

Gas meters — Conversion devices —

Part 1: Volume conversion

ICS 91.140.80

National foreword

This British Standard is the UK implementation of EN 12405-1:2005+A2:2010. It supersedes BS EN 12405-1:2005 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by **A1** **A1**.

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A list of organizations represented on GSE/25 can be obtained on request to its secretary.

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Compteurs de gaz - Dispositifs de conversion - Partie 1:
Conversion de volume

Gaszähler - Umwerter - Teil 1: Volumenumwertung

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

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Management Centre: Avenue Marnix 17, B-1000 Brussels

Contents

	Page
Foreword.....	9
1 Scope	10
2 Normative references	10
3 Terms, definitions and symbols.....	12
3.1 Terms and definitions	12
3.2 Symbols	15
3.3 A_1 Classification A_1	17
3.3.1 Mechanical classes	17
3.3.2 Electromagnetic environmental classes	17
4 Principle of measurement.....	17
4.1 Conversion as a function of temperature	17
4.2 Conversion as a function of pressure and temperature.....	17
4.3 Conversion as a function of pressure, temperature and deviation from the ideal gas law	18
4.4 Correction of the volume at measurement conditions	19
5 Rated operating conditions	19
5.1 Specified field of measurement.....	19
5.1.1 Specified measurement range for gas pressure	19
5.1.2 Specified measurement range for gas temperature.....	19
5.1.3 Gas characteristics.....	20
5.1.4 A_1 Base conditions A_1	20
5.2 A_1 Environmental conditions A_1	20
5.2.1 Ambient temperature range.....	20
5.2.2 Humidity range.....	20
5.2.3 A_1 Mechanical environment A_1	20
5.2.4 Electromagnetic environment	20
5.3 Power supply.....	20
6 Construction requirements.....	20
6.1 General.....	20
6.2 Casings	21
6.3 Indications	22
6.3.1 General.....	22
6.3.2 Electronic indicating device	23
6.4 Inputs for volume conversion	24
6.5 Battery powered conversion device	24
6.6 Security devices and alarms	25
7 Installation requirements	25
7.1 General.....	25
7.2 Temperature transducer	26
7.3 Pressure transducer.....	26
8 Performance.....	26
8.1 Reference conditions	26
8.2 Rated operating conditions	27
8.3 Maximum permissible errors	27
8.3.1 General.....	27
8.3.2 Error of conversion.....	28
8.3.3 Specific errors for a gas-volume conversion device, type 2.....	28
8.4 Conditions of matching the constituent elements of a conversion device type 2	28
8.5 Influence factors	29
2	

8.6	Disturbances	29
8.7	Durability	29
8.8	A1 Repeatability A1	29
8.9	A1 Reliability A1	30
9	Tests of conformity	30
9.1	Verification of the construction requirements	30
9.2	Verification of the performance requirements	30
9.2.1	Test conditions	30
9.2.2	Samples of gas volume conversion device type 1 required for testing	31
9.2.3	Samples of gas volume conversion devices type 2 required for testing	34
9.3	Test report	34
10	Marking	34
11	A1 Installation and operating instructions A1	35
Annex A	(normative) Type test	37
A.1	General conditions	37
A.1.1	General.....	37
A.1.2	Additional conditions specific to gas volume conversion devices type 1	37
A.1.3	Additional conditions specific to gas-volume conversion devices type 2.....	37
A.1.4	Test procedures	38
A.1.5	Verification of the construction requirements	39
A.2	Accuracy tests under reference conditions.....	39
A.2.1	Objective.....	39
A.2.2	Reference to documents.....	40
A.2.3	Procedure	40
A.2.4	Acceptance criteria.....	40
A.3	Effect of ambient temperature.....	40
A.3.1	Objective.....	40
A.3.2	Reference to documents.....	40
A.3.3	Procedure	40
A.3.4	Acceptance criteria.....	40
A.4	Effect of damp heat, steady state test.....	40
A.4.1	Objective.....	40
A.4.2	Reference to documents.....	40
A.4.3	Procedure	41
A.4.4	Acceptance criteria.....	41
A.5	Effect of damp heat, cyclic test.....	41
A.5.1	Objective.....	41
A.5.2	Reference to documents.....	41
A.5.3	Procedure	41
A.5.4	Acceptance criteria.....	42
A.6	Electrical power variation	42
A.6.1	Objective.....	42
A.6.2	Reference to documents.....	42
A.6.3	Procedure	42
A.6.4	Acceptance criteria.....	42
A.7	Short time power reductions	43
A.7.1	Objective.....	43
A.7.2	Reference to documents.....	43
A.7.3	Procedure	43
A.7.4	Acceptance criteria.....	43
A.8	Electrical bursts	43
A.8.1	Objective.....	43
A.8.2	Reference to documents.....	43
A.8.3	Procedure	43
A.8.4	Acceptance criteria.....	43
A.9	Electromagnetic susceptibility.....	44
A.9.1	Objective.....	44
A.9.2	Reference to documents.....	44
A.9.3	Procedure	44

A.9.4	Acceptance criteria.....	44
A.10	Electrostatic discharges	44
A.10.1	Objective	44
A.10.2	Reference to documents	44
A.10.3	Procedure	44
A.10.4	Acceptance criteria.....	45
A.11	Overload of pressure (only for type 1 and pressure transducers)	45
A.11.1	Objective	45
A.11.2	Reference to documents	45
A.11.3	Procedure	45
A.11.4	Acceptance criteria.....	45
A.12	Effect of vibrations	45
A.12.1	Objective	45
A.12.2	Reference to documents	45
A.12.3	Procedure	46
A.12.4	Acceptance criteria.....	46
A.13	Effect of shocks	46
A.13.1	Objective	46
A.13.2	Reference to documents	46
A.13.3	Procedure	46
A.13.4	Acceptance criteria.....	46
A.14	Overload of pressure (mechanical).....	46
A.14.1	Objective	46
A.14.2	Reference to documents	47
A.14.3	Procedure	47
A.14.4	Acceptance criteria.....	47
A.15	Durability	47
A.15.1	Objective	47
A.15.2	Reference to documents	47
A.15.3	Procedure	47
A.15.4	Acceptance criteria.....	48
A.16	Alarms operation	48
A.16.1	Objective	48
A.16.2	Reference to documents	48
A.16.3	Procedure	48
A.16.4	Acceptance criteria.....	48
A.17	A1 Repeatability	48
A.17.1	Objective	48
A.17.2	Reference to standards	48
A.17.3	Procedure	49
A.17.4	Acceptance criteria A1	49
A.18	A2 Short time DC power variations	49
A.18.1	Objective	49
A.18.2	Reference to standards	49
A.18.3	Procedure	49
A.18.4	Acceptance criteria A2	49
A.19	A2 Surges on supply lines and/or signal lines	49
A.19.1	Objective	49
A.19.2	Reference to standards	50
A.19.3	Procedure	50
A.19.4	Acceptance criteria A2	50
A.20	A2 Power frequency magnetic field	50
A.20.1	Objective	50
A.20.2	Reference to standards	50
A.20.3	Procedure	50
A.20.4	Acceptance criteria A2	50
Annex B	(normative) Pressure transducers	51
B.1	Scope	51
B.2	Rated operating conditions	51
B.2.1	Specified measurement range for pressure	51

B.2.2	Environmental class.....	51
B.2.3	Power supply	51
B.3	Construction requirements.....	51
B.3.1	General.....	51
B.3.2	Casings	51
B.3.3	Indications	51
B.4	Performances	52
B.4.1	Reference conditions	52
B.4.2	Rated operating conditions	52
B.4.3	Maximum permissible errors.....	52
B.4.4	Influence factors	52
B.4.5	Disturbances	52
B.4.6	Durability	52
B.5	Tests of conformity	53
B.5.1	Test conditions	53
B.5.2	Tests.....	53
B.5.3	Sample of pressure transducers required for testing	53
B.6	Marking	53
Annex C	(normative) Platinum resistance thermometer sensors.....	54
C.1	Scope	54
C.2	Operating rated conditions.....	54
C.2.1	Specified measurement range for temperature.....	54
C.2.2	Environmental class.....	54
C.3	Construction requirements.....	54
C.4	Performances	54
C.5	Marking	55
C.5.1	Required markings	55
C.5.2	Verification mark.....	55
C.6	Metrological verifications	55
C.6.1	Type approval	55
C.6.2	Initial verification	56
C.7	Verification procedure.....	56
C.7.1	Visual inspection	56
C.7.2	Type testing (type approval).....	56
C.7.3	Samples of PRT required for testing	56
C.7.4	Initial verification	56
Annex D	(normative) Temperature transducers	58
D.1	Scope	58
D.2	Rated operating conditions	58
D.2.1	Specified measurement range for temperature.....	58
D.2.2	Environmental class.....	58
D.2.3	Power supply	58
D.3	Construction requirements.....	58
D.3.1	General.....	58
D.3.2	Casings	58
D.3.3	Indications	58
D.4	Performances	59
D.4.1	Reference conditions	59
D.4.2	Rated operating conditions	59
D.4.3	Maximum permissible errors.....	59
D.4.4	Influence factors	59
D.4.5	Disturbances	59
D.4.6	Durability	59
D.5	Tests of conformity	60
D.5.1	Test conditions	60
D.5.2	Tests.....	60
D.5.3	Sample of temperature transducers required for testing.....	60
D.6	Marking	60
Annex E	(informative) Model type test report for conversion devices	61

E.1	General.....	61
E.1.1	General remarks.....	61
E.1.2	Number of pages.....	61
E.1.3	Laboratory's identification.....	61
E.1.4	Applicant.....	61
E.1.5	Identification of device(s) submitted for testing	61
E.2	Accuracy tests under reference conditions.....	62
E.2.1	Ambient temperature during the test.....	62
E.2.2	Test equipment used	62
E.2.3	Test results.....	62
E.3	Ambient temperature.....	63
E.3.1	Effect of dry heat.....	63
E.3.2	Effect of cold	64
E.4	Effect of damp heat, steady state test	66
E.4.1	Ambient temperature during the test.....	66
E.4.2	Test equipment used	66
E.4.3	Test results.....	66
E.5	Effect of damp heat, cyclic test	67
E.5.1	Ambient temperature during the test.....	67
E.5.2	Test equipment used	67
E.5.3	Test results.....	68
E.6	Electrical power variation	69
E.6.1	AC power supply.....	69
E.6.2	DC power supply or battery supply	71
E.7	Short time power reductions	72
E.7.1	Test equipment used	72
E.7.2	Test results.....	72
E.8	Electrical bursts	73
E.8.1	Test equipment used	73
E.8.2	Test results.....	73
E.9	Electromagnetic immunity	75
E.9.1	Test equipment used	75
E.9.2	Test results.....	75
E.10	Electrostatic discharges	75
E.10.1	Test equipment used	75
E.10.2	Test results.....	76
E.11	Effect of an overload of static pressure	76
E.11.1	Ambient temperature during the test.....	76
E.11.2	Test equipment used	76
E.11.3	Test results.....	77
E.12	Effect of vibrations	78
E.12.1	Ambient temperature during the test.....	78
E.12.2	Test equipment used	78
E.12.3	Test results.....	78
E.13	Effect of shocks	79
E.13.1	Ambient temperature during the test.....	79
E.13.2	Test equipment used	79
E.13.3	Test results.....	79
E.14	Mechanical resistance to overload of static pressure	80
E.14.1	Ambient temperature during the test.....	80
E.14.2	Test equipment used	80
E.14.3	Test results.....	80
E.15	Durability	80
E.15.1	Ambient temperature during the test.....	80
E.15.2	Test equipment used	80
E.15.3	Test equipment used	81
E.16	 Alarms operation.....	84
E.16.1	Ambient temperature during the test.....	84
E.16.2	Test equipment used	84
E.16.3	Test results.....	84
E.17	Repeatability 	84

E.18	Ⓐ ₂ Short time DC power variations.....	84
E.18.1	Test equipment used.....	84
E.18.2	Test results Ⓐ ₂	84
E.19	Ⓐ ₂ Surges on supply lines and/or signal lines	85
E.19.1	Test equipment used.....	85
E.19.2	Test results Ⓐ ₂	85
E.20	Ⓐ ₂ Power frequency magnetic field	86
E.20.1	Test equipment used.....	86
E.20.2	Test results Ⓐ ₂	86
Annex F	(informative) Model type test report for associated transducers	88
F.1	General.....	88
F.1.1	General remarks	88
F.1.2	Number of pages	88
F.1.3	Laboratory's identification.....	88
F.1.4	Applicant	88
F.1.5	Identification of device(s) submitted for testing	88
F.2	Accuracy tests under reference conditions.....	89
F.2.1	Ambient temperature during the test	89
F.2.2	Test equipment used.....	89
F.2.3	Test results.....	89
F.3	Ambient temperature.....	89
F.3.1	Effect of dry heat	89
F.3.2	Effect of cold	90
F.4	Effect of damp heat, steady state test.....	91
F.4.1	Ambient temperature during the test	91
F.4.2	Test equipment used.....	91
F.4.3	Test results.....	91
F.5	Effect of damp heat, cyclic test.....	92
F.5.1	Ambient temperature during the test	92
F.5.2	Test equipment used.....	92
F.5.3	Test results.....	93
F.6	Electrical power variation	93
F.6.1	AC power supply	93
F.6.2	DC power supply or battery supply	95
F.7	Short time power reductions	95
F.7.1	Ambient temperature during the test	95
F.7.2	Test equipment used.....	95
F.7.3	Test results.....	96
F.8	Electrical bursts	96
F.8.1	Ambient temperature during the test	96
F.8.2	Test equipment used.....	96
F.8.3	Test results.....	96
F.9	Electromagnetic immunity.....	97
F.9.1	Ambient temperature during the test	97
F.9.2	Test equipment used.....	97
F.9.3	Test results.....	98
F.10	Electrostatic discharges	98
F.10.1	Ambient temperature during the test	98
F.10.2	Test equipment used.....	98
F.10.3	Test results.....	99
F.11	Effect of an overload of static pressure	99
F.11.1	Ambient temperature during the test	99
F.11.2	Test equipment used.....	99
F.11.3	Test results.....	100
F.12	Effect of vibrations	101
F.12.1	Ambient temperature during the test	101
F.12.2	Test equipment used.....	101
F.12.3	Test results.....	101
F.13	Effect of shocks	101
F.13.1	Ambient temperature during the test	101

F.13.2	Test equipment used	101
F.13.3	Test results	102
F.14	Mechanical resistance to overload of static pressure	102
F.14.1	Ambient temperature during the test.....	102
F.14.2	Test equipment used	102
F.14.3	Test results	102
F.15	Durability	103
F.15.1	Ambient temperature during the test.....	103
F.15.2	Test equipment used	103
F.15.3	Test results	103
F.16	 Repeatability 	105
Annex ZA (informative)  Relationship between this European Standard and the Essential Requirements of EU Directive 2004/22 Measuring Instruments Directive 		106
Bibliography		111

Foreword

^{A1} This document ^{A2} (EN 12405-1:2005+A2:2010) ^{A2} has been prepared by Technical Committee CEN/TC 237 “Gas meters”, the secretariat of which is held by BSI.

This ^{A2} *deleted text* ^{A2} European Standard ^{A2} *deleted text* ^{A2} shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by ^{A2} April 2011 ^{A2}, and conflicting national standards shall be withdrawn at the latest by ^{A2} April 2011 ^{A2}.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2004/22 Measuring Instruments Directive (MID).

For relationship with EU Directive 2004/22, see informative Annex ZA, which is an integral part of this document. ^{A1}

This document includes Amendment 1, approved by CEN on 2006-07-06 and Amendment 2, approved by CEN on 2010-09-19.

This document supersedes ^{A2} EN 12405-1:2005 ^{A2}.

The start and finish of text introduced or altered by amendment is indicated in the text by tags ^{A1} ^{A1} and ^{A2} ^{A2}.

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

Due to technical developments the layout of the document has been changed and EN 12405 will appear in parts:

- Part 1: Volume conversion (this European Standard),
- Part 2: Energy conversion (in preparation),
- Part 3: Data loggers.

Further parts are under consideration, following the technical progress.

In the preparation of this European Standard, the content of OIML Publication, “International Document 11”, “International Recommendations 6” and “International Recommendations 32” and the content of member bodies’ national standards on gas-volume electronic conversion devices have been taken into account.

^{A1} *deleted text* ^{A1}

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

1 Scope

This European Standard specifies the requirements and tests for the construction, performance, safety and conformity of gas-volume electronic conversion devices associated to gas meters, used to measure volumes of fuel gases of the 1st and 2nd families according to EN 437.

This European Standard is intended for type testing, the detailed relevant provisions of which are given in Annex A.

Only three kinds of conversion are treated in this European Standard:

- conversion as a function of temperature only (called T conversion);
- conversion as a function of the pressure and of the temperature with constant compression factor (called PT conversion);
- conversion as a function of the pressure, the temperature and taking into account the compression factor (called PTZ conversion).

A1 This document is not relevant to temperature conversion integrated into gas meters which only indicate the converted volume. **A1**

EN 12405-2 for energy conversion is in preparation.

Gas-volume conversion devices consist of a calculator and a temperature transducer or a calculator, a temperature transducer and a pressure transducer locally installed.

For application of this European Standard, a conversion device may be, as a choice of the manufacturer, considered as a complete instrument (Type 1) or made of separate elements (Type 2), according to the definitions given in 3.1.18.1 and 3.1.18.2.

In this last case, the provisions concerning pressure transducers, temperature sensors and temperature transducers are given in Annexes B, C and D respectively.

Any conversion device can provide an error curve correction for a gas meter.

NOTE When rendering an account to an end user the readings from the conversion device can be used in conjunction with the readings from a gas meter conforming to EN 1359, EN 12480, or EN 12261, as appropriate, or to any other appropriate and relevant international or national standard for gas meters, without prejudice of national regulations.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 437, *Test gases — Test pressures — Appliance categories*

EN 1776, *Gas supply systems — Natural gas measuring stations — Functional requirements*

A2 *deleted text* **A2**

EN 55011, *Industrial, scientific and medical (ISM) radio-frequency equipment — Radio disturbance characteristics — Limits and methods of measurement (CISPR 11:1997, modified)*

EN 60068-2-1, *Environmental testing — Part 2: Tests — Tests A: Cold (IEC 60068-2-1:1990)*

EN 60068-2-2, *Basic environmental testing procedures — Part 2: Tests — Tests B: Dry heat* (IEC 60068-2-2:1974 + IEC 60068-2-2A:1976)

EN 60068-2-30, *Environmental testing — Part 2: Tests — Test Db and guidance: Damp heat, cyclic (12 + 12 hour cycle)* (IEC 60068-2-30:1980 + A1:1985)

EN 60068-2-31, *Basic environmental testing procedures — Part 2: Tests — Test Ec: Drop and topple, primarily for equipment-type specimens* (IEC 60068-2-31:1969 + A1:1982)

EN 60068-2-78, *Environmental testing — Part 2-78: Tests — Test Cab: Damp heat, steady state* (IEC 60068-2-78:2001)

EN 60079-0, *Electrical apparatus for potentially explosive atmospheres — Part 0: General requirements* (IEC 60079-0:2004)

EN 60079-1, *Electrical apparatus for potentially explosive atmospheres — Flameproof enclosures "d"* (IEC 60079-1:2003)

EN 60079-2, *Electrical apparatus for potentially explosive atmospheres — Part 2: Pressurized apparatus "p"* (IEC 60079-2:2001)

Ⓐ₂ EN 60079-5, *Explosive atmospheres — Part 5: Equipment protection by powder filling "q"* (IEC 60079-5:2007)

EN 60079-6, *Explosive atmospheres — Part 6: Equipment protection by oil immersion "o"* (IEC 60079-6:2007) Ⓐ₂

EN 60079-7, *Electrical apparatus for potentially explosive atmospheres — Increased safety "e"* (IEC 60079-7:2001)

Ⓐ₂ EN 60079-11, *Explosive atmospheres — Part 11: Equipment protection by intrinsic safety "i"* (IEC 60079-11:2006)

EN 60079-25, *Electrical apparatus for explosive gas atmospheres — Part 25: Intrinsically safe systems* (IEC 60079-25:2003) Ⓐ₂

EN 60529, *Degrees of protection provided by enclosures (IP code)* (IEC 60529:1989)

Ⓐ₁ EN 60730-1:2000, *Automatic electrical controls for household and similar use — Part 1: General requirements* (IEC 60730-1:1999, modified) Ⓐ₁

EN 60751, *Industrial platinum resistance thermometer sensors* (IEC 60751:1983 + A1:1986)

EN 60950-1, *Information technology equipment — Safety — Part 1: General requirements* (IEC 60950-1:2001, modified)

EN 61000-4-2, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 2: Electrostatic discharge immunity test — Basic EMC publication* (IEC 61000-4-2:1995)

EN 61000-4-3, *Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques — Radiated, radio-frequency, electromagnetic field immunity test* (IEC 61000-4-3:2002)

EN 61000-4-4, *Electromagnetic compatibility (EMC) — Part 4-4: Testing and measurement techniques — Electrical fast transient/burst immunity test* (IEC 61000-4-4:2004)

Ⓐ₂ EN 61000-4-5, *Electromagnetic compatibility (EMC) — Part 4-5: Testing and measurement techniques — Surge immunity test* (IEC 61000-4-5:2005) Ⓐ₂

EN 61000-4-6, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 6: Immunity to conducted disturbances, induced by radio-frequency fields* (IEC 61000-4-6:1996)

EN 61000-4-8, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 8: Power frequency magnetic field immunity test* (IEC 61000-4-8:1993 + A1 2001) ^{A2}

EN 61000-4-11, *Electromagnetic compatibility (EMC) — Part 4-11: Testing and measurement techniques — Voltage dips, short interruptions and voltage variations immunity tests* (IEC 61000-4-11:2004)

EN 61000-4-29, *Electromagnetic Compatibility (EMC) — Part 4-29: Testing and measurement techniques — Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests* (IEC 61000-4-29:2000) ^{A2}

EN ISO 12213-2:2005, *Natural gas — Calculation of compression factor — Part 2: Calculation using molar-composition analysis* (ISO 12213-2:1997)

EN ISO 12213-3:2005, *Natural gas — Calculation of compression factor — Part 3: Calculation using physical properties* (ISO 12213-3:1997)

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1

absolute static pressure

value of the static pressure of the gas relative to vacuum

^{A1} **3.1.2**

base conditions

specified conditions to which the measured quantity of gas is converted ^{A1}

EXAMPLES Temperature of 273,15 K and absolute pressure of 1,013 25 bar¹ or temperature of 288,15 K and absolute pressure of 1,013 25 bar.

3.1.3

calculator

electronic device that receives the output signals from the associated gas meter and transducers and processes them

3.1.4

conversion factor

factor equal to the volume at base conditions divided by the corrected volume, or if there is no gas meter correction, equal to the volume at base conditions divided by the volume at measurement conditions

3.1.5

conventional true value (of a quantity)

value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose

3.1.6

corrected volume

volume at measurement conditions corrected for the error curve of the gas meter

3.1.7

correction

value added algebraically to the uncorrected result of a measurement to correct the systematic error

3.1.8

correction factor

numerical factor by which the measured volume is multiplied to correct it to compensate the error curve of the gas meter

3.1.9

display

element or assembly of elements of the indicating device on which the results of measurement and memorized values are displayed

3.1.10

disturbance

influence quantity having a value within the limits specified but outside the specified rated operating conditions of the measuring instrument

NOTE An influence quantity is a disturbance if the rated operating conditions for that influence quantity are not specified.

3.1.11

durability

ability of an instrument to maintain its performance characteristics over a specified period of use

3.1.12

environmental class

class referring to the ambient temperature, humidity and power supply

3.1.13

error of conversion

difference between the conversion factor C displayed by a conversion device and the conventional true value of the conversion factor C_{CV} , expressed as a percentage of the conventional true value of the conversion factor

3.1.14

error of indication

indication of a measuring instrument minus the (conventional) true value of the corresponding input quantity

3.1.15

error of the calculator unit

error of the indicated volume at base conditions V_b , when the gas volume, pressure and temperature are simulated by signals, in accordance to the manufacturer specification of interfaces

NOTE The calculator error includes all conversion errors with the exception of the pressure and temperature transducer errors (i.e. signal conditioning, Z factor calculation (if applicable), other mathematical calculations etc.).

3.1.16

error of the pressure transducer

difference between the measured output signals from the pressure transducer and the nominal signal at the applied physical value

3.1.17

error of the temperature transducer

difference between the measured output signals from the temperature transducer and the nominal signal at the applied physical value

3.1.18

gas-volume conversion device

device that computes, integrates and indicates the volume increments measured by a gas meter if it were operating at base conditions, using as inputs the volume at measurement conditions as measured by the gas meter, and other parameters such as gas temperature and gas pressure

NOTE 1 The conversion device can also compensate for the error curve of a gas meter and associated measuring transducers.

NOTE 2 The deviation from the ideal gas law can be compensated by the compression factor.

3.1.18.1

gas volume conversion device type 1 (complete system)

conversion device with specific types of transducers for pressure and temperature or for temperature only

3.1.18.2

gas volume conversion device type 2 (separate component)

conversion device with external separate transducers for pressure and temperature or for temperature only and for separate calculator, which may be approved separately

NOTE The matching of the various elements constituting a conversion device type 2 is subjected to verification.

3.1.19

indicating device

part of a measuring instrument that displays an indication (alphanumeric string)

3.1.20

influence factor

influence quantity having a value within the specified rated operating conditions of the measuring instrument

3.1.21

influence quantity

quantity that is not a measurand but that affects the result of the measurement (e.g. ambient temperature)

3.1.22

intrinsic error

error of a measuring instrument, determined under reference conditions

3.1.23

maximum operating pressure

MOP

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

NOTE Normal conditions are: no fault in any device or stream.

3.1.24

measurement conditions

conditions of the gas, the volume of which is measured at the point of measurement (e.g. the temperature and the pressure of the gas)

3.1.25

measuring transducer

device that provides an output quantity having a determined relationship to the input quantity

3.1.26

overpressure

maximum static pressure to which the transducer may be submitted without durable alteration of its metrological characteristics : it is set in accordance with the maximum allowable pressure

A1 3.1.27

rated operating conditions

values for the measurand and influence quantities making up the normal working conditions of an instrument A1

A1 *deleted text* A1

3.1.28

reference conditions

condition of use prescribed for testing the performance of a measuring instrument or for inter-comparison of results of measurements

3.1.29

sensor

element of a measuring instrument or measuring chain that is directly affected by the measurand

3.1.30

specified measuring range of transducers

set of values of measurands (the pressure for the pressure transducer or temperature for the temperature transducer) for which the errors of the conversion device are intended to lie within the limits specified in this European Standard

NOTE The upper and lower limits of the specified measuring range are called maximum value and minimum value respectively.

EXAMPLE maximum absolute pressure: 12 bar; minimum absolute pressure: 4 bar.

3.1.31

specified field of measurement of a conversion device

set of values at measurement conditions for which the errors of the conversion device are within specified limits

NOTE 1 A conversion device has a measuring range for every quantity that it processes.

NOTE 2 The specified field of measurement applies to the characteristic quantities of the gas that are used to determine the conversion factor.

3.1.32

static gauge pressure

value of the static pressure of the gas relative to the ambient atmospheric pressure

3.1.33

uncertainty of measurement

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

3.1.34

volume

volume without specifying whether it is a corrected volume at measurement conditions or an uncorrected volume at measurement conditions

3.1.35

measurand

particular quantity subject to measurement

3.1.36

critical change value

value at which the change in the measurement result is considered undesirable 

3.2 Symbols

The symbols used in this European Standard are listed in Table 1.

Table 1 – Symbols

Symbols	Represented quantity	Units
V	volume : V_m or V_c	m^3
V_m	volume at measurement conditions	m^3
V_c	corrected volume (gas meter error)	m^3
V_b	volume at base conditions	m^3
V_{CV}	conventional true value of the volume	m^3
C	conversion factor	-
C_c	calculator conversion	-
C_f	correction factor	-
C_{CV}	conventional true value of the conversion factor	-
$f(Q)$	correction function	-
K or K'	coefficients	-
p	absolute pressure at measurement conditions	bar or MPa
p_b	absolute pressure at base conditions	bar or MPa
p_g	gauge pressure	bar or MPa
p_{CV}	conventional true value of the absolute pressure	bar or MPa
T	absolute temperature at measurement conditions	K
T_b	absolute temperature at base conditions	K
T_{min}	minimum absolute temperature	K
T_{max}	maximum absolute temperature	K
T_{CV}	conventional true value of the absolute temperature	K
Z	compression factor of the gas at measurement conditions	-
Z_b	compression factor of the gas at base conditions	-
Z_{CV}	conventional true value of the compression factor	-
p_{atm}	atmospheric pressure	bar or MPa
p_{max}	maximum absolute gas pressure	bar or MPa
p_{min}	minimum absolute gas pressure	bar or MPa
Q	flowrate	m^3/h
Q_{max}	maximum flowrate	m^3/h
Q_{min}	minimum flowrate	m^3/h
t_{am}	ambient temperature	$^{\circ}C$
$t_{am,max}$	maximum ambient temperature	$^{\circ}C$
$t_{am,min}$	minimum ambient temperature	$^{\circ}C$
t	gas temperature	$^{\circ}C$
t_{max}	maximum gas temperature	$^{\circ}C$
t_{min}	minimum gas temperature	$^{\circ}C$
U_{nom}	nominal supply voltage	V
f_{nom}	nominal supply frequency	Hz
e	total conversion factor error	%
e_f	error on the calculation of conversion factor	%
e_p	error on the pressure measurement	%
e_t	error on the temperature measurement	%
e_c	error on the conversion factor	%
e_v	error on the converted volume	%

3.3 Classification

3.3.1 Mechanical classes

M1 This class applies to instruments used in locations with vibration and shocks of low significance, e.g. for instruments fastened to light supporting structures subject to negligible vibrations and shocks transmitted from local blasting or pile-driving activities, slamming doors, etc.

M2 This class applies to instruments used in locations with significant or high levels of vibration and shock, e.g. transmitted from machines and passing vehicles in the vicinity or adjacent to heavy machines, conveyor belts, etc.

3.3.2 Electromagnetic environmental classes

E1 This class applies to instruments used in locations with electromagnetic disturbances corresponding to those likely to be found in residential, commercial and light industrial buildings.

E2 This class applies to instruments used in locations with electromagnetic disturbances corresponding to those likely to be found in other industrial buildings. 

4 Principle of measurement

4.1 Conversion as a function of temperature

In this case the conversion device consists of a calculator and a temperature transducer and it converts the volume to the base conditions.

The pressure is not measured, but may be included as a fixed value in the processing of the conversion factor.

The compression factor is not calculated, but may be included as a fixed value in the processing of the conversion factor.

The error of a gas volume conversion device, measuring only temperature, is calculated referring to the reference conversion factor as calculated taking into account the compression factor at a fixed set pressure and measured temperature.

The volume at base conditions is obtained from the relationship:

$$V_b = C \times V$$

C is the conversion factor given from the relationship:

$$C = \frac{K}{T}$$

K is a fixed value obtained from the relationship:

$$K = \frac{p}{p_b} \times T_b \times \frac{Z_b}{Z}$$

4.2 Conversion as a function of pressure and temperature

In this case, the conversion device consists of a calculator, a pressure transducer and a temperature transducer.

The compression factor may be considered as a fixed value calculated from mean measurement conditions and a determined gas composition.

The volume at base conditions is obtained by the relationship:

$$V_b = C \times V$$

C is the conversion factor given from the relationship:

$$C = K' \times \frac{p}{T}$$

K' is a fixed value obtained from the relationship:

$$K' = \frac{1}{p_b} \times T_b \times \frac{Z_b}{Z}$$

An absolute pressure transducer shall be used for absolute pressures below 21 bar.

For absolute pressures equal to or greater than 21 bar a gauge pressure transducer may be used.

In this case the value of the atmospheric pressure shall be the average value calculated taking into account the altitude of the installation site. This value shall be preset.

4.3 Conversion as a function of pressure, temperature and deviation from the ideal gas law

In this case, the conversion device consists of a calculator, a pressure transducer and a temperature transducer.

The general requirements indicated in 4.2 shall be enforced.

The deviation from the ideal gas law is compensated by the calculation of the compression factor using an appropriate equation as a function of pressure and temperature:

$$Z = f(p, T)$$

Settable gas properties and components inputs are used for the compression factor calculation.

The volume at base conditions is obtained from the relationship:

$$V_b = C \times V$$

C is the conversion factor given by the relationship:

$$C = \frac{p}{p_b} \times \frac{T_b}{T} \times \frac{Z_b}{Z}$$

The manufacturer shall specify the method used for compression factor calculation.

An absolute pressure transducer shall be used for absolute pressures below 21 bar.

For absolute pressures equal to or greater than 21 bar, a gauge pressure transducer may be used.

In this case, the value of the atmospheric pressure shall be the average value calculated taking into account the altitude of the installation site. This value shall be preset.

4.4 Correction of the volume at measurement conditions

The object of the correction function is to compensate the error of the gas meter, as determined in the calibration certificate.

The conversion device may be able (optionally) to correct the error of the gas meter.

When using this option it shall be ensured that the error curve to be used is relevant to the actual operational conditions.

If this correction is available, it shall be integrated in the configurations stated in 4.1, 4.2 and 4.3; in those cases, the volume marked as V means V_c .

The correction function of the conversion device shall be able to correct deviations recorded when calibrating the gas meter to which it is connected.

The error of the meter will be corrected by the use of a function $f(Q)$ in such a way that for each operating point:

$$V_c = V_m \times f(Q)$$

The manufacturer shall specify the method used.

If a non-linear interpolation between the calibration points is used, the manufacturer shall provide proof that the method has a better weighted (by flow) accuracy than the linear interpolation.

The choice of the parameters shall be so that the correction function $f(Q)$ remains, at all points, definite, continuous and derivable for rates of flow between $Q_{\min}$ and $Q_{\max}$.

The correction can only be applied if the gas meter produces at least 10 pulses per second at $Q_{\min}$. Below $Q_{\min}$ no correction is allowed and above $Q_{\max}$, the correction factor shall remain at the value obtained at $Q_{\max}$.

5 Rated operating conditions

5.1 Specified field of measurement

The field of measurement of the complete instrument shall be specified by the manufacturer.

5.1.1 Specified measurement range for gas pressure

The transducer shall be calibrated over the range specified by the manufacturer which shall be at least:

$$\frac{P_{\max}}{P_{\min}} > 2$$

5.1.2 Specified measurement range for gas temperature

The manufacturer shall specify the gas temperature range according to the following:

- normal range: -20 °C to +50 °C;
- limited range: a minimum range of 40 °C anywhere between the limits of the normal range;
- extended range: to be specified by the manufacturer.

5.1.3 Gas characteristics

Fuel gases of the first and second families according to EN 437.

A1 The manufacturer shall indicate the:

- gas family or group;
- maximum operating pressure. **A1**

5.1.4 **A1** Base conditions

The manufacturer shall specify the base conditions, or range of base conditions for converted quantities. **A1**

5.2 **A1** Environmental conditions **A1**

5.2.1 Ambient temperature range

A1 The manufacturer shall specify the ambient temperature range of the gas-volume conversion device with a minimum temperature range of 50 °C for the climatic environment, and the minimum temperature limit being either -40 °C, -25 °C, -10 °C or 5 °C, and the maximum temperature limit being either 30 °C, 40 °C, 55 °C or 70 °C. **A1**

5.2.2 Humidity range

The instrument shall operate in a relative humidity range of 10 % to 93 %.

A1 The manufacturer shall indicate whether the instrument is designed for condensing or non-condensing humidity as well as the intended location for the instrument.

If designed for non-condensing humidity, the device shall meet the requirements of Test A.4.

If designed for condensing humidity, the device shall meet the requirements of Test A.5. **A1**

5.2.3 **A1** Mechanical environment

The manufacturer shall specify the mechanical class for which the device is intended (M1 or M2) (see 3.3.1).

5.2.4 Electromagnetic environment

The device shall be able to operate under electromagnetic environmental class E2 (see 3.3.2). **A1**

5.3 Power supply

A1 The manufacturer shall specify the nominal value of the AC supply and/or the limits of DC supply.

The limits of DC supply shall be compatible with customers' requirements and/or the electricity supply of country of destination. **A1**

6 Construction requirements

6.1 General

6.1.1 All the constituent elements of a gas-volume conversion device shall be constructed of materials having appropriate quality to resist the various forms of degradation which may occur under normal operating conditions as specified by the manufacturer. A gas-volume conversion device shall, in all circumstances, withstand the influence factors and disturbances defined **A1** in 8.5 **A1**.

6.1.2 All the constituent elements of a gas-volume conversion device shall be designed in such a way that it does not degrade the accuracy of the measurement of the gas meter with which it is associated.

6.1.3 The gas-volume conversion device shall be constructed in such a way that any intervention, liable to influence the results of measurement, shall cause permanently visible damage to the conversion device or its protective seals, or set an alarm which shall be memorized in the event register. The seals shall be visibly fixed, and easily accessible.

Electronic seals shall comply with the following requirements:

- access shall only be obtained by using a password or a code $\boxed{A_1}$ that can be updated or by using a specific device $\boxed{A_1}$;
- the last intervention, at least, shall be registered in the memory, including date and time of intervention and a specific element to identify the intervention;
- It shall be possible to have access to the intervention(s) registered in the memory.

For gas volume conversion devices, where the given inputs may be dismantled or replaced, all connections and interfaces between the calculator and transducers or meter should be protected by separate seals to avoid the breaking of the main metrological seal in case of component replacement. Access to parameters which take part in the determination of the measured results or to the measured results themselves shall not be possible through the disconnected points, except if the conditions given in this paragraph are fulfilled.

6.1.4 The conversion factor shall be recalculated at intervals between the volume pulses not exceeding 1 min for a temperature conversion device and at intervals not exceeding 30 s for the other types of gas-volume conversion devices.

However, when no volume signal has been received from the gas meter for:

- over 1 min for a temperature conversion device; or
- over 30 s for other types,

recalculation is not required until the next volume signal is received.

6.1.5 Any interfaces and connections fitted within the conversion device allowing the connection of complementary devices shall not corrupt the metrological behaviour of the conversion device.

6.1.6 The interconnections and any interfaces between the calculator and the transducers are integral parts of the conversion device.

The manufacturer shall specify the length and characteristics of the interconnections and of any interfaces where these may affect the accuracy of measurement of the gas-volume conversion device.

6.1.7 Equipment used in hazardous areas shall meet the electrical requirements specified in the appropriate standards: $\boxed{A_2}$ EN 60079-0, EN 60079-1, EN 60079-2, EN 60079-5, EN 60079-6, EN 60079-7, EN 60079-11 and EN 60079-25 $\boxed{A_2}$.

6.1.8 All the constituent elements of a conversion device shall be constructed in such a way that the compatibility of electromagnetic disturbances conforms the requirements specified in EN 55011.

6.1.9 Casings shall meet the requirements concerning the security of the equipment as specified in EN 60950-1.

6.2 Casings

The casings of all the constituent elements of a conversion device shall have an ingress protection index (IP), specified in EN 60529, complying with the installation conditions specified by the manufacturer.

Any part of the conversion device designed for outdoor use and not intended to be installed in a weatherproof housing shall be at least in accordance with the severity level IP 65, specified in EN 60529.

6.3 Indications

6.3.1 General

6.3.1.1 The calculator shall be fitted with an indicating device that indicates:

- the incremented volume at base conditions V_b ;
- the incremented volume at measurement conditions V_m ;
- the incremented corrected volume V_c if applicable;
- the alarms' indications as defined in 6.6.

6.3.1.2 Additionally, the following information shall be indicated by a method described in 6.3.1.3:



- the base conditions in the form:
 - $T_b = \dots$ K;
 - $p_b = \dots$ bar;
- the conversion factor C ;
- the compression factor Z if applicable;
- the parameter values measured by the transducers (e.g. pressure p in bar, temperature t in °C);
- the correction factor C_f if applicable;
- the correction function $f(Q)$ if applicable;
- alarm(s) indication(s) additional to those defined in 6.6 if applicable;
- the entered data which affect the metrological result;
- gas properties used in Z computation if applicable;
- the reference to the method by which the compression factor is calculated or the constant, if applicable;
- the serial number of the transducers as appropriate;
- the upper and the lower limits of the specified measuring range of the temperature transducer in K or °C and the gauge or absolute pressure, in bar, of the pressure transducer as appropriate;
- the value of one volumetric pulse at measurement conditions in the form:
 - $1 \text{ imp} \equiv \dots \text{ m}^3 \text{ (or dm}^3\text{)};$ or
 - $1 \text{ m}^3 \text{ (or dm}^3\text{)} \equiv \dots \text{ imp};$
- the parameters for gas meter error correction curve if applicable;

- the indication of the end of life of the battery, if applicable;

A1

- the software version. **A1**
- It shall also be possible, at the time of the control operations described in Annex A, to display the values of the conversion factor and of the various quantities measured or calculated.

6.3.1.3 The information shown in 6.3.1.2 shall be indicated either on:

- the indicating device of the gas volume conversion device;
- a permanently attached information plate with indelible markings;
- an external attached indicating device;
- a combination of the above.

6.3.1.4 The volume at base conditions shall be preferentially displayed.

6.3.1.5 The method by which the quantities described in 6.3.1.2 may be displayed on the indicating device of the gas volume conversion device shall take one of the following forms:

- by means of direct operator input (e.g. the depression of push buttons, whereby each quantity may be selected by sequential operator inputs or combination of operator inputs. Each operator input shall select the current value of the quantity. If after 255 s there has been no operator input, the display shall revert to showing the volume at base conditions, or to visualising V_b by a simple operation (e.g. the depression of a push button);
- by means of automatic and sequential scrolling through the quantities that may be continuous, or initiated by an operator input. In this case the display shall show each parameter for 5 s and the volume at base conditions shall be shown every 15 s.

6.3.1.6 The identification and the unit of each quantity or parameter that can be indicated shall be clearly shown next to or upon the display unit of the calculator.

EXAMPLE Volume at base conditions, V_b , ...m³.

6.3.1.7 The scale interval of the display of the volume at base conditions shall be of the form 10^n units of volume. The value of the scale interval shall be clearly stated in the vicinity where the volume at base conditions is displayed.

6.3.1.8 The indicating device shall have at least 8 significant digits.

6.3.2 Electronic indicating device

6.3.2.1 The device indicating the volume at base conditions shall be provided with means for checking to ensure that the display is operating correctly.

6.3.2.2 The minimum height of the numerals for the display of converted volume V_b shall be 4 mm and the minimum width shall be 2,4 mm.

6.3.2.3 It shall be possible to read the index clearly and correctly, within an angle of 15° from normal to the window.

6.3.2.4 When all the digits of the indicating device are not used for the indication of the volume, every unused digit to the left of the significant digit shall indicate zero.

6.4 Inputs for volume conversion

The volume conversion device shall have an input that shall be able to process a signal from the associated gas meter. The input shall respond to every pulse in such a manner that no pulses are gained or lost by the volume conversion device.

The manufacturer shall specify the pulse input characteristic of the gas volume conversion device and the maximum frequency.

For a conversion device type 2, the interfaces between the calculator unit and the transducer shall be specified in terms of all parameters that may influence that measurement.

NOTE Meters can often be subject to considerable periods of time where there is no gas flow. During such periods, conventional LF and HF pulse outputs will, in effect, be operating at 0 Hz. Conversely, at maximum throughput, a typical meter's LF output could rise to 2 Hz and its HF output up to 5 kHz or higher. Any pulse input circuitry in a volume conversion device will have to be capable of dealing with such frequency ranges.

6.5 Battery powered conversion device

6.5.1 All the constituent elements of the conversion device powered by (a) replaceable battery(ies) shall work A_1 for a minimum of five years A_1 without replacing the battery(ies) under the following conditions:

- maximum of all frequency inputs;
- $t_{\text{amb,min}}$;
- p_{max} and T_{min} .

The manufacturer shall indicate the estimated life time of the battery in the above conditions.

The manufacturer shall specify the type of the battery and whether the battery can be changed in a hazardous area and if so, under which conditions.

NOTE These conditions do not take into account the consumption A_1 from any output and communication ports A_1 .

The battery compartment should make provisions to prevent unauthorised access. Batteries shall be replaced only after the breaking of a seal different from the metrological seal.

6.5.2 An indication shall be provided when 10 %, or less, of the life, or estimated life of the battery is remaining.

When the estimated life is calculated, the calculation shall be done taking into account the actual operating conditions specified by the manufacturer of the conversion device.

6.5.3 A battery exchange (if the battery is replaceable) shall be possible without breaking any metrological seals of the conversion device.

During the battery exchange the following information shall be retained:

- the volume at base conditions;
- the volume at measurement conditions;
- the corrected volume if applicable;
- the alarms' indications;
- the entered data which affect the metrological results;
- the last intervention, at least, as specified in 6.1.3.

The battery specified by the manufacturer shall be used.

6.6 Security devices and alarms

6.6.1 The devices shall be capable of detecting:

- if any of the measured or calculated values is outside the specified measurement ranges;
- if the instrument operates outside the limits of validity of the computing algorithm;
- if any of the electrical signals are outside the range of the input(s) of the calculator;
- an expiring battery.

With the exception of an expiring battery, as long as such a defective operation is detected by the conversion device, any further increase of the volume at base conditions shall not be permitted. The recording of volume at measurement conditions and, if applicable, the corrected volume shall continue to operate.

The resetting of the cleared alarm shall be possible only if the cause of the alarm has been eliminated. The reset device shall be capable of being sealed.

6.6.2 If the calculator is capable of estimating the amount of gas passed through the installation during the duration of the faulty condition(s), provision shall be taken to prevent the confusion between estimated values and the calculated volume at base conditions.

Substitute values shall be memorized/indicated separately.

EXAMPLE Stored in a different memory from the one specified in 6.6.3.

6.6.3 The information specified in 6.5.3 shall be memorized at least every hour and retained during an interruption, of whatever kind; computation shall resume with the values retained at the moment of an interruption. The memory shall be able to retain all the specified data for up to six months.

After an interruption or a failure and the restoration of values retained at the moment of interruption or failure, the conversion device shall be capable of restarting automatically.

6.6.4 The parameters used in the processing of the measurements, or intended to identify the constituent parts of the conversion device, shall be incapable of being changed except by a person authorized to make such changes. Those parameters shall be verifiable. Any change of the parameters shall:

- either entail the breaking of the conversion device's seals;
- or be recorded by the conversion device, together with an identifier specific to the person making the change and the date of the change.

6.6.5  Operation of alarms shall be tested in accordance with A.16. 

7 Installation requirements

7.1 General

The installation requirements shall be as specified in EN 1776.

The conversion device and the transducers shall be installed in a manner appropriate to the conditions necessary for their effective use. The installation and the presence of the conversion device shall not affect the measurement of volume at measurement conditions by the gas meter with which it is associated.

The conversion device and the transducers shall only be used in climatic conditions that are in accordance with the specified environmental classes.

The compatibility of the output of the gas meter and the input of the conversion device shall be verified. ^[A1] In addition it shall be verified that the display (converted and unconverted readings) shall have at least a sufficient number of numerals to ensure that the volume passed during 8 000 hours at the meter's flow rate of $Q_{\max}$ (and at the maximum likely conversion factor) does not return all of the numerals to their original position. ^[A1]

The installation in hazardous or potentially hazardous areas shall be done in conformity with ^[A2] EN 60079-0, EN 60079-1, EN 60079-2, EN 60079-5, EN 60079-6, EN 60079-7, EN 60079-11 and EN 60079-25 ^[A2].

The connections of transducers shall be done in accordance with manufacturers' requirements.

7.2 Temperature transducer

The purpose of the temperature transducer is to measure the gas temperature at measurement conditions.

It shall be possible to verify, on site, the temperature transducer.

7.3 Pressure transducer

The pressure transducer shall be connected to the pressure tapping (marked p_m) of the gas meter, if available.

In order to avoid the introduction of errors caused by variations in atmospheric pressure, a transducer of absolute pressure shall be used. Nevertheless, a gauge pressure transducer may be used if its minimum operating absolute pressure is equal or greater than 21 bar.

It shall be possible to verify, on site, the pressure transducer.

8 Performance

8.1 Reference conditions

The reference conditions are those given in 5.1, supplemented by the following:

- ambient temperature: $20\text{ °C} \pm 3\text{ °C}$ and the actual temperature shall not change by more than $\pm 1\text{ °C}$ during a test;
- ambient relative humidity : $60\% \pm 15\%$ and this relative humidity shall not change by more than 10 % during a test;
- AC mains powered equipment:
 - supply voltage nominal values;
 - supply frequency nominal values;
- DC mains powered equipment:
 - supply voltage nominal values;
- battery powered equipment:
 - supply voltage nominal values.

These reference conditions are used for the tests described in A.2.

8.2 Rated operating conditions

See Clause 5.

8.3 Maximum permissible errors

8.3.1 General

8.3.1.1 Conversion devices type 1

For conversion devices type 1, the maximum permissible errors (*MPE*) expressed as relative values, applicable to the volume at base conditions or to the conversion factor $\overline{A_1}$ shall be as specified $\overline{A_1}$ in Table 2.

The error of the gas meter is not taken into account.

$\overline{A_1}$ Table 2 — Maximum permissible errors (%) for conversion device type 1

Indication or element	Reference conditions	Rated operating conditions
Main indication for PT and PTZ conversion	0,5	1
Main indication for T conversion	0,5	0,7

$\overline{A_1}$

8.3.1.2 Conversion devices type 2

For conversion devices type 2, the maximum permissible errors (*MPE*) expressed as relative values, applicable to the various indications or the various separated elements, $\overline{A_2}$ shall be as specified $\overline{A_2}$ in Table 3.

The error of the gas meter is not taken into account.

Table 3 — Maximum permissible errors (%) for conversion device type 2

$\overline{A_2}$

Indication or element	Reference conditions	Rated operating conditions
Main indication (e_c) for PT and PTZ conversion	0,5	1
Calculator (e_r)	0,2	0,3
Temperature (e_t)	0,1	0,2
Pressure (e_p)	0,2	0,5
Main indication for T conversion only	0,5	0,7

$\overline{A_2}$

According to the regulations in force, the metrological control may concern the main indication and/or the characteristic values of the gas, taking account of the constitution of the instrument (complete device – separate elements) and the relevant metrological control operation.

The *MPE*s related to the calculator are to be considered only when it is subjected to a separate control.

8.3.2 Error of conversion

The percentage error e_c on the conversion factor is defined by the equation:

$$e_c = \frac{(C - C_{CV})}{C_{CV}} \times 100$$

The allowed error is given by:

$$e_c \leq MPE$$

8.3.3 Specific errors for a gas-volume conversion device, type 2

Specific errors exist for each component part of a gas-volume conversion device, type 2, (i.e. calculator, pressure transducer and temperature transducer). These errors are defined by the relationships:

$$e_f = \frac{(C_c - C_{CV})}{C_{CV}} \times 100$$

$$e_p = \frac{(p - p_{CV})}{p_{CV}} \times 100$$

$$e_t = \frac{(T - T_{CV})}{T_{CV}} \times 100$$

A1 The **A1** values of e_f , e_p and e_t shall be verified during the accuracy test defined in A.2.

The allowed combined error is given by:

$$|e| = |e_f| + |e_p| + |e_t| \leq MPE$$

The requirements related to the accuracy of the main indication shall be met.

8.4 Conditions of matching the constituent elements of a conversion device type 2

The matching of the constituent elements of a conversion device type 2 shall comply with the following requirements:

- a) each of all the elements shall be approved and verified separately;
- b) the complete assembly shall be subjected to a verification concerning:
 - the configuration;
 - the data and signals transmission;
 - the maximum error of the type 2 conversion device, which shall be within the *MPE* of the main indication according to Table 3;
- c) the rated operating conditions of the assembly shall be deemed as being equal to the common part of the measure ranges of each of the constituent elements of the conversion device;

- d) the transducers shall be mounted under the conditions specified in the type approval certificate, and according to the manufacturer's instructions;
- e) if a transducer is capable of generating and transmitting an alarm to the calculator, the conversion device shall handle this as an alarm.

8.5 Influence factors

- Ambient temperature (dry heat and cold): test defined in A.3;
- Damp heat, steady state: test defined in A.4;
- Cyclic damp heat: test defined in A.5;
- Electrical power variations: test defined in A.6;
- Effects of vibrations: test defined in A.12;
- Effects of shocks: test defined in A.13.

The relevant requirements are given in Table 4.

8.6 Disturbances

- Short time power reductions, for mains powered equipment: test defined in A.7;
- Electrical bursts: test defined in A.8;
- Electromagnetic susceptibility: test defined in A.9;
- Electrostatic discharges: test defined in A.10;
- Overload of pressure: test defined in A.11;
- Overload of pressure (mechanical): test defined in A.14;



- Short time DC power variations: test defined in A.18;
- Surges on supply lines and/or signal lines: test defined in A.19;
- Power frequency magnetic field: test defined in A.20.

The relevant requirements are given in Table 4.

8.7 Durability

After a period of use corresponding to an accelerated ageing, as defined in A.15, the relevant requirement shall be as given in Table 4.

8.8 Repeatability

The application of the same measurand under the same conditions of measurement shall result in the close agreement of 6 successive measurements (see A.17).

The test shall be carried out with one gas during the accuracy test, at $p_{\min}$ and T (see Table A.1).

The difference between the measurement results shall meet the requirement given in Table 4. ^{A1}

8.9 ^{A1} Reliability

A measuring instrument shall be designed to reduce as far as possible the effect of a defect that would lead to an inaccurate measurement result, unless the presence of such a defect is obvious. ^{A1}

9 Tests of conformity

9.1 Verification of the construction requirements

Construction requirements, as stated in Clause 6, are verified on one sample in accordance with the specifications given in A.1.

9.2 Verification of the performance requirements

9.2.1 Test conditions

^{A2} The device shall meet the requirements specified in Table 4.

Table 4 — List of relevant tests

Clause	Tests	Acceptance criteria	Timing	Test procedure
A.2	Accuracy	MPE	D	PR1
A.3	Ambient temperature	MPE	D	PR2
A.4	Damp heat, steady state	MPE	BDA	PR3
A.5	Cyclic damp heat	MPE	BA	PR3
A.6	Electrical power variation	MPE	BD	PR3
A.7	Short time AC power reductions	$\Delta e < MPE$	BD	PR4
A.8	Electrical bursts	$\Delta e < MPE$	BD	PR4
A.9	Electromagnetic immunity	$\Delta e < MPE$	BD	PR4
A.10	Electrostatic discharges	$\Delta e < MPE$	BD	PR4
A.11	Overload of pressure	$\Delta e < MPE$	BA	PR5
A.12	Random vibrations	MPE	BA	PR3
A.13	Shocks	$\Delta e < MPE$	BA	PR4
A.14	Overload of pressure (mechanical)	operable	A	PR4
A.15	Durability	$\Delta e < 0,5 MPE$	BA	PR2
A.16	Alarms operation	operable	D	PR4
A.17	Repeatability	$\Delta e < MPE/3$	D	PR2
A.18	Short time DC power variations	$\Delta e \leq MPE$	BD	PR4
A.19	Surges on supply lines and/or signal lines	$\Delta e \leq MPE$	BA	PR4
A.20	Power frequency magnetic field	$\Delta e \leq MPE$	BD	PR4
Test procedure: PR1, PR2, PR3, PR4 (See Annex A) Timing: B: Before, D: During, A: After Δe : see Annex E For the acceptance criteria, Δe needs to be compared with MPE given in Tables 2 and 3.				

The tests shall be performed using reference instruments traceable to national standards. The uncertainties shall be determined, including those arising from their use, and shall not exceed one fifth of the maximum permissible errors.

The conventional true value of the compression factor shall be computed according to EN ISO 12213-3:2005 or outside the limits of this method, with the methods described in EN ISO 12213-2:2005. When used with first family gases it is necessary to check this against a first family gas calculation method.

Following the type approval of a gas-volume conversion device, any modification(s) to the device shall be validated with tests relevant to the modification(s). A complete set of tests per modification is not required. ^(A2)

9.2.2 Samples of gas volume conversion device type 1 required for testing

^(A2) The number of samples to be tested is indicated in the tables below, according to the number of variants. Each gas volume conversion device tested shall satisfy the performance requirements specified in Clause 8.

The following provisions have to be taken into account:

- a) a conversion device may be offered with a choice of different pressure ranges (and/or temperature ranges). Each pressure (and/or temperature) range will invariably be due to the use of different pressure (and/or temperature) transducers. In addition, it may be that the manufacture uses several transducer suppliers, all providing transducers with the same measurement range.

In this clause, "variant" refers to each different type of transducer, or combination of, transducers howsoever caused.

- b) if the conversion device is intended to be used for T conversion and PT conversion, or for T conversion and PTZ conversion, an additional sample shall be submitted for test.

If the number of variants is higher or equal to 2 the number of samples applicable to the testing procedure shall be adapted in accordance with the characteristics of the different types of transducers.

The methods are illustrated through the three different cases as follows:

Case 1:

Where the number of variants is equal to 1 the number of samples shall be at least as given in Table 5:

Table 5 — Conversion devices type 1: test samples where only one variant of device is available (case 1)

Recommended sequence in which tests are carried out		Sample S1	Sample S2	Sample S3 ^a
Clause	Test			
A.2	Accuracy	X	X	X
A.16	Alarms' operation	X		X
A.17	Repeatability	X		X
A.3	Ambient temperature	X		X
A.4	Damp heat, steady state	X		X
A.5	Cyclic damp heat	X		X
A.6	Electrical power variation	X		X
A.7	Short time AC power reductions	X		X
A.8	Electrical bursts	X		X
A.9	Electromagnetic immunity	X		X
A.10	Electrostatic discharges	X		X
A.18	Short time DC power variations	X		X
A.19	Surges on supply lines and/or signal lines	X		X
A.20	Power frequency magnetic field	X		X
A.11	Overload of pressure	X		X
A.12	Random vibrations	X		X
A.13	Shocks	X		X
A.14	Overload of pressure (mechanical)	X		X
A.15	Durability		X	
^a If necessary, see provision b) above.				

Case 2:

Where the conversion device includes only one type of pressure transducer (e.g. transducer from the same supplier and from the same family) but the pressure transducer is available for three different measuring ranges R1, R2 and R3. In this case, the test samples are in accordance with Table 6.

Table 6 — Conversion devices type 1: test samples where there are three ranges of pressure transducers from the same family (case 2)

Recommended sequence in which tests are carried out		Sample range R1	Sample range R2	Sample range R3
Clause	Test			
A.2	Accuracy	X	X	X
A.16	Alarms' operation	X	X	X
A.17	Repeatability	X	X	X
A.3	Ambient temperature	X	X	X
A.4	Damp heat, steady state	X	X	X
A.5	Cyclic damp heat	X		
A.6	Electrical power variation	X		
A.7	Short time AC power reductions	X		
A.8	Electrical bursts	X		
A.9	Electromagnetic immunity	X		
A.10	Electrostatic discharges	X		
A.18	Short time DC power variations	X		
A.19	Surges on supply lines and/or signal lines	X		
A.20	Power frequency magnetic field	X		
A.11	Overload of pressure	X	X	X
A.12	Random vibrations	X		
A.13	Shocks	X		
A.15	Durability		X	
A.14	Overload of pressure (mechanical)	X	X	X

Case 3:

Where the conversion device includes three types of pressure transducers (P1, P2, P3) from different suppliers and/or different families? In this case, the test samples are in accordance with Table 7.