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Natural gas — Energy determination

Gaz naturel — Détermination de l'énergie

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Contents

Page

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 15112 was prepared by Technical Committee ISO/TC 193, *Natural gas*.

This second edition cancels and replaces the first edition (ISO 15112:2007), which has been technically revised.

Introduction

Since the early 1800s, it has been general practice for manufactured gas and, subsequently, natural gas to be bought and sold on a volumetric basis. Much time and effort has therefore been devoted to developing the means of flow measurement.

Because of the increasing value of energy and variations in gas quality, billing on the basis of thermal energy has now become essential between contracting partners and the need to determine calorific value by measurement or calculation has led to a number of techniques. However, the manner in which calorific value data are applied to flow volume data to produce the energy content of a given volume of natural gas has been far from a standardized procedure.

Energy determination is frequently a necessary factor wherever and whenever natural gas is metered, from production and processing operations through to end-user consumption. This International Standard has been developed to cover aspects related to production/transmission and distribution/end user. It provides guidance to users of how energy units for billing purposes are derived, based on either measurement or calculation or both, to increase confidence in results for contracting partners.

Other standards relating to natural gas, flow measurement, calorific value measurement, calculation procedures and data handling with regard to gas production, transmission and distribution involving purchase, sales or commodity transfer of natural gas can be relevant to this International Standard.

This International Standard contains ten informative annexes.

Natural gas — Energy determination

1 Scope

This International Standard provides the means for energy determination of natural gas by measurement or by calculation, and describes the related techniques and measures that are necessary to take. The calculation of thermal energy is based on the separate measurement of the quantity, either by mass or by volume, of gas transferred and its measured or calculated calorific value. The general means of calculating uncertainties are also given.

Only systems currently in use are described.

NOTE Use of such systems in commercial or official trade can require the approval of national authorization agencies, and compliance with legal regulations is required.

This International Standard applies to any gas-measuring station from domestic to very large high-pressure transmission.

New techniques are not excluded, provided their proven performance is equivalent to, or better than, that of those techniques referred to in this International Standard.

Gas-measuring systems are not the subject of this International Standard.

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*

3 Terms and definitions

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

3.1
accuracy of measurement
closeness of the agreement between a measurement result and a true value of the measurand

[ISO 14532:2001]

3.2
adjustment
⟨of a measuring instrument⟩ operation of bringing a measuring instrument into a state of performance suitable for its use

NOTE Adjustment may be automatic, semi-automatic or manual.

3.3
assignment method
⟨energy determination⟩ method to derive a calorific value to be applied to the gas passing specified interfaces having only volume measurements

3.4
availability
probability, at any time, that the measuring system, or a measuring instrument forming part of the measuring system, is functioning according to specifications

[EN 1776:1998]

3.5
bias
systematic difference between the true energy and the actual energy determined of the gas passing a gas-measuring station

3.6
calibration
set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values obtained using working standards

[ISO 14532:2001, 2.5.2.2]

3.7
superior calorific value

energy released as heat by the complete combustion in air of a specified quantity of gas, in such a way that the pressure, p_1, at which the reaction takes place remains constant, and all the products of combustion are returned to the same specified temperature, T_1, 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 T_1

[ISO 14532:2001, 2.6.4.1]

3.8
inferior calorific value
energy released as heat by the complete combustion in air of a specified quantity of gas, in such a way that the pressure, p_1, at which the reaction takes place remains constant, and all the products of combustion are returned to the same specified temperature, T_1, as that of the reactants, all of these products being in the gaseous state

[ISO 14532:2001, 2.6.4.2]

3.9
calorific value station
installation comprising the equipment necessary for the determination of the calorific value of the natural gas in the pipeline

3.10
adjusted calorific value
calorific value measured at a measuring station compensated for the time taken for the gas to travel to the respective volume-measuring station

3.11
corrected calorific value
result of correcting a measurement to compensate for systematic error

3.12
declared calorific value
calorific value that is notified in advance of its application to interfaces for the purpose of energy determination

3.13
representative calorific value
calorific value which is accepted to sufficiently approximate the actual calorific value at an interface

3.14
charging area
set of interfaces where the same method of energy determination is used

3.15
conversion
determination of the volume under reference conditions from the volume under operating conditions

3.16
correction
value added algebraically to the uncorrected result of a measurement to compensate for systematic error

NOTE 1 The correction is equal to the negative of the estimated systematic error.

NOTE 2 Since the systematic error cannot be known perfectly, the correction cannot be complete (see Annex I).

3.17
correction factor
numerical factor by which the uncorrected result of a measurement is multiplied to compensate for a systematic-error object

NOTE Since the systematic error cannot be known perfectly, the correction cannot be complete (see Annex I).

3.18
determination
set of operations that are carried out on an object in order to provide qualitative or quantitative information about this object

NOTE In this International Standard, the term “determination” is only used quantitatively.

3.19
direct measurement
measurement of a property from quantities which, in principle, define the property

NOTE For example, the determination of the calorific value of a gas using the thermoelectric measurement of the energy released in the form of heat during the combustion of a known amount of gas.

[ISO 14532:2001, 2.2.1.2]

3.20
energy
product of gas quantity (mass or volume) and calorific value under given conditions

NOTE 1 The energy may be called energy amount.

NOTE 2 Energy is usually expressed in units of megajoules.

3.21
energy determination
quantitative determination of the amount of energy of a quantity of gas based either on measurement or calculation using measured values

3.22
energy flow rate
energy of gas passing through a cross-section divided by time

NOTE Energy flow rate is usually expressed in units of megajoules per second.

3.23
fixed assignment
application without modification of the calorific value measured at one specific calorific-value-measuring station, or the calorific value declared in advance, to the gas passing one, or more, interfaces

3.24
gas transporter
company that conveys gas from one place to another through pipelines

3.25
grid simulation
calculation of a set of pressures and flow rates in a pipeline or a grid on the basis of given topology data, values of the flow rates at the inlet and outlet points and of the pressure and temperature at various points of the pipeline(s) by means of a mathematical model

NOTE The objective of any grid simulation is to yield information about a future state of gas pressures and flows. The result of the simulation is an estimation of the state of the gas flow.

3.26
interface
place on a pipe used for the transportation or supply of gas at which there is a change of ownership or physical custody of gas

NOTE Generally, an interface has an associated measuring station.

3.27
local distribution company
LDC
company that delivers gas to industrial, commercial and/or residential customers

3.28
measuring station
installation comprising all the equipment, including the inlet and outlet pipework as far as the isolating valves and structure within which the equipment is housed, used for gas measurement in custody transfer

[EN 1776:1998]

3.29
measuring system
complete set of measuring instruments and auxiliary equipment assembled to carry out specified measurements

NOTE Adapted from ISO/IEC Guide 99:2007, 3.2.

3.30
measuring instrument
device intended to be used for making measurements, alone or in conjunction with one or more supplementary devices

[ISO/IEC Guide 99:2007, 3.1]

3.31
plausibility
property of a value to be within reasonable limits

3.32
producer
company that extracts raw natural gas from reservoirs which, after processing and (fiscal) measurement, is supplied as dry natural gas to the transportation system

3.33
regional distributor
company that delivers gas to local distribution companies and/or industrial, commercial or residential customers

3.34
residential customer
person whose occupied premises are supplied with gas, wholly or in part, such gas not being used for any business purpose, commercial or industrial

3.35
systematic error
mean that would result from an infinitive number of measurements of the same measurand carried out under repeatability conditions minus a true value of the measurand

3.36
traceability
property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or International Standards, through an unbroken chain of comparisons all having stated uncertainties

NOTE This chain of comparisons is called a traceability chain.

3.37
uncertainty
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

3.38
variable assignment
application of a calorific value for an assignment procedure based on measurement(s) at calorific value station(s) to the gas passing one, or more, interfaces

NOTE That applied calorific value may take into account the time taken for the gas to travel from the calorific value station to the respective volume-measuring stations and other factors, to derive an average calorific value for a network, a state reconstruction of the variation of calorific values through a network, etc.

3.39
zero floating point
position in a grid conveying gas where there is a boundary with different gas qualities on either side

3.40
non-plausible data
measurement data that are obviously wrong taking into account the measurement situation at a measuring station and the gas flow situation

4 Symbols and units

Symbol	Meaning	SI unit	USC unit
E	energy	MJ	kWh
e	energy flow rate	MJ/s	kWh/h
H	calorific value	MJ/m^3; MJ/kg	kWh/m^3

NOTE 1 Where the calorific value is in megajoules per cubic metre and the gas volume is in cubic metres, or where the calorific value is in megajoules per kilogram and the gas mass is in kilograms, then the calculated energy is in megajoules.

Where the calorific value is in kilowatt-hours per cubic metre and the gas volume is in cubic metres, or where the calorific value is in kilowatt-hours per kilogram and the gas mass is in kilograms, then the calculated energy is in kilowatt-hours.

To convert the number of megajoules to the number of kilowatt-hours, divide the number by 3,6.

Symbol	Meaning	SI unit	USC unit
M	mass	kg	t
p	pressure (absolute)	Pa, kPa	bar, mbar
Q	quantity of gas	m^3, kg	t

NOTE 2 When the quantity is given in cubic metres, it is necessary that it should be qualified by temperature and pressure.

Symbol	Meaning	SI unit	USC unit
q_v	volume flow rate	m^3/h, m^3/s	
q_m	mass flow rate	kg/s, kg/h	
T	temperature (absolute)	K	
t	time	s, h, d	s, h, d
V	volume (gas)	m^3	
Z	compression factor		
ρ	density	kg/m^3	
ϑ	temperature	°C	°F

Subscripts

i	inferior calorific value
j	number of time intervals
n	normal reference conditions (273,15 K; 101,325 kPa)
r	ISO-recommended standard reference conditions (288,15 K; 101,325 kPa)
s	superior calorific value

5 General principles

The quantity of energy, E, contained in a given quantity of gas, Q, is given by the multiplication of the calorific value, H, by the respective quantity of gas.

Energy may be either measured directly (see Figure 1) or calculated from the quantity and the calorific value of the gas (see Figure 2).

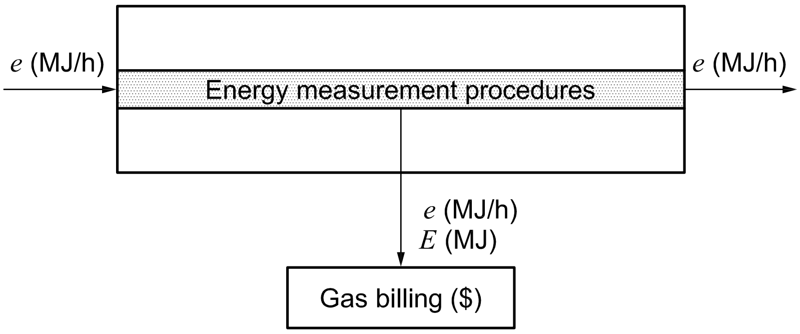

Figure 1 — Energy-measurement scheme

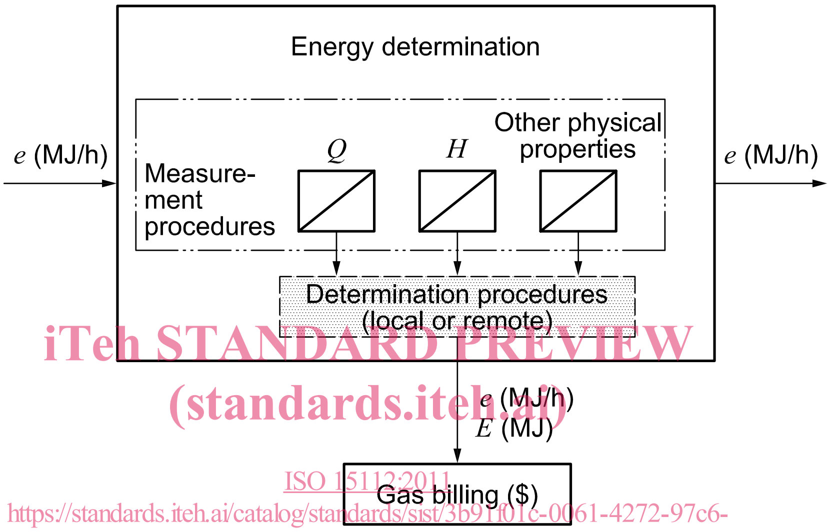

Figure 2 — Energy-determination scheme

Generally, the quantity of gas is expressed as a volume and the calorific value is on a volumetric basis. In order to achieve accurate determinations of energy, it is necessary that both the gas volume and calorific value be under the same reference conditions. The determination of energy is based either on the accumulation over time of calculation results from consecutive sets of calorific values and the concurrent flow rate values, or on the multiplication of the total volume and the representative (assigned) calorific value for that period.

Especially in situations of varying calorific values and when flow rates are determined at a place different from that of the (representative) calorific value, the effect on the accuracy caused by the difference in time between the determination of the flow rate and the calorific value shall be considered (see Clause 11).

The gas volume may either be measured and reported as the volume under the ISO-recommended standard reference conditions or be measured under some other conditions and converted to an equivalent volume under the ISO-recommended standard reference conditions, using an appropriate method of volume conversion. The method of volume conversion used at a specific gas-volume-measuring station may require gas quality data determined at other places. For the purpose of this International Standard, the ISO-recommended standard reference conditions of 288,15 K and 101,325 kPa, as defined in ISO 13443, should be used.

NOTE For the gas supply, other conditions can be used, corresponding to national standards or laws. Methods for conversion between different conditions for dry natural gases are given in ISO 13443.

The calorific value may be measured at the gas-measuring station or at some other representative point and assigned to the gas-measuring station. It is also possible for the quantity of gas and the calorific value to be expressed on a mass basis.

This general principle of energy determination is extended in Clause 10 to those cases when the quantity of gas is expressed on either a volumetric or a mass basis.

To achieve the calculation of the quantity of energy of the gas passing a gas-measuring station over a period of time, the methods of energy determination in Clauses 7 to 10 are used. Such methods involve an integration over the time period; that integration may be

— of the energy flow, or

— of the gas flow rate over time to obtain the quantity of gas, which is then multiplied by the representative calorific value.

The method of integration may depend on contractual agreements or national legislation.

The general principles of energy determination in Clauses 7 to 10 are independent of the method with which the integrations are carried out. The method of integration influences the uncertainty of the determined energy; these effects are considered in Clause 11.

6 Gas measurement

6.1 General

The types of measuring devices and methods used in real measuring stations depend among other things on

— the respective national requirements,

— the flow rate,

— the commercial value of the gas,

— the gas quality variations,

— the need for redundancy, and

— the instrument specification.

Only proven methods and measuring devices/products used at the respective interfaces should be used. An overview of the techniques and procedures currently used in different countries is shown in Annex A.

Methods used for flow and calorific value measurement shall be in accordance with standards, contractual agreements and/or national legislation, as appropriate.

Action should be taken to identify and reconcile systematic effects. For example, use of different national standards, regulations and/or operating procedures can introduce systematic differences; contract partners should determine the appropriate means to overcome these differences.

The quality of the measurement results, in general, depends on the following factors:

— operating conditions;

— maintenance frequency and quality;

— calibration standards;

- sampling and clean-up;
- changes in gas composition;
- ageing of measurement devices.

A high accuracy can be achieved if the requirements fixed by the manufacturers and by officials are met and all operating procedures for operating, calibration and maintenance are strictly observed.

6.2 Volume measurement

The volume flow-metering system of a natural-gas-measuring station consists of one or more meter runs. Generally, the meters measure the gas volume flow under actual operating conditions. Standards for orifice meters (ISO 5167-1) and turbine meters (ISO 9951) exist.

The selection of a flow-metering system for a specific application depends, as a minimum, on the following:

- conditions of flow;
- flow-measuring range;
- operating conditions, especially operating pressure;
- acceptable pressure loss;
- required accuracy.

For natural-gas volume flow measurement, the instruments mostly used at the interfaces 1 to 6 (see 7.1) are shown in Annex A.

6.3 Calorific value measurement

6.3.1 Measurement techniques and sampling

A calorific-value measuring system consists of a sampling system and a measurement device taken from one of the following groups:

- direct measurement (e.g. by combustion calorimeters);
- inferential measurement [e.g. by a gas chromatograph (GC)];
- correlation techniques.

To achieve a high accuracy of calorific value measurement, representative sampling is required. Guidelines are given in ISO 10715.

Depending on

- the measuring system,
- the operating procedures,
- the fluctuation of composition of the gas, and/or
- the quantity of gas delivered,