent of the pressure and the temperature of the gas mixture. Therefore the pressure and the temperature have to be specified.

NOTE 2 The volume fraction (2.1.3) and volume concentration (2.1.6) take the same value if, at the same state conditions, the sum of the component volumes before mixing and the volume of the mixture are equal. However, because the mixing of two or more gases at the same state conditions is usually accompanied by a slight contraction or, less frequently, a slight expansion, this is not generally the case.

2.2 Additional quantities involved in conversions of gas mixture composition

2.2.1
compression factor
Z
quotient of the volume of an arbitrary amount of gas at specified pressure and temperature and the volume of the same amount of gas, at the same state conditions, as calculated from the ideal gas law

NOTE 1 This definition is applicable to pure gases and to gas mixtures, therefore the term “gas” is used as a general term which covers pure gases as well as gas mixtures.

NOTE 2 By definition, the compression factor of an ideal gas is 1. At room temperature and atmospheric pressure, for many gases the compression factor differs only moderately from 1.

2.2.2
mixing factor
f
quotient of the volume of an arbitrary amount of a gas mixture at specified pressure and temperature and the sum of the volumes of all mixture components, before mixing, at the same state conditions

NOTE If the component volumes are strictly additive, i.e. if the sum of the component volumes before mixing is the same as the volume after mixing, the mixing factor is 1. At room temperature and atmospheric pressure, for many gas mixtures the mixing factor differs only slightly from 1.

2.2.3
density
ρ
quotient of the mass of an arbitrary amount of gas and its volume at specified pressure and temperature

NOTE This definition is applicable to pure gases and to gas mixtures, therefore the term “gas” is used as a general term which covers pure gases as well as gas mixtures.

2.2.4
molar volume
V_{mol}
quotient of the volume of an arbitrary amount of gas at specified pressure and temperature and its amount of substance

NOTE 1 This definition is applicable to pure gases and to gas mixtures, therefore the term “gas” is used as a general term which covers pure gases as well as gas mixtures.

NOTE 2 The amount of substance of a mixture is given by the sum of the amounts of substance of the components.

2.2.5
virial coefficients
coefficients in the expansion of the compression factor in terms of powers of a quantity of state

NOTE In practice, only two virial expansions are used, where the quantity of state is either the pressure, p, or the inverse molar volume, $1/V_{mol}$, as follows.

$$Z\left(V_{mol},T\right) = 1 + \frac{B(T)}{V_{mol}} + \frac{C(T)}{V_{mol}^2} + \ \ldots \quad (1)$$

$$Z\left(p,T\right) = 1 + B'(T)\,p + C'(T)\,p^2 + \ \ldots \quad (2)$$

2.2.5.1
second molar-volume virial coefficient
B
coefficient of $1/V_{mol}$ in the expansion of the compression factor in terms of inverse powers of the molar volume, V_{mol}

2.2.5.2
third molar-volume virial coefficient
C
coefficient of $1/V_{mol}^2$ in the expansion of the compression factor in terms of inverse powers of the molar volume, V_{mol}

2.2.5.3
second pressure virial coefficient
B'
coefficient of p in the expansion of the compression factor in terms of powers of the pressure p

2.2.5.4
third pressure virial coefficient
C'
coefficient of p^2 in the expansion of the compression factor in terms of powers of the pressure p

3 Symbols and units

Symbol	Quantity	SI unit
α	abbreviation of $p/(RT)$	mol/m^3
B	second molar-volume virial coefficient	m^3/mol
B'	second pressure virial coefficient	$1/Pa$
β	mass concentration	kg/m^3
c	mole concentration	mol/m^3
C	third molar-volume virial coefficient	m^6/mol^2
C'	third pressure virial coefficient	$1/Pa^2$
D	dilution factor	1
f	mixing factor	1
ϕ	volume fraction	1
i	gas mixture components (i = 1, 2, …, N)	—
j, k	gas mixture components (from 1 to N) (where needed in addition to symbol i)	—
m	mass	kg
M	molar mass	kg/mol
n	amount of substance	mol

Symbol	Quantity	SI unit
N	number of gas mixture components	—
p	pressure	Pa
p_{vap}	saturation vapour pressure	Pa
p_{dew}	dew pressure	Pa
R	molar gas constant (8,314 510)	J/(mol·K)
ρ	density	kg/m^3
S	(sample of) gas mixture	—
σ	volume concentration	m^3/m^3
t	Celsius temperature	°C
T	thermodynamic temperature	K
V	volume	m^3
V_{mol}	molar volume	m^3/mol
w	mass fraction	1
W	weight (of a gas cylinder)	kg
x	mole fraction	1
X_{ref}	reference value of state conditions ($X = p, T$)	same as for X
X_{crit}	critical component property ($X = p, T, V, Z$)	same as for X
X_{pscrit}	pseudo-critical mixture property ($X = p, T$)	same as for X
Z	compression factor	1

In addition to the symbols specified above, the following symbols are used to denote objects of generic mathematical expressions.