BRITISH STANDARD

BS 4161-8:
1987

Gas meters —

Part 8: Specification for electronic volume correctors

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Committees responsible for this British Standard

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British Gas plc
British Non-ferrous Metals Federation
Chief and Assistant Chief Fire Officers' Association
Department of Energy — Gas and Oil Measurement Branch
Institution of Gas Engineers
Society of British Gas Industries

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Foreword

This Part of BS 4161 has been prepared under the direction of the Gas Standards Committee. It complements BS 4161-7 and covers electronic instruments that are attached to industrial and commercial gas meters to indicate the volume of gas that has passed through the meter after correction to reference conditions of temperature and/or pressure.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 8, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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1 Scope

This Part of BS 4161 specifies requirements for electronic volume correctors used to convert a measurement of gas volume from one combination of temperature and/or pressure conditions to another. It covers equipment used at pressures not exceeding 7 bar[1)] with gas meters constructed primarily in accordance with BS 4161-5 and BS 4161-6 and with meters of similar types.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purpose of this Part of BS 4161, the definitions given in BS 5233 apply, together with the following.

2.1
electronic volume corrector

a device that electronically corrects the volume of gas which has passed through a gas meter under the conditions prevailing in the meter to any desired reference conditions and indicates the corrected volume

2.2
electronic pressure and temperature corrector

an electronic volume corrector that takes electrical signals, proportional to the metered gas pressure and temperature, from appropriate transducers. The magnitudes of these signals are then applied to an electrical signal from the gas meter, which is proportional to the actual volume of gas, in order to correct this volume to reference conditions. The corrector may also include a computed or fixed factor compressibility correction

2.3
electronic temperature corrector

an electronic volume corrector similar to that defined in **2.2**, except that pressure is not measured but may be included as a pre-set fixed multiplying factor which may itself incorporate compressibility in the correction process

2.4
gas

the gas produced from coal or oil-based feedstocks or natural gas or its synthetic equivalent or a combination of any of these. It may be either dry or saturated with water vapour

2.5
corrected volume (Q_c)

the volume measured at actual conditions of pressure and temperature converted to an equivalent volume at reference conditions of pressure, temperature and compressibility. It is given by the equation:

$$Q_c = Q_a \times \frac{P}{P_r} \times \frac{T_r}{T} \times \frac{Z_r}{Z}$$

where

Q_a is the measured volume at the actual conditions of pressure, P, temperature, T, and compressibility, Z;

P_r, T_r and Z_r are the reference conditions of pressure, temperature and compressibility respectively.

NOTE Pressure and temperature are expressed as absolute values (see **2.12** and **2.13**).

2.6
correction factor

the factor by which the measured volume is multiplied to derive the corrected volume. It is given by

$$\frac{Q_c}{Q_a}$$

2.7
computed correction factor (CF_c)

the correction factor indicated by the corrector

2.8
actual correction factor (CF_a)

the correction factor calculated from known values of inputs to the corrector and the stated method of compressibility calculation

2.9
error in correction (ϵ_c)

the difference between the computed correction factor (CF_c) and the actual correction factor (CF_a) expressed as a percentage of the actual correction factor. It is given by the equation:

$$\epsilon_c = \frac{CF_c - CF_a}{CF_a} \times 100$$

2.10
gauge pressure

pressure based on zero at the ambient atmospheric pressure

[1)] 1 bar = 10^5 N/m^2 = 10^5 Pa.

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2.11
maximum absolute pressure (p_{max})

maximum absolute pressure specified by the manufacturer for the pressure transducer

2.12
absolute pressure

pressure measured with respect to zero pressure in units of force per unit of area

2.13
absolute temperature

temperature based on the Kelvin scale

2.14
pulse

a current or voltage change which, after an interval of time, reverts to its original state; also the operation of a switch in like fashion

3 Materials

3.1 Materials of construction

The corrector shall be constructed of materials that shall not be adversely affected, e.g. by corrosion cracking, distortion, etc., by the environmental conditions in which it is designed to be installed.

3.2 Pressure transducer

Those parts of the transducer in contact with the gas shall be constructed of materials that are not adversely affected, e.g. by corrosion cracking, distortion, etc., when immersed in saturated gas or condensates.

3.3 Temperature transducer

When a temperature transducer is supplied requiring no thermowell, that part of the transducer housing in contact with the gas shall not be adversely affected, e.g. by corrosion cracking, distortion, etc., by the saturated gas or condensates.

4 Design

4.1 Enclosures

Any part of the corrector designed for outdoor use and not intended to be installed in a weatherproof housing shall be housed in an enclosure affording protection in accordance with at least IP 65 of BS 5490, when subjected to ambient temperatures in the range – 20 °C to + 50 °C.

4.2 Pressure transducer

That part of the specified or supplied pressure transducer which is subject to gas pressure shall meet the proof pressure test requirements of **5.2.2** of BS 6447:1984 when subjected to temperature in the range – 25 °C to + 60 °C.

4.3 Temperature transducer

When the temperature transducer is designed to be installed without a thermowell, that part of the transducer housing which is subject to gas pressure shall meet the proof pressure test requirements of **5.2.2** of BS 6447:1984 when subjected to temperature in the range – 25 °C to + 60 °C.

4.4 Gas meter signal

The corrector shall be able to accept a signal from a gas meter, proportional to the volume being registered and with one of the following forms:

a) a pulse with a defined relationship between frequency and volumetric flow rate as obtained from a slot or proximity sensor (see DIN 19 234):

maximum frequency	500 Hz (or 5 kHz where turbine wheel/blade sensing is employed)
nominal off current	⩽ 1 mA
nominal on current	⩾ 2.1 mA
no-load voltage of	min. 7.7 V
power supply	max. 9.0 V
required series	min. 550 Ω
resistance	max. 1 100 Ω

b) the operation of a switch type transmitter (e.g. a reed switch) being equivalent to a decimal multiple or submultiple of the unit of volume:

maximum frequency	1 Hz
minimum closed or open time	200 ms
maximum switch bounce time	10 ms

The switch shall be regarded as closed if the resistance at the meter output is less than 50 Ω and shall be regarded as open if the resistance at the meter output is greater than 100 kΩ.

4.5 Display

4.5.1 *Character size*. The minimum size of each displayed character shall be 5 mm high and 2.5 mm wide.

4.5.2 *Display*. If the display is electronic the corrector shall incorporate a means for testing the correct operation of the display and its associated electronics.

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4.5.3 *Corrected volume.* The corrector shall indicate the volume of gas passed through the meter corrected to reference conditions.

The display shall:

a) have a minimum of seven active digits with leading zeros shown;

b) be capable of registering a volume of gas passed in not less than 10 000 h operation at a maximum continuous flow using a maximum value of correction factor.

4.5.4 *Uncorrected volume.* The corrector shall be capable of displaying the uncorrected volume of gas passed through the meter.

The display shall:

a) have a minimum of seven active digits with leading zeros shown;

b) be capable of registering a volume of gas passed in not less than 10 000 h operation at a maximum continuous flow.

4.5.5 *Additional displays.* Means shall be provided to enable the operation of the corrector to be checked whilst in service. During a test routine the corrector shall continue to correct even when the main display is used to show test data (e.g. pressure, temperature, correction factor, etc.).

4.6 Power supply

4.6.1 *Battery supply.* A corrector designed to operate totally from internal batteries, when operated for 1 year, shall comply with clause **5** without requiring the batteries to be changed.

The corrector shall include provision to retain stored data during the minimum time of 15 min required to allow for the replacement of the batteries.

4.6.2 *Mains supply.* A corrector designed to operate from a mains supply, shall be able to accept voltages in the range 110 V to 120 V and/or 220 V to 240 V nominal at 50 Hz.

When standby batteries are included, to operate the corrector in the event of a mains failure, they shall be of an adequate capacity to provide 8 h operation when tested as described in **A.6.2**, and be capable of being automatically recharged.

4.7 Electrical safety

4.7.1 *Hazardous areas.* Any part of the correction system for installation in a hazardous area shall be suitable for the class or group appropriate to the gases concerned in accordance with the appropriate Parts of BS 5345 and be manufactured in accordance with the appropriate Parts of BS 5501.

NOTE Generally, the outputs from the corrector to the transducers and the transducers themselves need to be intrinsically safe.

4.7.2 *Protection against electric shock.* For correctors powered from a mains supply the system shall be designed to ensure reasonable personal protection in accordance with BS 5458.

4.8 Sealing

Provision for sealing transducers and enclosures shall be made so that unauthorized interference will be noticeable.

5 Performance

5.1 General

When tested as described in **A.1** to **A.4**, **A.5.1**, **A.5.3** and **A.7** temperature and pressure/temperature correctors shall comply with **5.2** or **5.3** as appropriate. In addition, all correctors shall comply with **5.4**.

5.2 Temperature correctors

5.2.1 *Normal operating conditions.* Under the following conditions, the error on the computed correction factor shall be less than ± 0.4 % of the actual correction factor:

a) over an ambient temperature range of 0 °C to 20 °C;

b) over a gas temperature range of – 20 °C to 50 °C.

5.2.2 *Extreme ambient temperature.* When it is specified that the corrector shall be operated at ambient temperatures outside the range 0 °C to 20 °C, any error on the computed correction factor greater than that specified in **5.2.1** shall not exceed ± 0.01 % of the actual correction factor per degree Celsius.

5.2.3 *Stability with time.* The error on the computed correction factor shall not change by more than ± 0.15 % of actual correction factor in 30 days.

5.3 Pressure/temperature correctors

5.3.1 *Normal operating conditions.* Under the following conditions, the error on the computed correction factor shall be less than ± 0.75 % of the actual correction factor at the maximum pressure of the correction system as specified by the manufacturer:

a) over an ambient temperature range of 0 °C to 20 °C;

b) over a gas temperature range of – 20 °C to 50 °C.

The pressure at which the error on the computed correction factor, under the same conditions, exceeds ± 1.25 % shall be declared by the manufacturer.

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5.3.2 *Extreme ambient temperature*. When it is specified that the corrector shall be operated at ambient temperatures outside the range 0 °C to 20 °C, any error on the computed correction factor greater than that specified in **5.3.1** shall not exceed ± 0.05 % of the actual correction factor per degree Celsius.

5.3.3 *Stability with time.* The error on the computed correction factor shall not change by more than ± 0.25 % of the actual correction factor in 30 days.

5.3.4 *Effect of over-pressure on the pressure transducer*. After application of an over-pressure of $1.1P_{max}$, pressure transducers shall comply with **5.3.1** a) and b), **5.3.2** and **5.3.3**.

5.4 Temperature and pressure/temperature correctors

5.4.1 *Damp heat test*. After testing as described in **A.5.3**, there shall be no visible accumulation of condensate and no visible degradation of components.

5.4.2 *Mains power supply*. Any additional error to the corrected flow during or after the perturbations specified in **A.5.4.2** to **A.5.4.4** after setting up the corrector in accordance with **A.5.4.1** shall not exceed 0.1 %.

5.4.3 *Electromagnetic interference*. During the tests described in **A.5.5** the error on the computed correction factor shall not exceed that specified in **5.2.1** or **5.3.1** as appropriate.

5.4.4 *Mechanical shock*. After testing as described in **A.5.6**, the error on the computed correction factor shall not exceed that specified in **5.2.1** or **5.3.1** as appropriate.

5.4.5 ***Battery life***

5.4.5.1 *Battery powered corrector*. When tested as described in **A.6.1**, the batteries shall give full operation for at least 1 year.

5.4.5.2 *Mains powered corrector with standby batteries*. When tested as described in **A.6.2**, the standby batteries shall give full operation for at least 8 h.

6 Marking

6.1 Identity label

An identity label or labels shall be permanently attached to each volume corrector and shall state the following:

a) manufacturer's name;

b) serial number;

c) year of manufacture, if serial number is not unique;

d) type or model number;

e) number and date of this British Standard, i.e. BS 4161-8:1987[2)].

6.2 Calibration data label

A further label shall be attached to each volume corrector and shall have provision to be marked as follows:

a) the working range of pressure correction (for correctors incorporating pressure correction);

b) the working range of temperature correction;

c) any pre-set correction made for other variables;

d) volume pulse significance;

e) maximum pulse repetition rate;

f) reference conditions;

g) barometric pressure, where a gauge pressure transducer is used;

h) type of compressibility correction applied or reference to handbook.

[2)] Marking BS 4161-8:1987 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

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Appendix A Test methods

A.1 Test arrangements

A.1.1 ***Installation***

The corrector shall be mounted and, if required, adjusted in accordance with the manufacturer's instructions.

A.1.2 ***Temperature input***

If the corrector is designed to sense temperature using a Class B resistance thermometer complying with BS 1904, resistances with tolerance better than ± 0.1 Ω may be used to simplify the test procedure. The values of these resistors shall comply with the resistance/temperature relationship given in BS 1904.

If any other form of temperature transducer is supplied, the transducer shall be placed in a temperature controlled oil/water bath in which the temperature over the period of the test is determined to better than ± 0.25 °C.

A.1.3 ***Pressure input***

On electronic correctors accepting a pressure input, the pressure transducer specified or supplied by the manufacturer shall be used. The pressure applied to the transducer shall be determined to better than ± 0.1 % of actual reading.

A.1.4 ***Volume input***

A.1.4.1 *Gas meter fitted with a high frequency output*. The test signal shall be simulated in accordance with **4.4** a) up to a maximum frequency stated by the manufacturer of the corrector.

A.1.4.2 *Gas meter fitted with a low frequency output*. A test signal shall be simulated in accordance with **4.4** b) at the maximum frequency stated by the manufacturer of the corrector.

A.2 Variables measured

In addition to the simulated inputs described in **A.1.2** to **A.1.4**, the following measurements shall be made at each combination of input settings.

a) An output from the corrector which can be equated to the correction factor applied by the corrector.

For some correctors this may have to be determined by recording the increase in the corrected volume after a known increase in uncorrected volume. This increase shall be large enough to determine the actual error in correction to better than ± 0.05 % of reading.

b) Outputs from the corrector which can be equated to the corrected and uncorrected volume.

A.3 Test conditions

Energize the corrector and associated transducers for at least 1 h before commencing any test.

Unless otherwise stated in this appendix, perform all tests at an ambient temperature of 20 ± 2 °C, and at nominal supply voltage and frequency where applicable.

A.4 Effect of corrector variables

A.4.1 ***Variation in volume pulse frequency***

NOTE This test applies to correctors with high frequency input only.

Apply a known pressure of approximately 0.75 maximum working gauge pressure.

Simulate a gas temperature equivalent to the maximum gas temperature, i.e. 50 °C.

Change the frequency of the input that simulates the signal from the gas meter in steps equivalent to the following pulse rates:

0.02 Q_{max}, 0.05 Q_{max}, 0.33 Q_{max}, 0.66 Q_{max} and 1.0 Q_{max}

where

Q_{max} is the maximum pulse rate specified for the corrector by the corrector manufacturer.

Determine the error in correction for each of the pulse rates. If the errors in correction are all within ± 0.1 % of each other, the tests specified in **A.4.2**, **A.4.3** and **A.5** shall be performed with the flow signal set to the frequency equivalent to Q_{max}.

If the errors in correction are not within ± 0.1 % of each other, the tests specified in **A.4.2**, **A.4.3** and **A.5** shall be performed at each of the above pulse rates.

A.4.2 ***Variation in gas pressure (where applicable)***

Simulate a gas temperature equal to the reference temperature.

Apply a pressure to the pressure transducer increasing in five approximately equal increments over the working pressure range specified by the manufacturer.

Reduce the pressure from the maximum to the minimum specified by the manufacturer in the same incremental steps as above.

Take measurements as described in **A.2** at each setting. Repeat this procedure four times.

A.4.3 ***Variation in gas temperature***

Apply a known pressure of approximately 0.75 maximum working gauge pressure to the pressure transducer.

Increase the simulated gas temperature from – 20 °C to + 50 °C in steps of approximately 10 °C.

Take measurements as described in **A.2** at each setting.

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A.5 Effect of external influences

A.5.1 ***Ambient temperature***

A.5.1.1 *All correction systems*. Test complete correction system as described in **A.4.2** at the following ambient temperatures in the sequence shown:

20, 10, 0, – 10, 20, 30, 50, 20 °C

The temperature shall be changed at a rate such that condensation does not take place.

A.5.1.2 *Systems with separate pressure transducer*. In addition to testing the correction system as described in **A.5.1.1**, test the system with the pressure transducer subjected to the temperature variations as described in **A.5.1.1**, but with the corrector at a constant 20 ± 2 °C.

A.5.2 ***Effect of over-pressure***

Apply a known pressure of approximately $0.75P_{max}$, a simulated gas temperature of 50 °C and the maximum input pulse frequency.

Take measurements as described in **A.2**.

Subject the pressure transducer to a pressure of $1.1\ P_{max}$ for 1 min.

Restore the conditions as specified above.

After an interval of 5 min repeat the measurements described in **A.2**.

A.5.3 ***Damp heat test***

Energize the corrector and maintain it for a period of at least 12 h at an ambient temperature of 40 ± 1 °C and at a relative humidity of at least 95 %.

Apply the pressure and gas temperature inputs described in **A.5.2**.

Keep the environmental chamber, in which these tests are performed, closed. Then with the corrector still operating, decrease the temperature to 20 ± 2 °C in not less than 1 h.

Allow the equipment to dry before making any further tests.

A.5.4 ***Mains power supply***

A.5.4.1 *General*. Set the inputs to the corrector to give the maximum correction factor at maximum pulse rate.

A.5.4.2 *Variation in power supply*. Vary the voltage by + 10 % and – 15 % of its nominal value.

A.5.4.3 *Reductions and interruptions in voltage*. With intervals of at least 10 s between each interruption, reduce the voltage five times from its nominal voltage by:

a) 100 % for approximately 10 ms;

b) 50 % for approximately 20 ms;

c) 20 % for approximately 50 ms.

A.5.4.4 *Mains borne interference*. Apply randomly phased transient overloads of either polarity to the system. Supply these transients in common mode and series mode from an impedance of 50 Ω, the amplitude, rise time, duration and repetition rate being in accordance with Table 1.

Table 1 — Amplitude, rise time, duration and repetition rate

Amplitude	Rise time	Half-amplitude duration	Repetition rate
500 V	5 ns	100 ns	12 Hz
1 500 V	35 ns	3 µs	12 Hz
5 % of nominal value	Sine wave superimposed on the mains		30 kHz – 150 kHz
1 V	Sine wave superimposed on the mains		150 kHz – 400 MHz

A.5.5 ***Electromagnetic interference***

A.5.5.1 *Induction field*. Place a conductor carrying a 50 Hz alternating current of 10 A a distance of 25 mm from the correction system and associated cables.

A.5.5.2 *Radio frequency interference*. Place the correction system in a field of electromagnetic radiation of 3 V/m field strength. Sweep the frequency from 20 MHz to 500 MHz at a rate of 0.005 octave per second. This procedure shall be followed with the field applied along each of three mutually perpendicular axes in turn.

A.5.5.3 *Electro-static discharges*

NOTE This test does not apply to instruments for installation in hazardous areas.

Produce an electro-static discharge of 6 kV with an energy of 2 mJ and a repetition rate of not more than 0.1 Hz on:

a) a conductive surface on the corrector; and

b) a conductive surface in the vicinity of the corrector.

A.5.6 ***Mechanical shock***

NOTE During this test the correction system need not be energized and replaceable batteries should not be fitted.

Mount each part of the correction system in a rigid fixture by their normal support points so as to protect any protrusions, e.g. switches, glands, etc.

Allow the assembly to fall freely from a height of 25 mm onto a steel plate not less than 8 mm thick, fixed to a concrete base not less than 500 mm thick.

Drop the unit three times on each of the six faces.

Monitor changes in performance after these tests by testing the complete correction system as described in **A.4.2** but without the repeat tests.

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A.6 Battery life

A.6.1 ***Battery supply (where applicable)***

Fit a new battery or set of batteries to the corrector.

Under the pressure and temperature conditions described in **A.5.2** and a volume input equivalent to the average pulse rate permitted by the manufacturer but not less than 0.2 Hz, operate the corrector with pressure and temperature data measured at every pulse.

After 1 year take measurements as described in **A.4.2** without the repeat tests.

NOTE In place of this test an accelerated test equivalent to 1 year's normal use at the manufacturer's stated conditions may be used.

A.6.2 ***Standby batteries for mains powered correctors (where applicable)***

Energize the corrector from the mains supply for at least 120 h.

Under the pressure and temperature conditions described in **A.5.2** and a volume input equivalent to 0.66 of the maximum pulse rate, switch off the mains supply and record the time.

Operate the corrector from the internal battery power supply for a period of 8 h, then test it as described in **A.4.2** but without the repeat tests.

A.7 Stability with time

Test the corrector as described in **A.4.2** without the repeat tests.

Read the displays, both corrected and uncorrected at the start of the test.

Maintain a pressure of 0.75 P_{max}, a simulated gas temperature of 50 °C and a volume input equivalent to 0.66 of the maximum specified pulse rate for at least 30 days taking relevant readings after 15 days and at the end of the test.

Repeat the procedure described in **A.4.2** but without the repeat tests.

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Publications referred to

BS 1904, *Specification for industrial platinum resistance thermometer sensors.*

BS 4161, *Gas meters.*

BS 4161-5, *Positive displacement diaphragm meters for pressures up to 7 bar.*

BS 4161-6, *Rotary displacement and turbine meters for gas pressures up to 100 bar.*

BS 4161-7, *Mechanical volume correctors*[3].

BS 5233, *Glossary of terms used in metrology (incorporating BS 2643).*

BS 5345, *Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture).*

BS 5458, *Specification for safety requirements for indicating and recording electrical measuring instruments and their accessories.*

BS 5490, *Specification for classification of degrees of protection provided by enclosures.*

BS 5501, *Electrical apparatus for potentially explosive atmospheres.*

BS 6447, *Specification for absolute and gauge pressure transmitters with electrical output.*

DIN 19 234, *Electrical position sensors with signal converters used in intrinsically safe two line d.c. systems*[4].

[3] Referred to in the foreword only.
[4] Published by Deutsches Institut für Normung (DIN) and available from BSI Sales, Linford Wood, Milton Keynes MK 14 6LE.

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