



BSI Standards Publication

Gas infrastructure — Gas measuring systems — Functional requirements

National foreword

This British Standard is the UK implementation of EN 1776:2025. It supersedes BS EN 1776:2015, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GSE/33, Gas supply.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Contents

Page

European foreword	7
Introduction	8
1 Scope.....	9
2 Normative references.....	9
3 Terms and definitions	11
4 General requirements	18
4.1 General.....	18
4.2 Safety and environment	19
4.3 Quality and measurement management system	19
5 Basic requirements for gas measuring systems	20
5.1 General.....	20
5.2 Classification of the gas measuring system	20
5.2.1 General.....	20
5.2.2 Minimum requirements Class A and Class B.....	21
5.2.3 Minimum requirements Class C and Class D	22
5.3 Gas measuring system modules	22
6 Energy Determination.....	23
6.1 General.....	23
6.2 Requirements for measurements used in energy determination.....	24
6.2.1 Base conditions.....	24
6.2.2 Flow measurement.....	24
6.2.3 Gross calorific value (GCV)	24
6.3 Calculation method of energy using assigned GCV and P, T, Z values	26
6.4 Calculation method of energy using an on-site CVDD and on-site PTZ-Conversion	26
6.5 Calculation method of energy using an assigned GCV and PTZ-conversion	26
6.6 Calculation method of energy using PT-Conversion and assigned GCV and Z value	26
6.7 Calculation method of energy using T-Conversion and assigned GCV, and P, Z values ..	26
6.8 Gas temperature conversion	26
6.9 Gas pressure conversion	27
6.10 Compressibility conversion	27
6.11 PTZ-conversion.....	27
6.12 Uncertainty of energy determination.....	27
7 Design of gas measuring system.....	28
7.1 General.....	28
7.2 Safety provision.....	28
7.3 Housing.....	28
7.4 Gas measuring station.....	29
7.5 Gas measuring installation.....	29
7.5.1 General.....	29
7.5.2 Continuity of supply.....	32
7.5.3 Gas meters.....	32
7.5.4 Gas meters with additional functionalities and remotely operated valve.....	33
7.6 Calorific value determination system	33

7.6.1	General	33
7.6.2	Sampling	34
7.6.3	Provisions for calibration.....	34
7.7	Gas pressure measurement	34
7.7.1	General	34
7.7.2	Gas pressure measurement Class A and Class B.....	34
7.7.3	Gas pressure determination Class C and Class D.....	35
7.8	Gas temperature measurement	35
7.9	Conversion device	36
7.10	Compression factor.....	36
7.11	Pipework requirements.....	36
7.11.1	For Class A and Class B measuring installation	36
7.11.2	For Class C and Class D measuring installation	37
7.12	Valves.....	37
7.12.1	General	37
7.12.2	By-pass.....	37
7.13	Parallel meter runs.....	37
7.14	Pulsations and vibrations.....	38
7.14.1	General	38
7.14.2	Pulsating effects related to specific flow meter types.....	39
7.15	Filter	39
7.16	Gas conditioning, hydrate protection.....	39
7.17	Duplication/redundancy of measuring instruments	39
7.18	Venting.....	40
7.19	Ventilation.....	40
7.20	Odorants and/or additives.....	40
7.21	Electromagnetic compatibility (EMC)	40
7.22	Documented provisions	40
7.22.1	General	40
7.22.2	Data handling (Security)	41
8	Construction of a gas measuring installation	41
8.1	General	41
8.2	Specific requirements for thermowells.....	42
8.3	Specific requirements for (differential) pressure transducers.....	42
8.4	Specific requirements for sampling systems for CVDD's	42
8.5	Corrosion protection	42
8.6	Equipment in hazardous area	43
9	Testing of the gas measuring installation/station.....	43
9.1	Strength and tightness test	43
9.1.1	General	43
9.1.2	Test report	43
9.2	Purging	43
10	Pre-commissioning and commissioning of the gas measuring installation.....	44
10.1	General	44
10.2	Pre-commissioning checks.....	44
10.2.1	General	44
10.2.2	Electrical or electronic system.....	44
10.3	Commissioning and re-commissioning	44
10.3.1	General	44
10.3.2	Gas meters.....	45
10.3.3	Instrumentation.....	46
10.3.4	Initial comparison check.....	46

10.4	Acceptance, documentation and hand-over	46
10.5	Post-commissioning checks	47
11	Operation and maintenance	47
11.1	General.....	47
11.2	Reference equipment	48
11.3	Gas meters	49
11.3.1	General.....	49
11.3.2	Rotary displacement meters.....	49
11.3.3	Turbine meters.....	49
11.3.4	Vortex meters.....	50
11.3.5	Ultrasonic meters	50
11.3.6	Orifice Meters.....	50
11.4	Conversion devices.....	50
11.5	Calorific value determination device	51
11.6	Sensors.....	51
11.7	Calibration/verification and maintenance records	51
12	Decommissioning	52
	Annex A (informative) Guideline for the selection of meters	53
	Annex B (informative) Sensor test procedures.....	59
B.1	Differential pressure sensors.....	59
B.1.1	General.....	59
B.1.2	High static pressure testing	59
B.1.3	“Footprint testing”	59
B.1.4	Atmospheric calibration	60
B.2	Pressure sensors	60
B.3	Temperature sensors	60
B.3.1	Platinum resistance thermometers (PRTs)	60
B.3.2	Other temperature sensors.....	60
B.4	Density sensors.....	60
B.4.1	Density sensors for operating conditions.....	60
B.4.2	Density sensors for base conditions	62
	Annex C (informative) Set of formulae to calculate volume or mass to energy	63
C.1	General.....	63
C.2	Calculation of volume.....	64
C.3	Calculation of mass.....	64
C.4	Calculation of energy	64
	Annex D (informative) Determination of the acceptance criteria for the uncertainty of the energy determination	65
D.1	General.....	65
D.2	Measurement Systems	65
D.3	Energy Determination Systems	66

Annex E (informative) Specific national examples of the assessment of conformity of the metrological performance of a gas measuring system	67
E.1 Introduction	67
E.2 Example 1	68
E.3 Example 2	72
E.4 Example 3	74
E.5 Example 4	77
E.6 Example 5	80
E.7 Example 6	83
E.8 Example 7	88
Annex F (informative) Documentation and records	93
F.1 Documentation	93
F.2 Records.....	93
F.3 Responsibilities for documentation and records	93
Annex G (informative) Typical examples of positions of gas measuring installations.....	95
Annex H (informative) Significant technical changes from the last edition of this standard, EN 1776:2015.....	96
Annex I (informative) Hydrogen and its blends with natural gas.....	98
I.1 General	98
I.2 5.2.2 Minimum requirements Class A and Class B.....	98
I.3 6.2.2 Flow measurement.....	99
I.4 6.2.3.1 Gross calorific value (GCV)/ General considerations.....	100
I.5 6.2.3.2 Calorific value determination device (CVDD).....	100
I.6 6.3 Calculation method of energy using assigned GCV and P, T, Z values.....	100
I.7 6.4 Calculation method of energy using an on-site CVDD and on-site PTZ-Conversion	100
I.8 6.5 Calculation method of energy using an assigned GCV and PTZ-conversion.....	100
I.9 6.6 Calculation method of energy using PT-Conversion and assigned GCV and Z value	100
I.10 6.7 Calculation method of energy using T-Conversion and assigned GCV, and P, Z values	100
I.11 6.10 Compressibility conversion	100
I.12 6.11 PTZ-conversion.....	100
I.13 6.12 Uncertainty of energy determination.....	101
I.14 7.2 Safety provision	101
I.15 7.5.3 Gas meters	101
I.16 7.11. Compression factor	101
I.17 7.11.1 Pipework requirements.....	101

I.18	7.15.1 General	102
I.19	7.15.2.1 Turbine meter	102
I.20	7.15.2.2 Rotary displacement meter.....	102
I.21	7.15.2.3 Ultrasonic meter (non-domestic)	102
I.22	8.1 General	102
I.23	8.2 Specific requirements for thermowells.....	102
I.24	8.6 Electrical equipment in hazardous area	102
I.25	9.1.1 General.....	103
I.26	10.2.1 General	103
I.27	10.2.2 Electrical or electronic system	103
I.28	10.3.1 General	103
I.29	10.3.2. Gas meters.....	103
I.30	10.3.2.2 Non-domestic ultrasonic meters	103
I.31	10.3.2.3 Orifice plate meter.....	104
I.32	10.3.2.4 Coriolis meter	104
I.33	11.2 Reference equipment	104
I.34	11.3.1 General	104
I.35	11.3.4 Vortex meters	105
I.36	11.5 Calorific value determination device.....	105
I.37	B 4.1.4 Hydrogen test.....	105
I.38	G Typical examples of positions of gas measuring installations	105
	Bibliography	107

European foreword

This document (EN 1776:2025) has been prepared by Technical Committee CEN/TC 234 “Gas infrastructure”, the secretariat of which is held by DIN.

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 June 2025, and conflicting national standards shall be withdrawn at the latest by June 2025.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1776:2015.

EN 1776:2025 includes significant technical changes with respect to EN 1776:2015, which are described in Table H.1 in Annex H.

This version of the document comprises a major revision of EN 1776:2015. The scope of the standard is expanded and now includes natural gas / hydrogen blends and hydrogen, as mentioned in CEN/TR 17797. For this purpose, the document has been amended.

This document has been prepared under a standardization request addressed to CEN by the European Commission.

This document has in part been developed in response to the work of the European Standards Organisations (CEN/CENELEC/ETSI) under the Commission Mandate M/441. The standard is applying in conjunction with CEN/CLC/ETSI TR 50572, *Functional Reference Architecture for Communications in Smart Metering Systems* and EN 16314, *Gas meters – Additional functionalities* (often referred to as a smart gas meter).

Directive 2009/73/EC concerning common rules for the internal market in natural gas and the related Regulation (EC) No 715/2009 on conditions for access to the natural gas transmission networks also aim at technical safety (security) including technical reliability of the European gas system. These aspects are also in the scope of CEN/TC 234 standardization. In this respect CEN/TC 234 evaluated the indicated EU legislation and amended this technical standard accordingly, where required and appropriate.

This document covers the environmental aspects relevant to the design, construction, operation, and maintenance and commissioning/decommissioning of gas measuring systems, where appropriate, in accordance with CEN Guide 4 and CEN/TR 16388.

In preparing this document, a basic understanding of gas infrastructure by the user has been assumed.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

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

Introduction

This document specifies different classes of measuring systems, each having their own specific requirements.

By nature, a measuring system is an aggregate of several components. In this document, it is assumed that each component is in full compliance with applicable CEN or ISO standards, if any.

This document allows the user to choose between different accuracy classes of measuring systems, the choice of which can be justified on economic grounds.

This document specifies common basic principles for gas infrastructure. Users of this document are expected to be aware that there can exist more detailed national standards and/or codes of practice in the CEN member countries.

This document is intended to be applied in association with these national standards and/or codes of practice setting out the basic principles as outlined in Clause 1 of this document.

1 Scope

This document specifies functional requirements for the design, construction, testing, commissioning/decommissioning, operation, maintenance and, where appropriate, calibration, together with suitable documented provisions for all new gas measuring systems and any major changes of existing systems.

This document also specifies accuracy classes of measuring systems and thresholds applicable to these classes. Demonstration of compliance is achieved through the selection, installation and operation of appropriate measurement instruments, together with suitable documented provisions for calculations. Examples of demonstration of compliance are provided for each accuracy class; however, they are not prescriptive solutions.

This document is applicable for gases of the 2nd family as classified in EN 437. It is also applicable for treated non-conventional combustible gases complying with EN 437 and for which a detailed technical evaluation of the functional requirements (such as injected biomethane) is performed ensuring there are no other constituents or properties of the gases that can affect the metrological and physical integrity of the measuring systems. This version mentions technical topics to consider when hydrogen and natural gas / hydrogen blends flow through the measuring systems. Blends with a hydrogen content between 20mol% and 98 mol% are not considered by this standard. This document applies to hydrogen with a purity as specified in CEN/TS 17977 for rededicated natural gas systems.

This document can also be used as a guideline for measuring systems for other gases e.g. gaseous CO₂ for CCUS.

This document does not apply to raw or sour gases.

This document does not apply to gas measurement in CNG filling stations.

This document gives guidelines when designing, installing and operating gas meters with additional functionalities (smart gas meters).

Communication protocols and interfaces for gas meters and remote reading of gas meters are outside the scope of this document and are covered by the appropriate parts of the EN 13757 series, which provide a number of protocols for meter communications. Supervisory control and data acquisition protocols (SCADA) are also not covered by this document.

Unless otherwise specified all pressures used in this document are gauge pressures.

For associated pressure regulating systems the requirements of EN 12186 and/or EN 12279 apply.

For requirements on design, housing, lay-out, materials for components, construction, ventilation, venting and overall safety of gas measuring systems within the scope of this document, the EN 15001 series, EN 12186, EN 12279 and/or EN 1775 apply additionally, where relevant.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE There is assumption that any guidance within these standards will be updated to include hydrogen.

EN 1594, *Gas infrastructure - Pipelines for maximum operating pressure over 16 bar - Functional requirements*

EN 1775, *Gas supply - Gas pipework for buildings - Maximum operating pressure less than or equal to 5 bar - Functional recommendations*

EN 12186, *Gas infrastructure - Gas pressure regulating stations for transmission and distribution - Functional requirements*

EN 12279, *Gas supply systems - Gas pressure regulating installations on service lines - Functional requirements*

EN 12327, *Gas infrastructure - Pressure testing, commissioning and decommissioning procedures - Functional requirements*

EN 12405 (all parts), *Gas meters — Conversion devices*

EN 15001-1, *Gas Infrastructure - Gas installation pipework with an operating pressure greater than 0,5 bar for industrial installations and greater than 5 bar for industrial and non-industrial installations - Part 1: Detailed functional requirements for design, materials, construction, inspection and testing*

EN 15001-2, *Gas supply systems - Gas installation pipework with an operating pressure greater than 0,5 bar for industrial installations and greater than 5 bar for industrial and non-industrial installations - Part 2: Detailed functional requirements for commissioning, operation and maintenance*

EN 16314, *Gas meters - Additional functionalities*

EN IEC 60079-10-1, *Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres (IEC 60079-10-1)*

EN 60079-14, *Explosive atmospheres - Part 14: Electrical installations design, selection and erection (IEC 60079-14)*

EN 60079-17, *Explosive atmospheres - Part 17: Electrical installations inspection and maintenance (IEC 60079-17)*

EN 61000 (all parts), *Electromagnetic compatibility (EMC) (IEC 61000 (all parts))*

EN ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 1: General principles and requirements (ISO 5167-1)*

EN ISO 5167-2, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 2: Orifice plates (ISO 5167-2)*

EN ISO 6141, *Gas analysis - Contents of certificates for calibration gas mixtures (ISO 6141:2015)*

EN ISO 6142-1, *Gas analysis - Preparation of calibration gas mixtures - Part 1: Gravimetric method for Class I mixtures (ISO 6142-1)*

EN ISO 6143, *Gas analysis - Comparison methods for determining and checking the composition of calibration gas mixtures (ISO 6143)*

EN ISO 6975, *Natural gas - Extended analysis - Gas-chromatographic method (ISO 6975)*

EN ISO 10715, *Natural gas - Gas sampling (ISO 10715)*

EN ISO 10723, *Natural gas - Performance evaluation for analytical systems (ISO 10723)*

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

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

EN ISO 15970, *Natural gas - Measurement of properties - Volumetric properties: density, pressure, temperature and compression factor (ISO 15970)*

EN ISO 20765-1, *Natural gas - Calculation of thermodynamic properties - Part 1: Gas phase properties for transmission and distribution applications (ISO 20765-1)*

EN ISO 20765-2, *Natural gas - Calculation of thermodynamic properties - Part 2: Single-phase properties (gas, liquid, and dense fluid) for extended ranges of application (ISO 20765-2)*

EN ISO 20765-5, *Natural gas - Calculation of thermodynamic properties - Part 5: Calculation of viscosity, Joule-Thomson coefficient, and isentropic exponent (ISO 20765-5)*

EN ISO 80079-36, *Explosive atmospheres - Part 36: Non-electrical equipment for explosive atmospheres - Basic method and requirements (ISO 80079-36)*

ISO 2186, *Fluid flow in closed conduits — Connections for pressure signal transmissions between primary and secondary elements*

ISO 10790, *Measurement of fluid flow in closed conduits — Guidance to the selection, installation and use of Coriolis flowmeters (mass flow, density and volume flow measurements)*

ISO/IEC Guide 98-1, *Guide to the expression of uncertainty in measurement — Part 1: Introduction*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 98-3 Supplement 1, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995) — Supplement 1: Propagation of distributions using a Monte Carlo method)*

ISO/IEC Guide 98-3 Supplement 2, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995) — Supplement 2: Extension to any number of output quantities)*

ISO/IEC Guide 98-4, *Uncertainty of measurement — Part 4: Role of measurement uncertainty in conformity assessment*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp/>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

accuracy of measurement

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

3.2

additional components

elements or devices, required to ensure correct measurement or intended to facilitate the measuring operations, or which could in anyway affect the measurement

EXAMPLE Additional components can be

- a) filter;
- b) flow conditioning device;
- c) branch or by-pass line;
- d) valves;
- e) pressure reduction devices located upstream or downstream of the meter;
- f) sampling systems;
- g) piping.

3.3

analyser

equipment which by means of any technology (chromatography, spectrometry, etc.) is able of measuring or calculating some chemical or physical properties of the gas (composition, wobble index, purity, etc.)

3.4

authorized person

person who is appointed to fulfil a given task on gas measuring systems

3.5

availability

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

3.6

bidirectional flow measurement

situation where a network can receive gas flow in one direction or the other

EXAMPLE For example, distribution networks that are interconnected and gas flow is transferred from one to the other as required.

3.7

base condition

specified condition to which the measured quantities of gas are converted

Note 1 to entry: Operating and base conditions relate to the volume of gas to be measured or indicated only and should not be confused with “rated operating conditions” and “reference conditions” which refer to influence quantities.

3.8

bias

systematic difference between the true value of measurand and its determined value

3.9 calorific value determination device CVDD

measuring instrument for obtaining the calorific value of gas. The CVDD can comprise multiple devices

3.10 class

accuracy class of measurement systems based on the maximum level of uncertainty of the system and its constituent elements

Note 1 to entry: Accuracy classes can be A, B, C or D.

Note 2 to entry: Each class has an uncertainty and elements, see point 5.2 where the classes and the elements of the measurement system are defined.

3.11 competent person

person who is qualified, trained and experienced to perform activities to gas measuring systems

3.12 compression factor Z

ratio of the volume of an arbitrary mass of gas, at a specified pressure and temperature to the volume of the same mass of gas under the same conditions as calculated from the ideal-gas law

Note 1 to entry: The compression factor (Z) indicates the extent to which gas deviates from ideal gas behaviour.

3.13 conversion device

device that converts a quantity at metering conditions to a quantity to base conditions or energy

3.13.1 energy conversion device

device which calculates, integrates and displays energy using quantity at base conditions and the calorific value and/or the gas composition

3.13.2 volume conversion device

device that converts the quantity measured at measuring conditions into a quantity at base conditions

3.14 custody transfer

change in responsibility for the conveyance of gas, this can or cannot involve a change of ownership of the gas

3.15 documented provision

provision established by the operator of a gas measuring system in order to give confidence that operations are performed according to metrological expectations

3.16 drift

slow change of a metrological characteristic of a measuring instrument

3.17

energy determination

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

3.18

fail-safe

characteristic of a device to go to a safe operating condition when a failure occurs

3.19

gas measuring installation

complete set of measuring instruments and additional components assembled to carry out specified measurements

3.20

gas measuring station

one or more gas measuring installation(s) including its housing, compound, the inlet and outlet pipework as far as the isolating valves

Note 1 to entry: Measuring station does not normally apply for gas measuring installation for residential and commercial use, even if there is housing.

3.21

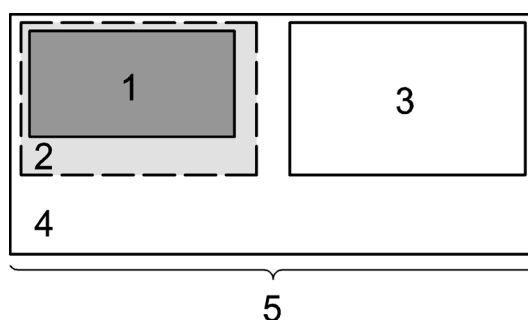
gas measuring system

system of gas measuring installation, documented provisions and where appropriate a gas measuring station

Note 1 to entry: The output of the gas measuring system is energy (kWh or MJ), that is the product of gas volume at base conditions or mass and gross calorific value.

Note 2 to entry: Differing physical principles are used to determine gas volume or mass passing through the meter. The most commonly used techniques are mentioned in this European Standard.

Note 3 to entry: Figure 1 illustrates a typical gas measuring system.



Key

- 1 gas measuring installation
- 2 gas measuring station
- 3 documented provisions
- 4 gas measuring system
- 5 output: energy

Figure 1 — Illustration of gas measuring system

3.22**gas measuring system operator**

natural or legal person who is responsible for the operation and maintenance of the measuring system

Note 1 to entry: The gas measuring system operator is referred to be the operator.

3.23**gas meter**

instrument designed to measure, memorise and display the quantity of gas (volume or mass) that has passed it

3.24**gross calorific value****GCV**

amount of heat, determined on molar, mass or volume basis, which would be released by the complete combustion in air of a specified quantity of gas, in such a way that the pressure at which the reaction takes place remains constant, and all the products of combustion are returned to the same specified temperature 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 this specified temperature

Note 1 to entry: GGCV is often referred to as H_s in other standards.

3.25**hazardous area**

area in which an explosive gas atmosphere is present or can be expected to be present, in quantities such that special precautions for the construction, installation and use of equipment are required as defined in EN IEC 60079-10-1:2021

3.26**housing**

building, compartment or cabinet that is used to contain the metering system, in order to protect it from environmental factors and external interference

3.27**installation effect**

difference in performance of the measuring instrument between the calibration conditions and actual conditions of use

Note 1 to entry: This difference can be caused by different flow conditions due to velocity profile, perturbations, or by different working regimes (pulsation, intermittent flow, alternating flow, vibrations, etc.).

3.28**low metering pressure**

pressure close to atmospheric pressure, where the influence of a fixed compressibility of 1 is smaller than 1/10 of the stated MPE of the gas measuring system

3.29**maximum permissible error****MPE**

extreme absolute value of error permitted by specification

Note 1 to entry: Conformity with an MPE is based on calibration results for individual instruments and on statistical methods for measuring systems.

3.30

measuring condition

condition of the gas at which the quantity is measured at the point of measurement (temperature and pressure of the measured gas)

3.31

measuring instrument

device intended to be used for measurements, alone or in conjunction with supplementary device(s)

EXAMPLE Gas meter, calorific value determination device.

3.32

metering temperature

absolute gas temperature to which the indicated quantity of gas is related

3.32.1

$T_{\min}$

lowest ambient temperature the gas measuring station can operate

3.32.2

$T_{\max}$

maximum ambient temperature the gas measuring station can operate

3.33

maximum experimental safe gap

MESG

standard gap width of a flammable gas or vapour that is the lowest value of the limit gap width that is measured by varying the mixture composition in accordance with EN ISO/IEC 80079-20-1 ("ignition flashover in the most flammable mixture")

Note 1 to entry: The limiting gap width is the gap width at which flame transmission is not possible for a given mixture composition.

3.34

non-intrusive meter device

device which, without being inserted in the measuring line and without affecting the conditions of the gas, is capable of recording the flow rate

Note 1 to entry: It is usually applied on the surface of the pipes carrying the gas to be measured.

3.35

Pressure

3.35.1

absolute pressure

pressure of the gas measured with the reference to an absolute vacuum

3.35.2

gauge pressure

difference between the absolute pressure of the gas and the atmospheric pressure at the place and time of the measuring

3.35.3**design pressure****DP**

pressure on which design calculations are based

Note 1 to entry: A part of a measuring installation designed for a design pressure DP can comprise components designed for a different maximum allowable pressure PS.

It can also be a component that is designed for the maximum permissible pressure PS (see also EN 764-1)

3.35.4**maximum incidental pressure****MIP**

maximum pressure which a system can experience for a short time, limited by the safety device(s)

3.35.5**maximum operating pressure****MOP**

maximum pressure at which a system can be operated continuously under normal operating conditions

Note 1 to entry: Normal operating conditions are: no fault in any device or stream.

3.35.6**metering pressure** **P_m**

absolute pressure at which the volume of gas is measured

3.35.7**temporary operating pressure****TOP**

pressure at which a system can be operated temporarily under control of the regulating device(s)

3.36**representative calorific value**

individual calorific value or a combination of calorific values that is considered to be, according to the constitution of the measuring system, the most appropriate calorific value to be associated with the metered quantity in order to calculate the energy

3.37**responsible person**

person who is responsible for design, construction, commissioning, operation and maintenance of the measuring installation and/or system

3.38**reverse flow**

situation where gas flow from a lower pressure network is injected into a higher pressure network upstream of the lower pressure network

EXAMPLE For example, when a distribution network receives a gas supply from a renewable gas injection plant and the distribution network cannot handle the capacity of this injection; in this case, the “excess” gas is injected into the transmission network upstream of the distribution network.

3.39

sensor

device for measuring certain measurands which are characteristic of the gas (temperature, pressure, calorific value, etc.)

3.40

smart meter

meter with additional functionalities one of which is data communication

3.41

stability

ability of a measuring system, or a measuring instrument, to perform its functions for a specified period of time

3.42

stripped gas

natural gas from which large amounts of easily liquefiable components have been removed

3.43

traceability

property of the result of a measurement or a 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

3.44

uncertainty

parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand as defined in ISO/IEC Guide 98-3.

4 General requirements

4.1 General

All parties involved shall exchange all appropriate information to ensure effective design, installation, commissioning and operation of the measuring system.

A gas measuring system shall comprise:

- a gas measuring installation;
- documented provisions; and
- where appropriate, a gas measuring station.

NOTE 1 The typical measuring system is illustrated in the Figure 1.

The accuracy requirement for the gas measuring system (i.e. the maximum permissible error) shall be determined applying 5.3. The system shall then be designed in such a way that the required accuracy is achieved by validating against 6.12 and confirming it meets the requirements for the selected class.

When requested, the achieved accuracy of the system shall be available to involved parties to demonstrate compliance with the selected class.

Annex D provides a general approach to demonstrating compliance in accordance with 6.12.

The gas measuring installation should be located in a building, a compound, a cabinet in such a way it is protected from any material environmental impacts. Unless it unduly affects their integrity, operation, or accuracy some higher capacity gas measuring installations may also be installed in open air.

When selecting the location, the recommendation of the operator of the installation and the manufacturer's instructions shall be sought.

EN 1776 does make numerous references to product standards that could be impacted by hydrogen, as also stated in CEN/TR 17797:2022. The relevant technical committees and working groups are in the process to amend the product standard accordingly. The components needed for a Gas measuring system, the related product standards that might need adaptation to hydrogen and responsible TCs, are listed in CEN/TR 17797:2022, Table 6.

Therefore, the approach for the revision of this document is to provide in a separate annex the specific requirements for hydrogen in case hydrogen is mixed to natural gas or hydrogen is present as the main gas. Where applicable in the clauses there will be referred to Annex I for the additional hydrogen specific requirement and the relevant (product) standard.

NOTE 2 There can be national requirements for design, construction, operation and/or maintenance of a gas measuring system.

4.2 Safety and environment

The gas measuring system shall be designed and constructed such that it operates in a safe manner. The owner/operator shall have safety procedures describing how the installation including the housing is managed.

All personnel involved in design, installation, testing, commissioning, operation and/or maintenance of the gas measuring system shall be competent and have adequate safety training. For safety management EN 17649 can be applied.

Specific attention shall be given to health and environmental aspects such as an acceptable noise level during operation.

NOTE 1 Environmental requirements, e.g. noise limits and/or health requirements can exist on national level.

The owner/operator of the measuring system shall inform the consumer or the person responsible for the property on any risks associated with the system.

EXAMPLE Instructions stating the precautions to be taken if the smell of gas persists.

NOTE 2 This can be achieved by the affixing of appropriate warning notices.

4.3 Quality and measurement management system

The operator shall have a quality management applicable to the complete gas measuring system (see Figure 1) including all activities undertaken for the purpose of energy determination in accordance with this European Standard. A quality management shall be used over the entire lifetime of a measuring system.

Reference should be made to EN ISO 10012 and/or EN ISO 9000 series of standards or to equivalent quality system standards.

NOTE 1 National regulations can constitute compliance with the requirement for a quality management.

NOTE 2 National regulations can require that some inspection and testing of the measuring accuracy are witnessed and accepted by an authorized and competent person.

5 Basic requirements for gas measuring systems

5.1 General

The output of the gas measuring system is energy (kWh or MJ), that is the product of gas volume at base conditions or mass and calorific value.

NOTE 1 Differing physical principles are used to determine gas volume or mass passing through the meter. The most commonly used techniques are mentioned in this document.

Involved parties shall ensure that the method of energy determination is traceable, reliable and satisfies the basic gas and energy determination requirements such as accuracy, security as well as economic criteria.

NOTE 2 Legal accuracy requirements on a national level can exist.

The method shall be sufficiently accurate to reduce random and systematic errors to such a level that contractual obligations are fulfilled and that it can be justified on technical or economic considerations.

The energy determination shall be based on measured or attributed values of gas composition of the gas passing through the gas meter. The formulae for calculating the volume or mass into energy are given in Annex C. Example methods for determining the quantities of energy are described in EN ISO 15112 and EN 12405-2.

When designing an energy determination system the following two steps should be undertaken:

- a) classification of measuring system according to its accuracy class (see 5.2);

NOTE 3 The introduction of accuracy classes serves two main purposes. It offers a means of ensuring minimum accuracy requirements (i.e. appropriate accuracy of measurement is employed). It permits installation of a cost-effective measuring system (i.e. not at excessive cost).

- b) identification of separate modules of the measuring system (see 5.3).

NOTE 4 Each module performs a specific function within the energy determination process. Each module can be either an instrument or group of instruments (e.g. a meter or a calorific value determining device) or a calculation or functional process (e.g. assignment of a calorific value, or conversion of quantity of gas to energy using a representative calorific value).

The methodology how to combine the modular accuracies to derive overall accuracy is given in Clause 6 and Annex E.

NOTE 5 A number of examples are offered in Annex E for clarification of the approach set out in this clause. However, these examples are informative and cannot be taken as evidence that any particular equipment or provisions meet a particular accuracy requirement.

5.2 Classification of the gas measuring system

5.2.1 General

The accuracy class of the gas measuring system shall be specified as an expanded uncertainty on energy determination over the billing period:

- a) Class A gas measuring system with an in-service uncertainty less than or equal to 1,2 %.
- b) Class B gas measuring system with an in-service uncertainty greater than 1,2 % and less than or equal to 2,5 %.

- c) Class C gas measuring system with an in-service uncertainty greater than 2,5 % and less than or equal to 3,5 %.
- d) Class D gas measuring system with an in-service uncertainty greater than 3,5 % and less than or equal to 8,0 %.

Based on the four accuracy classes A to D, the responsible person shall choose the most appropriate class for the measuring system under consideration.

NOTE 1 In some situations it can be appropriate to relax a performance class.

NOTE 2 The maximum percentages used for the classes are referring to the technical abilities of gas measuring systems and do not pre-empt any stipulations or allowances on uncertainty limits.

For hydrogen or hydrogen blends, refer to Annex I.

The choice of the accuracy class shall be based at least on:

- capacity of the installation (maximum flowrate, annual volume);
- measuring instrument MPE;
- gas pressure and temperature (and hence the value of the compression factor);
- gas composition.

NOTE 3 Type of installation can influence the accuracy class, for example location of the gas measuring system on the gas network (see Annex G).

See EN ISO 15112 for further details on energy determination.

Accurate and reliable energy determination can be undertaken by using the various modules a) to f) described in 5.3 below.

5.2.2 Minimum requirements Class A and Class B

For Class A and Class B gas measuring systems, the pressure (P), temperature (T), compression factor (Z) conversion (PTZ conversion) shall be carried out from the metering pressure, and the metering temperature according to the EN 12405 series.

For determination of energy and PTZ-conversion the same GCV and/or gas composition shall be used. Exceptions may be possible in the following cases:

- economical reason;
- minimum capacity requirements;
- in the case of two or more sources of supply with different gas qualities, either a CVDD shall be installed or documented provisions shall provide a representative gas quality;
- measurement of physical properties (e.g. density meter, or a Z-meter).

Corrections should be made retrospectively between the declared fixed gas composition and assessed actual composition.

Minimum requirements in Class A for gas measuring installation:

- a) The online gas composition shall be measured by at least one local CVDD and which is used for the PTZ conversion and the energy determination.

- b) Depending on the capacity of the gas measuring installation a second CVDD and duplicated gas meters in series and/or pressure and temperature conversion shall be considered. Parties shall specify criteria for deciding whether duplicate measurement in series is needed. When duplicated instruments are installed, the average value between the two systems should be used for energy determination.

Minimum requirements for Class B for gas measuring installation:

- c) This class of installation shall have installed a volume conversion device using pressure and temperature measurements. Depending on the metering pressure, the compression factor (Z) should be determined on-site or attributed as a fixed factor.
- d) In contrary to class A, in class B declared fixed gas composition may be used if no CVDD is installed.

NOTE The PTZ-conversion is assumed to be carried out most of the time from a declared fixed gas composition, so basically no CVDD is installed in the gas measuring installation. The determination of energy can be performed locally or remotely and is carried out from this same declared GCV or from an on line CVDD.

- e) Calorific value shall be determined using one of the following methods:

- 1) continuous sampling on site;
- 2) periodical sampling on site;
- 3) determined remotely;
- 4) attributed fixed factors in accordance with documented provisions.

For hydrogen or hydrogen blends, refer to Annex I.

5.2.3 Minimum requirements Class C and Class D

Volume conversion can be carried out as

- T- conversion;
- PT-conversion;
- PTZ-conversion;

according to the EN 12405 series.

The attributed gross calorific value (GCV) for that charging area should be calculated by using the method contained within the documented provisions. The GCV should be averaged over a pre-determined time period (daily, monthly or annually).

If an area is supplied by more than one entry point, a flow weighted average GCV should be calculated from gas flows at each entry point. Different approaches on this subject are given in EN ISO 15112.

For temperature, pressure and compressibility reference is made to 6.6.

NOTE For hydrogen or hydrogen blends, refer to Annex I.

5.3 Gas measuring system modules

When considering a measuring system individual modules shall be identified. Examples are given in Annex E.

When combining the modules of the measuring system they all shall be under the same base conditions.

NOTE At the individual module level, the error associated with the module can depend on the value of one or more input parameters, e.g. error in volume at metering conditions and/or error in calorific value of a CVDD.

Some of these modules can be assumed, attributed or derived whilst others are measured in accordance with 5.3.

Consideration should be given to the following essential gas measuring system modules:

- a) gas volume/mass: this measurement is at measuring conditions;
- b) gas pressure: the absolute pressure within the meter is required for conversion of the volume measured to the same base condition. Gas pressure can be measured on site (gauge or absolute) or attributed;
- c) gas temperature: the absolute temperature within the meter is required for conversion of the volume measured. This can be measured on site or attributed;
- d) compression factor: for low metering pressures the compression factor has no significant influence and can therefore be attributed the value of 1, or in case of the known fixed value can be used. Depending on the measuring system accuracy required, for higher pressure systems, the compression factor is based on measurement and/or calculated;
- e) representative gross calorific value: It can be expressed in mass or in volume using the same base conditions. For installations of Class C and Class D it is derived by using documented provisions;
- f) density: this value is needed to convert the calorific value in volume to the calorific value in mass or vice versa.

6 Energy Determination

6.1 General

When designing a gas measuring system it shall be ensured that the calorific value is determined at the measuring installation or upstream on the network spin.

If the gas composition and calorific value are not determined at the gas measuring installation, the CVDD shall be installed in appropriate location of the network to be representative for the gas passing through the gas measuring installation. The positioning of the sampling points of a CVDD shall be representative of the gas passing through the meter run(s).

The method used to determine the GCV by the measuring system shall be included within the documented provisions.

For a Class A system, the GCV shall be determined at the measuring installation.

For a Class B system, an assessment shall be made on how representative the actual calorific value is of the gas composition passing through the measuring installation.

For a Class C system or Class D system, attributed values for the gross calorific value shall be used, as described in the documented provisions. The gross calorific value shall be measured in different locations to provide a representative sample at the gas measuring installation.

NOTE 1 National requirements or company specifications for the tolerance in attributed calorific values can apply.

Accuracy characteristics of the selected instruments shall be sufficient to allow the energy determination in measuring system.

NOTE 2 National requirements can exist.

For the chosen accuracy class no error in energy shall exceed the MPE for the specified accuracy class over the operational range for the measuring system (flow rates, compositions, etc.).

Energy determination shall be carried out using one of the methods described in 6.3 to 6.7.

NOTE 3 For the overall measuring system, the error in energy for the measuring system depends upon all of the input parameters that affect the errors arising from each module of the measuring system. A measuring system therefore shows a distribution of errors in energy from a combination of distributions of errors arising within the individual modules.

NOTE 4 For hydrogen or hydrogen blends, refer to Annex I.

6.2 Requirements for measurements used in energy determination

6.2.1 Base conditions

All parties should employ the same base conditions when comparing measurements of volume, calorific value and energy. Factors for conversion between different base conditions are provided in EN ISO 13443.

6.2.2 Flow measurement

The involved parties shall ensure that the method used for determining gas volume flow rate or mass flow rate:

- is traceable to international standards;
- reliable under full range of operational conditions (e.g. pressure, temperature, flow);
- satisfies the basic gas and energy determination requirements, such as safety and economics;
- meets the accuracy requirements of the selected class.

Meters based on different physical principles can be used. The most commonly-used techniques are included in 7.5.3 and Annex A.

6.2.3 Gross calorific value (GCV)

6.2.3.1 General considerations

The GCV of the gas shall be determined by measurement or by attribution of an appropriate representative value.

NOTE 1 The measurement techniques can be divided into three groups:

- based on composition measurement according to EN ISO 6976;
- based on combustion calorimetry according to EN ISO 15971;
- correlative techniques (limited range and accuracy).

When determining GCV based on composition, the existence of components not determined by the chosen analytical technique should be taken into account.

Where GCV measurement by a local CVDD is not economically justified, the GCV shall be calculated based on one or more measurements at representative points on the pipeline.

NOTE 2 Among these kinds of calculations, the gas quality tracking system is a special assignment method for the calculation of gas qualities at any time and at any place in a pipeline or a grid, by means of a grid simulation or a state reconstruction based on gas qualities measured at all supplying points on the pipeline. See EN ISO 15112.

The accuracy of the GCV determination shall be sufficient to ensure that the overall accuracy of the measuring system is within the MPE of the selected accuracy class.

NOTE 3 For hydrogen or hydrogen blends, refer to Annex I.

6.2.3.2 Calorific value determination device (CVDD)

The accuracy of the CVDD shall be determined.

NOTE 1 CVDDs can generally be characterized into three types:

- those in which calorific value is determined by measurement using non-separative means and for which guidance on selection and operation is provided in EN ISO 15971;
- those in which calorific value is determined by calculation using EN ISO 6976 from a gas composition measured using a suitable separative technique, such as gas chromatography; For hydrogen or hydrogen blends, refer to Annex I;
- those in which calorific value is determined from correlations of calorific value with other properties (such as speed of sound, thermal conductivity, dielectric permittivity, carbon dioxide content, hydrocarbon content) that are measured by suitable means.

NOTE 2 GCV determination can be subject to national legal requirements and controls, which can specify a particular technique or instrument and the manner of its operation.

If gas chromatographs are installed and used as gas analysers, these should be set up to carry out analysis according to EN ISO 6974 series. The operating conditions for the gas chromatographs shall be based on a performance evaluation complying with EN ISO 10723.

When assessing the accuracy of a CVDD at least the following factors shall be taken into account:

- a) sampling and conditioning;
- b) speed of response of CVDD;
- c) uncertainty on the composition of any working calibration gas;
- d) in case of separative techniques presence of components not analysed;
- e) absence of contamination;
- f) linearity of the instrument(s) over the composition range;
- g) ambient conditions;
- h) low limit detection;
- i) overall accuracy of the CVDD when one or more devices are employed.

NOTE 3 The areas associated with nonlinearity of the CVDD can be reduced by requiring the calibration gas to be close to the expected composition of the gas sampled from the line, or by using a multi-point calibration.

NOTE 4 In the case of gas chromatographs, areas associated with nonlinearity can be determined by performance evaluation according to EN ISO 10723.

When constituents not detected by the CVDD are present at a significant level, adequate corrective calculation shall be carried out according to EN ISO 6975 series. The traceability of the calibration gas shall be established.

Limits for sum of the unnormalized molar concentrations for a gas chromatography analysis shall be specified in the documented provisions. Data acceptance criteria shall be set.

NOTE 5 Values can be given by legal metrology or contractual limits.

6.3 Calculation method of energy using assigned GCV and P , T , Z values

The volume at measuring conditions shall be converted to volume at base conditions using assigned T , P and Z . The totalized volume shall be converted to energy using an assigned GCV.

For hydrogen or hydrogen blends, refer to Annex I.

6.4 Calculation method of energy using an on-site CVDD and on-site PTZ-Conversion

The flow-rate at measuring conditions shall be converted to flow-rate at base conditions using a measured T , P and Z (PTZ-conversion) and then shall be converted to energy flow by multiplication by a continuously measured GCV. Energy shall be totalized, typically using a flow computer. Z shall be calculated from continuously measured T , P and gas composition.

For hydrogen or hydrogen blends, refer to Annex I.

6.5 Calculation method of energy using an assigned GCV and PTZ-conversion

The flow-rate at measuring conditions shall be converted to flow-rate at base conditions using a measured T , P and Z (PTZ-conversion) and then shall be totalized. The totalized volume shall be converted to energy using an assigned calorific value. Z shall be calculated from live T and live P assuming a specified gas composition.

For hydrogen or hydrogen blends, refer to Annex I.

6.6 Calculation method of energy using PT-Conversion and assigned GCV and Z value

The flow-rate at measuring conditions shall be converted to flow-rate at base conditions using a measured T and P (PT-conversion) and then shall be totalized using an assigned Z . The totalized volume shall be converted to energy using an assigned GCV.

For hydrogen or hydrogen blends, refer to Annex I.

6.7 Calculation method of energy using T-Conversion and assigned GCV, and P , Z values

The flow-rate at measuring conditions shall be converted to flow-rate at base conditions using a measured T and then totalized using assigned P and Z values. The assigned P value should take into account the altitude, lock-up pressure zone as well as the accuracy class of the pressure regulator and the supply pressure when appropriate. The totalized volume is then converted to energy using an assigned GCV.

NOTE Lock-up pressure zone and accuracy class are specified in EN 334.

For hydrogen or hydrogen blends, refer to Annex I.

6.8 Gas temperature conversion

In order to convert volume at measuring conditions to base conditions, the gas temperature shall be measured at a location that ensures that it is representative of the temperature of the gas being metered.

Recommendations for temperature measurement are provided in EN ISO 15970 or in the relevant parts of the EN 12405 series.

6.9 Gas pressure conversion

In order to convert volume at measuring conditions to base conditions, the pressure shall be measured at a location that ensures that it is representative of the pressure of the gas being metered and in accordance with the relevant product standards.

Recommendations for pressure measurement are provided in EN ISO 15970, or the relevant parts of the EN 12405 series.

6.10 Compressibility conversion

When volume at operating conditions is converted to base conditions, using a Z calculated for the gas at operating conditions, the calculation shall be performed in accordance with EN ISO 12213-1 or EN ISO 20765-1, EN ISO 20765-2, or EN ISO 20765-5, as appropriate.

When the gas is fed online to a gas analyser (for example gas chromatograph) and at high pressure for (re-vaporized) LNG and stripped gases EN ISO 12213-2, or EN ISO 20765-1, EN ISO 20765-2, as appropriate shall be applied.

When only the GCV, relative density, hydrogen and carbon dioxide content are known, together with the relevant pressures and temperatures EN ISO 12213-3 should be applied.

NOTE EN ISO 12213-3 only applicable for a limited range of physical characteristics.

For hydrogen or hydrogen blends, refer to Annex I.

6.11 PTZ-conversion

Conversion techniques used shall demonstrate the specified accuracy and shall be suitable for the measuring conditions (see 7.9).

The specified accuracy is calculated in accordance with the relevant standards.

NOTE P , T and Z can be processed simultaneously by a single device.

For hydrogen or hydrogen blends, refer to Annex I.

6.12 Uncertainty of energy determination

The uncertainty in energy determination shall be assessed in accordance with one of the following references:

- ISO/IEC Guide 98-1 and ISO/IEC Guide 98-3;
- ISO/IEC Guide 98-3 Supplement 1 and 2;
- ISO/IEC Guide 98-4 or ISO 5168;

NOTE 1 The text of the ISO/IEC Guide 98 series equates to JCGM 10X including JCGM 105, JCGM 106 and JCGM 107 (JCGM = Joint Committee for Guides in Metrology).

Bias shall be identified and minimized.

NOTE 2 In some applications of a Class B, C or D system it can be appropriate to do so by specifying a maximum permissible bias.

NOTE 3 Using the series of ISO/IEC Guide 98-3 and ISO/IEC Guide 98-1 and JCGM 105 and JCGM 107 the bias can be taken into account by enlarging the “uncertainty” attributed to the result, instead of applying it to the reported result of a measurement.

NOTE 4 The assessment of the conformity of the metrological performance of a measuring system is carried out according to ISO/IEC Guide 98-4, "Uncertainty of measurement — Part 4: Role of measurement uncertainty in conformity assessment". Annex D indicates how such conformity assessment can be carried out in the context of an energy determination system.

Annex E provides some typical examples of conformity of metrological performance of gas measuring systems.

7 Design of gas measuring system

7.1 General

Design of a typical gas measuring system is shown on the Figure 1.

7.2 Safety provision

When designing a gas measuring system, safety provisions shall be integrated to ensure its safe access, egress, construction, operation, inspection and maintenance and located such that risk and nuisance to the environment and its operation are kept within acceptable limits.

NOTE 1 Acceptable limits can refer to noise.

The gas measuring installation and station shall have at least one inlet and one outlet valve to allow it to be safely isolated and to undertake any maintenance.

NOTE 2 In case of domestic gas meter having one inlet valve is sufficient.

As part of the design of the installation and station the electrical safety shall be considered. All electrical installations shall comply with the applicable European Standards.

For associated pressure regulating systems the requirements of EN 12186 and/or EN 12279 apply.

For requirements on design, housing, lay-out, materials for components, construction, ventilation, venting and overall safety of gas measuring systems within the scope of this document, the EN 15001 series, EN 12186, EN 12279 and/or EN 1775 apply additionally, where relevant. For hydrogen or hydrogen blends, refer to Annex I.

The possible hazardous area in any housing, station and installation shall be assessed and classified according to EN IEC 60079-10-1.

For any non-electrical equipment with its own potential ignition source it shall be assessed and classified according to EN ISO 80079-36.

A risk assessment should be made according to EN 1127-1.

Any electrical installation in a hazardous area shall comply with 8.6.

7.3 Housing

All meter housings shall be well ventilated and shall be adequate in size, layout and design to undertake all installation, commissioning and maintenance requirements.

The design of a measuring station, including the layout, housing and materials for the housing, shall comply with the relevant requirements of EN 12186, EN 12279, EN 1775 or the EN 15001 series, where applicable.

For measuring installations without pressure regulation the most relevant standards shall be chosen depending on inlet pressure and capacity.

The housing shall ensure the performance of the gas measuring installation by keeping it within its specified operating conditions. The housing shall prevent any expected external influence to affect the performance gas measuring installation.

The following list of expected external influences is not limited, but depends on the location of the gas measuring installation:

- mechanical influences such as vibrations and shocks;
- electromagnetic influences;
- weather conditions such as ambient temperature, direct sunlight, wind, lightning and humidity.

7.4 Gas measuring station

A measuring station shall comprise:

- a measuring installation (see 7.5);
- additional components (see 7.12, 7.15 and following);
- where appropriate a housing (see 7.3).

Any additional components shall be installed in accordance with the installation requirements and shall not adversely affect the measurement results.

7.5 Gas measuring installation

7.5.1 General

The design of the installation varies according to its required accuracy in accordance with classification stated in 5.3.

The measuring installation shall comprise a gas meter and one or more of the following components:

- a) conversion device;
- b) change-over equipment to select the appropriate number of meter runs to meet the actual load of the station;
- c) CVDD;
- d) valves, pipes, flow conditioners, gaskets and joints;
- e) lagging for thermal insulation and noise reduction;
- f) filters and separators;
- g) electrical installation, lightning protection, earthing;
- h) detection systems such as gas and/or fire detection (see also EN 60079-29-1, EN 15001-1);
- i) bidirectional (or reverse) flow management;
- j) communication;
- k) others.

A gas measuring installation can be connected with other gas installations.

NOTE 1 Typical examples of positions of gas measuring installations are shown in Figure G.1

EXAMPLE 1 As part of a pressure regulating installation.

Any additional connected installation or equipment shall not adversely affect the integrity of the gas measuring installation or its measurement.

EXAMPLE 2 Connected installations can be gas pressure regulating installations, gas drying facilities, odorization injection equipment.

The gas measuring installation shall be designed such that the correct functioning is ensured for all specified pressure and temperature ranges as well as, where appropriate different gas types and impurities present in the gas.

The specified pressure and temperature range shall cover at least MOP, TOP, MIP, minimal pressure at the inlet of the installation, $T_{\min}$, $T_{\max}$ and ambient temperature.

The design shall also take into account environmental factors such as vibrations, pulsation and noise.

The design shall ensure appropriate access/egress for inspection, removal or replacement of the gas meter.

In case of an emergency, it shall be possible to shut down the installation safely.

The capacity and the correct functioning of the installation shall be based on the minimum and maximum values for:

- a) volume or mass flow rate;
- b) gas temperature;
- c) velocity of gas in the meter run;
- d) metering pressure;
- e) acceptable pressure loss;
- f) range of constituents (composition of the gas);
- g) contaminants in the gas;
- h) internal diameter of the connection of the gas meter (to avoid steps in diameters and subsequent flow disturbances).

All pressure containing components of the gas measuring installation shall withstand the strength test pressure. The strength test pressure is derived from the design pressure (DP) of the upstream system.

NOTE 2 See EN 12007 series and EN 1594 for further information on this subject.

The technology selected for the gas measuring installation shall be sufficiently accurate to reduce random and systematic errors to such a level that contractual or legal obligations are fulfilled and that can be justified on technical and economic reasons.

The gas measuring installation should be installed as close as possible to the point where the change of responsibility takes place to avoid unmeasured gas.

Unidirectional gas measuring installation shall be designed to avoid reverse flow during operation for example by installing a non-return valve. The installed valve shall not be adversely affect the gas measurement and should be installed in accordance with the manufacturer's instructions.

Where the gas measuring installation incorporates more than one meter run, each run shall have its own upstream and downstream means of isolation, to provide the possibility of maintenance on the individual meter run and re-calibration of the flow meter at a calibration facility.

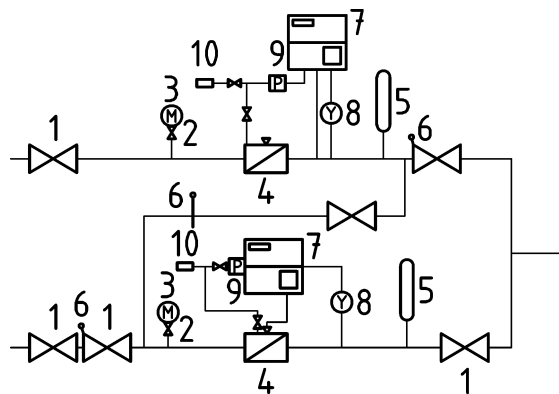
Where in-service verification of the measuring instrument(s) is required, appropriate provisions shall be made.

EXAMPLE 3 Examples of appropriate provisions:

- multiple measuring stream;
- spool for the installation of a temporary reference meter;
- the use of meters with (self-) diagnostics capability;
- two meters in series for online comparison.

In case of multiple measuring stream of the same size and each with a single gas meter, it is recommended that parallel lines can be temporarily reconfigured in series.

Figure 2 illustrates a typical process diagram for a gas measuring system



Key

- 1 Shut-off valve
- 2 3-way valve with connection for standard pressure manometer
- 3 Pressure gauge appropriate to the working pressure
- 4 Meter in combination with flow straightener (if necessary)
- 5 Temperature gauge
- 6 Spectacle blind plate
- 7 Electronic volume converter/ flow computer
- 8 Transmitter / probe, temperature
- 9 Pressure transmitter/ sensor
- 10 Pressure tap with sealable valve for verifications

Figure 2— Example of the process diagram for the gas measuring system

For testing of pressure sensors see Annex B.

NOTE 3 Also known as z-configuration.

The primary measuring values shall be safeguarded for a stated minimum duration of time, which is agreed between two or more parties and in accordance with documented provisions. If the safeguarding relies on electrical power, provision shall be taken to prevent electrical power failure, voltage fluctuation or overload (lightning strike).

EXAMPLE 4 Use mechanical index, no-break power for the whole installation, battery powered flow meters.

Where appropriate, the gas measuring installation shall take into account EN 12186, the EN 15001 series and EN 12279 when considering:

- a) valves, pipes, gaskets and joints;
- b) lagging for thermal insulation and noise reduction;
- c) filters and separators;
- d) electrical installation, equipotential bonding, lightning protection, earthing;
- e) detection systems such as gas and/or fire detection (see also EN 60079-29-1, EN 15001-1).

Provisions shall be taken to ensure all of the equipment is mechanically secure and properly supported during operations.

7.5.2 Continuity of supply

Continuity of supply is not normally necessary for a Class D installation. However for other installations it should be considered if cessation of the gas supply can cause a safety hazard, or risk to life or significant risk to property (see 7.11.1 and 7.12).

When continuity of supply is deemed to be essential the following should be considered:

- a) additional meter run ($n+1$ m runs, where n is the number of meter runs needed for the design capacity);
- b) incorporate a bypass in the metering installation;
- c) non-intrusive meter type e.g. ultrasonic gas meter.

NOTE Example for incorporated bypass can be a rotary meter with an integrated bypass provision, in case of a stalling meter.

7.5.3 Gas meters

The meter shall be selected so that it will operate correctly and safely under all operating conditions. Annex A gives guidelines on the selection of meters.

Any gas meter shall meet the national metrological and safety requirements of the country where the meter is installed. Gas meters shall conform to relevant European Standards, where applicable.

NOTE More information can be found also in European regulations.

Examples are given in Annex A. For hydrogen or hydrogen blends, refer to Annex I.

When selecting a meter, consideration shall be given to the system (installation) requirements including the following:

- flow rate (expected minimum and maximum);
- direction of flow;