BRITISH STANDARD

BS 4161-6: 1987

Incorporating Amendment No. 1

Gas meters —

Part 6: Specification for rotary displacement and turbine meters for gas pressures up to 100 bar

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Gas Standards Committee (GSE/-) to Technical Committee GSE/25, upon which the following bodies were represented:

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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Contents

Foreword

This Part of BS 4161 has been prepared under the direction of the Gas Standards Committee. It is a revision of BS 4161-6:1979, which is withdrawn.

In the preparation of this standard account has been taken both of commercial factors associated with export and of European harmonization by incorporating relevant requirements of the following.

Statutory Instrument 1983: No. 684: The Gas Meter Regulations 1983

Statutory Instrument 1980: No. 1058: The Measuring Instruments (EEC Requirements) Regulations 1980, as amended by Statutory Instrument 1618:1984

Statutory Instrument 1983: No. 1246: The Measuring Instruments (EEC Requirements) (Gas Volume Meters) Regulations 1983, which implement EEC Council Directive 71/318/EEC and its subsequent technical progress amendments

This standard relates to meters for gaseous fuels which register the volume of gas passed. These meters may be used for measuring gases other than gaseous fuel, but the suitability of the meter for any other gas should be verified with the manufacturer. The standard covers indexes reading in either cubic metres or cubic feet. The pressures quoted are gauge pressures.

It should be noted that only existing designs of meter are permitted to register in cubic feet. Under the Weights and Measures Units of Measurement Regulations 1976, Statutory Instrument 1976: No. 1674, new meter designs are required to register in cubic metres.

These meters may be fitted with a volume corrector; such devices for the type of meter specified in this standard are generally interchangeable with, or additional to, the index.

The construction and performance requirements of mechanical volume correctors are given in Part 7. A new Part 8 giving performance requirements for electronic volume correctors is in preparation.

NOTE Where gas is supplied through a meter which is stamped under the Gas Act, the meter has to comply with the current meter regulations.

The other Parts of BS 4161 covering temperature and pressure compensating devices and other types of gas meter, are as follows.

— *Part 1: Meters of plate construction up to 1 000 cubic feet per hour rating (obsolescent)*;

— *Part 2: Meters of plate construction above 1 000 cubic feet (28 cubic metres) per hour rating (obsolescent)*;

— *Part 3: Unit construction meters of 6 cubic metres (or 212 cubic feet) per hour rating*[1)];

— *Part 4: Plate constructed positive displacement diaphragm meters for a pressure of 350 mbar (5 lbf/in^2) and up to 170 cubic metres (6 000 cubic feet) per hour rating (obsolescent)*;

— *Part 5: Positive displacement diaphragm meters for pressures up to 7 bar*[1)];

— *Part 7: Mechanical volume correctors*;

— *Part 8: Specification for electronic volume correctors.*

[1)] Under revision.

Installation of these meters is the subject of BS 6400 and, for above 75 mbar pressure, of "Recommendations on gas measurement practice IGE/GM/1 Installation of high-pressure gas meters", published by the Institution of Gas Engineers.[2)]

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 12, 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.

[2)] Available from the Institution of Gas Engineers, 17 Grosvenor Crescent, London SW1 7GSO.

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1 Scope

This Part of BS 4161 specifies requirements for the construction and performance of rotary displacement and turbine meters registering in cubic metres or cubic feet, for all gas pressures up to 100 bar[3)].

All pressures quoted are gauge pressures.

NOTE 1 Information that a purchaser is recommended to provide is given in Appendix A.
NOTE 2 The titles of the publications referred to in this Part of BS 4161 are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 4161 the definitions given in BS 1179 apply, together with the following.

2.1
rotary displacement meter

a meter in which the measuring compartment is formed between the walls of a stationary chamber and an element or elements which is or are rotated by the gas flow. The rotation of the elements is transmitted mechanically or otherwise to an index which registers the volume of gas passed

2.2
turbine meter

an inferential meter in which the gas flow drives a turbine wheel linked mechanically or by other means to an index which registers the volume of gas passed

2.3
meter accuracy

the accuracy of a meter, expressed as a percentage and obtained from the expression:

$$\frac{(\text{registered volume} - \text{actual volume})}{\text{actual volume}} \times 100$$

where both volumes relate to the same pressure and temperature conditions

2.4
purchaser

the organization or individual who buys the finished gas meter for its own use or as an agent of the owner

2.5
manufacturer

the organization that is responsible to the purchaser for the design and manufacture of the gas meter, including the pressure casing

NOTE The design and manufacturing functions can be carried out by separate organizations.

2.6
inspecting authority

the body or association that checks that the design, materials and construction comply with the requirements of this standard

2.7
regulating authority

the authority in the country of installation that is legally charged with the enforcement of the requirements of the law and regulations of that country relating to pressure vessels

2.8
casing design pressure

the pressure to be used in the equations for the purposes of strength calculation

2.9
design temperature range

the temperature range that is to be used for the purposes of calculation

2.10
maximum working pressure

the maximum pressure permitted in service

NOTE To ensure that meter performance is not adversely affected, for the purposes of this standard, the maximum working pressure and the casing design pressure should be the same.

3 Ratings and type

NOTE See item a) of Appendix A.

3.1 Meter rating m^3/h or ft^3/h

3.1.1 *General.* The meter rating shall be determined from the actual volume of air passing when the meter is tested with air of density 1.2 kg/m^3 [4)] at less than 100 mbar pressure.

3.1.2 *Rotary displacement meters.* The meter shall be rated according to its maximum and minimum flows at one of the Q_{max} rates and the corresponding Q_{min} rate given in Table 1, columns 1 and 2, or at a decimal multiple or submultiple of one of the Q_{max} rates and corresponding Q_{min} rate.

For meters reading in cubic feet the ratings shall be within 10 % of the converted metric values. Q_{min} shall be either one-twentieth of Q_{max} or less than one-twentieth of Q_{max}, but the minimum flow shall be equivalent to one of the Q_{min} values given in Table 1, column 2, or a decimal multiple or submultiple thereof.

[3)] 1 bar = 10^5 N/m^2 = 100 kPa.
[4)] Air in a normal test room is generally about this density, e.g. in condition 15 °C, 1 013 mbar, wet.

3.1.3 *Turbine meters.* The meter shall be rated according to its maximum and minimum flows at one of the Q_{max} rates and the corresponding Q_{min} rate given in Table 1, columns 1, 3, 4 and 5, or at a decimal multiple or submultiple of one of these rates: Q_{min} shall be not greater than the corresponding multiple of the value given in column 5.

NOTE The meters are classified according to their flow rangeability, i.e.:

type 20 indicates a 20 : 1 rangeability;
type 10 indicates a 10 : 1 rangeability;
type 5 indicates a 5 : 1 rangeability.

For example, a type 10 turbine meter with a maximum meter rating of 650 m^3/h will have a minimum rating of 65 m^3/h.

For meters reading in cubic feet the ratings shall be within 10 % of the converted metric values. Q_{min} shall be either one-twentieth of Q_{max} or less than one-twentieth of Q_{max}, but the minimum flow shall be equivalent to any one of the Q_{min} values given in Table 1, columns 3, 4 and 5, or a decimal multiple or submultiple thereof.

3.2 Pressure rating

The pressure rating shall be the maximum working pressure stated by the manufacturer (see clause **5** and item e) of **8.1**).

3.3 Stated density range

If, for turbine meters, the operating density range, as stated on the meter dial or data plate, varies from the test density of 1.2 kg/m^3, the Q_{min} rates given in Table 1 shall be changed in accordance with note 2 to that table.

NOTE In such cases consideration should be given to testing at conditions representative of those of the gas to be metered. (see also item i) of **8.1**.)

Table 1 — Meter ratings

1	2	3	4	5
All meters	**Rotary displacement meters**	**Turbine meters**		
		Type 20	**Type 10**	**Type 5**
Q_{max}	Q_{min}	Q_{min}	Q_{min}	Q_{min}
m^3/h	m^3/h	m^3/h	m^3/h	m^3/h
25	1.3	1.3	2.5	5.0
40	2.0	2.0	4.0	8.0
65	3.2	3.2	6.5	13.0
100	5.0	5.0	10.0	20.0
160	8.0	8.0	16.0	32.0
200[a]	10.0[a]	10.0[a]	20.0[a]	40.0[a]
250	13.0	13.0	25.0	50.0
320[a]	16.0[a]	16.0[a]	32.0[a]	65.0[a]
400	20.0	20.0	40.0	80.0
500[a]	25.0[a]	25.0[a]	50.0[a]	100[a]
650	32.0	32.0	65.0	130
800[a]	40.0[a]	40.0[a]	80.0[a]	160[a]
1 000	50.0	50.0	100	200
1 300[a]	65.0[a]	65.0[a]	130[a]	250[a]
1 600	80.0	80.0	160	320

NOTE 1 Decimal multiples and submultiples of the values in the table are acceptable.

NOTE 2 The minimum flow rate of turbine meters varies with the density of the gas in accordance with the following equation:

$$Q_{min,o} = Q_{min,c}\sqrt{\rho_c / \rho_o}$$

where:

$Q_{min,o}$ is the minimum flowrate at operating conditions;
$Q_{min,c}$ is the minimum flowrate at calibration conditions;
ρ_c is the density of the calibration gas;
ρ_o is the density of the operating gas.

[a] These ratings are included to cover meters currently being made, but they are non-preferred ratings according to EEC Directive 71/318/EEC, as amended by 74/331/EEC, 78/365/EEC and 82/623/EEC.

4 Design and materials

NOTE See Appendix A.

4.1 General

Meters shall be designed and manufacturing tolerances shall be set so as to allow interchangeability of components of the same size and type. Provision shall be made to prevent unauthorized replacement of interchangeable components, e.g. by means of an appropriate seal.

NOTE It is essential that materials and their treatment be such that they are not affected adversely by operating conditions. External holes for screws, pins, etc., which are used for the attachment of data badges or for the assembly of parts of the meter, shall not penetrate gas ways. The minimum wall case thickness shall be maintained between these holes and gas ways.

4.2 Pressure

Over the working pressure range, a rotary displacement meter shall withstand the following:

a) a rate of change of pressure of 350 mbar/s;

b) a differential pressure of not less than 125 % of that generated by the meter at the maximum rate of flow (maximum working pressure) for 30 min.

4.3 Temperature

The meter shall be suitable for operation over the temperature range – 20 °C to + 50 °C.

4.4 Strength and balance

The meter shall be run at 50 % above Q_{max} for 30 min without damage, when tested with air of density 1.2 kg/m^3.

4.5 Casing

4.5.1 *Casing materials*

4.5.1.1 *All design pressures.* The material of the casing shall be one of the following:

a) spheroidal graphite cast iron in accordance with BS 2789;

b) aluminium alloy in accordance with BS 1470, BS 1474 or BS 1490;

c) cast steel in accordance with BS 1504-161 grade 480, ASTM A216 or ASTM A352 (see **4.5.1.2**);

d) steel plate in accordance with BS 1501;

e) barstock in accordance with ASTM A105;

f) steel forgings in accordance with BS 1503.

If steel pipe forms the basis of the meter body it shall comply with BS 3600.

4.5.1.2 *Design pressures in excess of* 7 bar. Steel plate and sections for pressure parts shall be made from fully killed steels which shall either be chosen from those listed in section 2 of BS 5500:1988 or shall be materials of equivalent design strength.

NOTE 1 If used, materials of equivalent design strength should be the subject of agreement between the purchaser and the manufacturer.

NOTE 2 For cast materials used for pressure parts, the manufacturer and the purchaser should ensure that the founder provides a quality control system which is acceptable to them both. The quality control procedures should include stage inspection to prove foundry techniques, to reveal unacceptable defects and to facilitate examination of the castings at all stages of manufacture. Acceptable levels of non-destructive testing and repair procedures for defects should be the subject of agreement between the purchaser, manufacturer and inspecting authority.

4.5.2 *Casing design*

4.5.2.1 *General.* The casing design pressure shall be the same as the stated maximum working pressure.

4.5.2.2 *Casing for maximum working pressures not exceeding* 7 bar. The casings shall be designed in accordance with good engineering practice and procedures, which shall be recorded and available.

Where the design has been proved by means of calculations, these shall show that the general membrane stress in any part of the casing during testing does not exceed 85 % of the minimum specified yield strength of the material.

Where the casing is of a well-established type for which no recorded design procedures are available or of a design whose shape prevents accurate design calculations, one sample of each model size and type of casing shall be subjected to a proof test. The method and result of this proof test shall be recorded and made available to the purchaser or inspecting authority. Following a satisfactory proof test the design shall not be changed without further proof testing. The proof test, which is a type test, shall be carried out by using strain gauges or a strain indicating coating technique as detailed in BS 5500 or an alternative recognized pressure vessel standard, or by performing a hydrostatic test at a pressure of five times the maximum working pressure, but at least 2 bar, for 30 min without yielding.

NOTE The intention of such tests is to prove that the design is acceptable without calculation.

Upon completion of manufacture every casing shall be strength-tested to 1.5 times the maximum working pressure for a minimum of 15 min; there shall be no distortion.

4.5.2.3 *Casings for maximum working pressures above* 7 bar. The construction of the casing for maximum working pressures above 7 bar shall be in accordance with BS 5500 or other recognized pressure vessel standard in addition to the requirements of this standard.

NOTE 1 Attention is drawn to the design categories defined in section 3 of BS 5500:1988. It is important to consider the implications of these categories before commencing design. They are not primarily based upon the application but upon the type and degree of non-destructive testing; this will be influenced by the casing thickness as well as the application. As an example, category 1 requires 100 % radiographic or ultrasonic examination of all welded joints; category 3 requires only visual examination but the stress level is limited to a very low value, which results in the use of thicker material.

It is possible to obtain exclusion from the need to apply BS 5500 if the stress level in all parts of the pressure shell is below 10 % of the allowable design stress for the material, as specified in section 2 of BS 5500:1988.

NOTE 2 Alternative specifications may be used provided that these are acceptable to the regulating authority.

NOTE 3 Attention is drawn to the various responsibilities for design, manufacture and inspection included in BS 5500.

The minimum design temperature shall be – 20 °C.

Slip-on flanges are not permitted above class 150. Full penetration welds shall be used for the attachment of all nozzles to casings. Stress relief heat treatments shall be in accordance with the pressure vessel specification.

Each meter casing shall be provided with a non-corrodible nameplate permanently attached to a conspicuous part of the casing. The attachment method shall be considered as part of casing design.

In addition to the markings specified in clause **8** the separate nameplate shall show the following details as specified in the design standard, e.g. BS 5500:

a) number of the pressure vessel standard, e.g. BS 5500;

b) name of manufacturer;

c) manufacturer's identification number, i.e. serial number;

d) casing design pressure;

e) casing design temperature range;

f) hydrostatic test pressure;

g) date of manufacture;

h) identification mark of the inspecting authority.

Upon completion of the manufacture of the casing a hydrostatic test shall be carried out in the presence of the inspecting authority's representative. The test shall be as specified in **5.8** of BS 5500:1988 or the appropriate sections of alternative specifications; the hydrostatic test pressure shall be a minimum of 1.5 times the casing design pressure. At the hydrostatic test pressure, the general membrane stress in any part of the casing shall not exceed 85 % of the minimum yield strength of the material.

NOTE A leakage test on the fully assembled meter is also required (see **5.2**).

4.5.3 *Surface protection.* All outer surfaces of the meter shall be protected as necessary against corrosion and be suitable for the environment in which it is intended that the meter will be installed.

4.6 Connections

The inlet and outlet connections shall be flanged for nominal pipe bores above 50 mm (2 in); for nominal bores of 50 mm (2 in) and below they shall be either flanged or threaded in accordance with BS 21.

4.7 Connection flanges

4.7.1 Steel flanges shall comply with either BS 1560-2, BS 3293 or Tables 16/1, 16/2 or 16/3 of BS 4504-1:1969.

4.7.2 Cast iron flanges shall comply either with the flange requirements specified in Table 16/12 of BS 4504-1:1969 or with BS 5150, with the following exceptions.

a) Class 125 flanges for nominal pipe sizes over 600 mm (24 in) shall comply in outside diameter, thickness and drillings with the values specified in BS 3293 for class 150 flanges.

b) Class 250 flanges shall comply in outside diameter, thickness, drillings and facing dimensions with the values specified for class 300 flanges in BS 1560-2 or BS 3293.

4.7.3 Meter body faces for flange joints shall have dimensions necessary for satisfactory mating in accordance with BS 1560-2, BS 3293 or BS 4504-1 as appropriate, and shall have mechanical strengths over the operating pressure/temperature range not inferior to flanges specified in **4.7.1** and **4.7.2** as appropriate. Any tapped bolt holes in the body shall be in accordance with the appropriate flange standard adopted.

4.7.4 Class 125 flanges shall be plain (flat) faced; class 600 and higher pressure rated flanges shall be either of the raised face type or have ring-joint facings; all other flanges shall be of the raised face type.

4.8 Impellers and turbine rotors

4.8.1 *Impellers.* The material of the impellers of rotary displacement meters shall be of an appropriate grade of grey cast iron in accordance with BS 1452, spheroidal graphite cast iron in accordance with BS 2789, steel in accordance with BS 1503 or BS 1504, or aluminium in accordance with BS 1472 or BS 1490. The impellers shall be protected, if necessary, against corrosion by the particular gas which the meter is designed to handle (see item e) of Appendix A). The impellers shall be dynamically balanced.

4.8.2 *Turbine rotors.* The turbine rotors of turbine meters shall be dimensionally stable and be of corrosion-resistant material or protected against corrosion by the particular gas which the meter is designed to handle (see item e) of Appendix A). The turbine rotors shall be dynamically balanced.

4.9 Bearings

Impellers and turbine rotors shall be carried in a bearing(s) which shall be protected from ingress of dirt from the gas stream.

The bearing(s) shall withstand any end thrust which, in rotary displacement meters, may arise from the normal installation tolerances (e.g. any levelling tolerances specified by the manufacturer) or from operating conditions in turbine meters.

In rotary displacement meters, means shall be provided to prevent lubricant entering the measuring chamber under normal operating conditions.

4.10 Lubrication

Means shall be provided for checking the oil level and for filling and draining the lubrication system, where necessary.

4.11 Index windows

4.11.1 *General.* The index window shall be of either plate glass complying with **4.11.5** or material of equivalent performance and useful life and complying with **4.11.2** and **4.11.7**.

A window which, in normal operation, is subjected to the gas pressure shall be tested for soundness with the casing, as specified in clause **5**.

4.11.2 *Index window requirements.* Both as supplied and after being subjected to the accelerated deterioration tests described in **4.11.7**, samples of window panes or mouldings shall comply with **4.11.3** to **4.11.6**. Perform the accelerated deterioration tests on samples that have not been previously subjected to the flammability test.

4.11.3 *Visual inspection.* The window pane or moulding shall show no crazing or blisters. The portion through which the index is viewed shall be transparent, have a high polish, and cause no visual distortion of the matter to be viewed within an angle of 15° from the normal to the window.

4.11.4 *Rigidity.* With the window fitted on the meter as in operation and at a temperature of 30 ± 2 °C, a 10 mm diameter wooden rod applied normal to any external part of the window or moulding with a force of 200 N shall not cause the window or moulding to touch any moving part of the mechanism.

4.11.5 *Impact.* The window, fitted in the meter as in operation and at a temperature of – 5 ± 1 °C, shall withstand the impact of a 25 mm diameter solid steel ball dropped three times, from a height of 250 mm, striking the centre of the window and falling normal to its plane.

4.11.6 *Flammability.* Test the window in accordance with BS 2782:Method 140E. For this test use a complete window as the test specimen and position the centre of the window with its external face downwards on the centre of the wire grid.

4.11.7 ***Accelerated deterioration tests***

4.11.7.1 *General.* Subject one test specimen to the deterioration tests described in **4.11.7.2.1** and **4.11.7.2.2**. Subject another test specimen to the tests described in **4.11.7.3**. After these deterioration tests and before being subjected to the flammability test the samples shall still fit the meter (see also **4.11.2**).

4.11.7.2 *Effect of ultraviolet light and loss of volatile plasticizer*

4.11.7.2.1 *Radiation test.* Expose the window for five periods of 8 h duration to the radiation of a suspended sun lamp which has been used for not less than 50 h and not more than 400 h. The light source shall be a combination tungsten filament mercury-arc enclosed in glass which has a low transmission below 280 nm. The glass envelope shall be conical in shape and silvered internally to form a reflector. The lamp shall be rated at 275 W to 300 W.

Position the window on the white index with its outer face towards the lamp and 400 mm from the bottom and the axis of the lamp. The surrounding air shall not be confined and shall be free to circulate.

After each exposure, except the last, immerse the window completely in distilled water for 16 h. Clean it with distilled water and carefully dry it with cotton wool after each immersion period.

4.11.7.2.2 *Loss of volatile plasticizer.* Heat the window in air at a temperature of 100 ± 3 °C for 24 h. Support the window in such a manner as to discourage deformation.

4.11.7.3 *Resistance to chemical substances.* Constrain the window as it will be in the meter and then totally immerse it in the following substances in turn, in the order listed, at a temperature of 20 ± 30 °C:

a) sodium carbonate (20 % concentration by mass) for 2 h;

b) paint thinners (approximately 50 % *V*/*V* aromatic and 50 % *V*/*V* aliphatic hydrocarbons) for 1 h.

Clean the window with distilled water and carefully dry it with cotton wool after each immersion.

4.12 Index

4.12.1 *General.* The index shall be direct reading, and the unit "m^3" or "ft^3" shall be visible on the indicating device.

The index shall display the measured gas volume under the actual operating conditions (i.e. cubic metres or cubic feet at the operating temperature and pressure).

The indicating device shall have sufficient capacity to show a volume equal to at least 10 000 h of operation at the maximum continuous throughput. The index and its drive shall be sealed, or be capable of being sealed, in such a way that unauthorized intervention is impossible without breaking the seal.

4.12.2 *Mechanical counters*

4.12.2.1 The drums of the indicating device shall be not less than 16 mm in diameter. The drums shall be marked with the numerals 0 to 9, and shall indicate the measured gas volume in cubic metres or cubic feet or decimal multiples or submultiples of a cubic metre or a cubic foot.

4.12.2.2 The numerals shall be white in colour on a black background except for submultiples specified in **4.12.2.4**, which shall be red on a black background; all numerals shall be of uniform height. A complete revolution of a drum shall, during the last one-tenth of its travel, i.e. from 9 to 0, cause the advance of the next highest drum by one unit.

4.12.2.3 When the drum of the lowest order is a decimal multiple of a cubic metre or a cubic foot, the indicating device shall bear either:

a) one or more fixed zeros after the last drum; or

b) the indication "× 10" (or × 100', etc.).

4.12.2.4 Numerals indicating submultiples of a cubic metre or cubic foot shall be surrounded by a red visor and shall be separated from the preceding numerals, indicating units and multiples by a clear decimal marker.

4.12.2.5 The test drum (i.e. that of the lowest order) shall rotate continuously during the operation of the meter. The value of one revolution of this drum shall lie between 0.1% and 1.0 % of the maximum hourly capacity of the meter, and the drum shall have at least 10 equidistant graduations, marked 0 to 9. The distance between sub-divisions of the equidistant graduations shall be at least 1 mm so that the accuracy of the meter can be checked.

It is permissible for the test drum to have a reference mark of sufficient size to permit photoelectric scanning. The reference mark shall not conceal the graduation and shall not interfere with the accuracy of reading.

NOTE If necessary, it is permissible for the reference mark to be in the form of the Figure 0, i.e. as a "reflective zero".

4.12.2.6 The pointer or other means provided for reading the graduations shall be fine enough to permit accurate and easy reading.

4.12.3 *Electronic counters*

4.12.3.1 The numerals shall have minimum dimensions of 5 mm height and 2.5 mm width.

4.12.3.2 The counter shall incorporate a facility to test for operation of the display and its associated electronics and shall have a minimum of seven active digits with leading zeros shown.

4.13 Extra outputs

4.13.1 *Mechanical output shafts.* Provision shall be made for covering and sealing the free ends of any output shafts when they are not being used and provision shall also be made for sealing any attachment to the meter.

Where a single drive shaft is provided, the value per revolution or "speed constant C" (i.e. 1 revolution = "a" m^3 or "b" ft^3, where "a" and "b" are numbers), the direction of rotation of the shaft and the maximum permitted torque, in N·mm, shall be marked on the shaft or at an adjacent point on the meter.

Where several drive shafts are provided, each shaft shall be identified by the letter M with a subscript, in the form M_1, M_2, etc., together with an indication of its speed constant C and its direction of rotation. The summation of torques applied to the shafts shall not exceed the maximum permissible torque A (in N·mm) which can be applied to the drive shaft M_1 with the slowest speed constant C_1 if all the torque were to be applied to that shaft.

The distribution of the maximum permissible torque between all the shafts in use shall be proportional to the inverse ratio of the speed of those shafts relative to the speed of the slowest shaft.

The maximum permissible torque applied to the meter is distributed between the shafts according to the expression:

$$K_1 M_1 + k_2 M_2 + \ldots K_n M_n \leqslant A \qquad (1)$$

where

A is the maximum permissible torque (in N·mm) which can be applied to the drive shaft with the highest constant, where the torque is applied only to this shaft and this shaft shall be identified by the symbol M_1;

K_i ($i = 1, 2, \ldots n$) is a constant determined from $K_i = C_1/C_i$;

M_i ($i = 1, 2 \ldots n$) is the torque applied to the drive shaft identified by the symbol M_i;

C_i ($i = 1, 2 \ldots n$) is the constant for the drive shaft identified by the symbol M_i.

Expression (1) shall appear on the meter in accordance with item h) of **8.1**.

4.13.2 *Electrical outputs.* If a meter incorporates integral pulse generators or electrical switches, there shall be marked on the meter, adjacent to the electrical output connection, an indication of the value of the pulse, i.e. either:

"1 pulse = x m^3 or y ft^3"

or

"1 m^3 or 1 ft^3 = z pulses"

where x, y and z are numbers.

NOTE When electrical equipment is used in association with meters in hazardous areas, reference should be made to BS 5345.

4.14 Pressure test points

4.14.1 *General.* Pressure test points or tappings provided in the meter shall be furnished with a suitable means of closure, e.g. a plug, capable of being sealed against unauthorized interference.

The pressure tapping for the reference pressure shall be clearly and indelibly marked "pr" and the other pressure tappings "p".

4.14.2 *Rotary displacement meters.* Meters shall incorporate both inlet and outlet static pressure tappings for measuring the pressure absorption. The inlet pressure shall constitute the reference pressure.

4.14.3 *Turbine meters.* The meters shall incorporate a pressure tapping permitting, if necessary indirectly, the determination of the pressure immediately upstream of the turbine wheel as a reference pressure.

4.14.4 *Circular tappings.* The tapping shall be a circular cylinder with a length of at least 2.5 times the bore diameter, measured from the inner surface of the meter gasway. The bore diameter shall be not less than 3 mm.

NOTE The cross-sectional area should not exceed 80 mm^2.

4.14.5 *Slit tappings.* Pressure tappings of slit shaped section shall have a minimum dimension of 2 mm in the direction of flow through the meter gasway and a minimum cross-sectional area of 10 mm^2. The tapping shall have a length of at least 2.5 times the major slit dimension, measured from the inner surface of the meter gasway.

NOTE The cross-sectional area should not exceed 80 mm^2.

4.15 Sealing glands

4.15.1 *General.* Where sealing glands are used, a sample seal shall comply with **4.15.2** and **4.15.3**, when housed and tested as used in the meter.

4.15.2 *Chemical resistance.* A sample seal shall resist chemical attack by any of the constituents of the gas with which the meter is intended to be used.

Constrain the sample seal in a manner identical to its fixing in the meter and suspend it for not less than 100 h in an atmosphere fully saturated with the constituent[5)] being considered. At the end of this test the sample seal shall not exhibit any change that would affect the performance of the meter for which it is intended.

4.15.3 *Wear resistance.* The sample seal shall not show signs of deterioration or permanent deformation after it has been subjected to the number of revolutions that are equivalent to 1 000 h of operation at full throughput.

5 Strength and leakage testing

5.1 Casing strength

After machining, the complete casing shall be pressure tested to comply with **4.5.2**, subject to the components being mounted for test such that they are stressed in a manner representative of final assembly.

5.2 Leakage

The completely assembled gas containing parts of the meter shall be pneumatically tested for external leakage to a pressure 1.1 times the maximum working pressure, which shall be maintained for 10 min with no detectable leakage. The test pressure shall be increased at a rate not exceeding 350 mbar/s.

6 Performance

6.1 Accuracy

6.1.1 When measured in accordance with Appendix B, the accuracy of the meter as tested when using the meter index shall be within ± 2 % of the actual volume, from Q_{min} to $0.2Q_{max}$ for rotary displacement meters and for turbine meters of types 20 and 10, when Q_{min} is less than 0.2 Q_{max}, and within ± 1.0 % from $0.2Q_{max}$ to Q_{max} for all meters.

NOTE **B.3.3** applies only to Roots type meters.

When the maximum torques indicated on the meter (see **4.13.1**) are applied to the drive shafts, the indication of the meter at Q_{min} shall not vary by more than the values given in Table 2.

6.1.2 The calibration curve from Q_{min} to Q_{max} shall be not entirely within the upper or the lower quartile of the tolerance band.

5) Toluene/heptane mixture for gas containing aromatic/aliphatic hydrocarbons and pentane for liquefied petroleum gases.

6.2 Starting resistance in rotary displacement meters

The flow at which the meter begins to operate shall be not more than 1% of Q_{max}.

Table 2 — Variations in indication of meter at Q_{min}

Q_{min}	Variations in indications at Q_{min}
	%
$0.05Q_{max}$	1
$0.1Q_{max}$	0.5
$0.2Q_{max}$	0.25

7 Instructions for installation and maintenance

Installation and maintenance instructions, including those for routine checks, shall be provided by the manufacturer.

The viscosity classification of liquid lubricants to be used shall be stated, in accordance with the grade designations in BS 4231, for the meter operating temperature range declared by the manufacturer.

8 Marking

8.1 Inscriptions

Each meter shall bear the following permanent inscriptions, either on the dial or on a special data plate or divided between the two in such a way that there is no modification to any pressurized part of the meter (see **5.1**):

a) the name of the meter manufacturer and, if different, the supplier;

b) the serial number and year of manufacture;

c) Q_{max} in m^3/h or ft^3/h (see **3.1**);

d) Q_{min} in m^3/h or ft^3/h (see **3.1**);

e) the maximum working pressure in bar (see **3.2**);

f) the nominal cyclic volume in dm^3 or ft^3 (rotary displacement meters only);

g) the lubricant classification where necessary (see clause **7**);

h) any inscriptions required by **4.13.1** and/or **4.13.2**;

i) the range of densities for which the calibration is valid, where a meter is calibrated at other than a test density of 1.2 kg/m^3;

j) the number of this British Standard, i.e. BS 4161-6:1987[6)].

8.2 Inscription for meters of over 7 bar working pressure

A separate nameplate shall be supplied in accordance with **4.5.2.3**.

8.3 Direction of flow

The direction of flow shall be clearly and permanently indicated on the meter. On meters for horizontal flow the normal direction of flow when looking at the meter index shall be from left to right.

9 Preparation for despatch

After inspection and before preparation for despatch, each meter shall be dried and cleaned.

NOTE 1 Painting of a finished meter is optional to the manufacturer unless otherwise specified by the purchaser (see item k) of Appendix A).

Meter openings shall be covered to exclude dirt and other foreign matter from the interior of the meter. Threaded and machined surfaces shall be well covered with a rust-preventative.

NOTE 2 A meter shall be prepared for despatch in such a way as to minimize the possibility of damage to inside or outside parts during storage or in transit.

Faces of flanges and exposed connection threads shall be protected over their entire surface.

NOTE 3 The type of protector and method of attachment should be approved by the purchaser.

[6)] Marking BS 4161-6:1987 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.

Appendix A Information to be supplied by the purchaser

In any enquiry or order or both, the purchaser should provide the following information in writing:

a) meter rating and type (see clause **3**);

b) type of index (m^3 or ft^3) (see **4.12**);

c) maximum and minimum working pressure (mbar, bar as appropriate) (see **3.2**);

d) type and size of connection (mm or in) (see **4.6** and **4.7**);

e) the gas for which the meter is required;

f) any special requirements, e.g. for an escapes badge, quality control requirements, material certification;

g) maximum and minimum operating temperature;

h) the number of this standard, i.e. BS 4161-6;

i) output requirements (see **4.13**);

j) notification, if appropriate, that materials are to be inspected and tested in the presence of the purchaser's representative;

k) any painting or protective coating requirements (see clause **9** and **4.5.3**).

Appendix B Testing for accuracy

NOTE See **6.1.1**.

B.1 General

The accuracy test can be done directly either by passing air through a reference meter and the meter under test in series or by using a calibrated holder. If the meter under test is too large to be tested directly in series with a reference meter, it can be tested indirectly by storing the air passing through the meter under test in an inflatable holder before passing this air through a reference meter.

Where the capacity of the meter under test is such that these methods cannot be applied at Q_{max}, one of the methods is used up to the flow rate at which the slip of the meter under test is stabilized. For rotary displacement meters, the slips at other points over this rate and up to Q_{max} are determined by either the hand slip or the blocking method, and are used to complete the calibration of the meter under test.

B.2 Apparatus

Any reference meter or calibrated holder shall have been calibrated, and such a calibration shall be traceable to a reference standard of, for example, the Department of Energy or the National Physical Laboratory.

For the indirect method the inflatable holder can be an impervious bag which can be completely emptied of air, and the reference meter can be of any convenient size, provided that it has been calibrated accurately at one or more convenient flow rates.

The test apparatus shall be capable of measuring volumes to within an accuracy of ± 0.25 %.

NOTE When testing turbine meters, flow straighteners or a sufficient length of pipe upstream and downstream of turbine meters should be incorporated in the test rig to ensure that the velocity profiles at the inlets of turbine meters are properly developed and free from swirl. The flow should also be free from pulsations.

Before any accuracy test, prove the test apparatus for soundness. The temperature of the air passing through both the meter under test and reference meter, or from the calibrated holder, shall not vary during the test by more than 1 °C.

Note the pressure of the air at the inlet of both the meter under test and the reference meter, or in the calibrated holder, and use it, if necessary, to correct the volume of air passed to the pressure at the inlet of the reference meter. The pressure at each inlet, or in the calibrated holder, shall not vary during the test by more than 0.5 mbar.

B.3 Methods

B.3.1 *Direct methods*

Pass air at a density of 1.2 kg/m^3 at various flow rates (termed calibration points) either through the reference meter or from a calibrated holder, and then in series through the meter under test. Note and record the differential pressure at each calibration point, together with the temperature. Note the volume passed through the reference meter, or from the calibrated holder, at each calibration point; correct it if necessary, and compare it with that recorded on the index of the meter under test.

NOTE It should be noted that in some cases resonance can be set up at certain points between two meters in series.
If this occurs at calibration points, the following steps may have to be taken to deal with it.

a) Use a reference meter of different design or capacity for part or all of the test range.

b) Use calibration points above and below the point of resonance; determine the calibration at intermediate points by interpolation.

c) Interpose a capacity or baffle drum or other device between the two meters.

B.3.2 ***Indirect method***

Pass air at a density of 1.2 kg/m^3 through the meter under test until equilibrium conditions are attained at the desired flow rate (calibration point). Then switch the flow to the empty inflatable holder. After a timed period, switch the flow from the holder. Then pass the contents of the holder through the reference meter at the rate at which it was calibrated. Note the volume passed through the reference meter, correct it if necessary, and compare it with the volume fed into the holder, as recorded on the index of the meter under test.

B.3.3 ***Slip methods***

NOTE These are applicable to Roots type meters only.

B.3.3.1 *General.* Determine the slip at the maximum flow rate used in **B.3.1**. Then determine the slips at this and other flow rates up to Q_{max} of the meter under test, in accordance with **B.3.3.2** or **B.3.3.3**. To achieve this, first determine experimentally the differential pressure across the meter at the maximum flow obtained in **B.3.1** and at each other flow rate (calibration point) up to Q_{max} of the meter under test.

B.3.3.2 *Hand slip method.* Employ the hand slip method if the meter under test can be rotated by external means. Rotate the meter mechanism by hand or other means with its inlet and/or outlet closed, at speeds which give the differential pressures determined as in **B.3.3.1**. Note the speed of rotation at each differential pressure. Calculate the slip at each of these points from the known (calculated) volumetric displacement of the meter. Take the slip so determined to be the static slip when the meter is substantially stationary. For the purposes of calibration, take the dynamic slip at operating speeds as half of the static slip.

B.3.3.3 *Blocking method.* If the meter cannot be rotated by external means, determine the slip by blocking the meter with the major axes of the impeller profiles at right angles to each other. Pass air through the meter, and measure the slip, using another calibration meter, at differential pressures corresponding to those produced by the meter when operating at the calibration point as in **B.3.3.1**.

Rotate the impellers forward through 45°, block them again and repeat the test. Continue this sequence until the meter has been tested with the impellers in eight positions.

Average the results. For the purposes of calibration, take the average slip so determined as the static slip. Take the dynamic slip at operating speeds as half of the static slip.

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Publications referred to

BS 21, *Specification for pipe threads for tubes and fittings where pressure-tight joints are made on the threads (metric dimensions).*

BS 1179, *Glossary of terms used in the gas industry.*

BS 1452, *Specification for grey iron castings.*

BS 1470, *Specification for wrought aluminium and aluminium alloys for general engineering purposes: plate, sheet and strip.*

BS 1472, *Specification for wrought aluminium and aluminium alloys for general engineering purposes. Forging stock and forgings.*

BS 1474, *Specification for wrought aluminium and aluminium alloys for general engineering purposes: bars, extruded round tubes and sections.*

BS 1490, *Specification for aluminium and aluminium alloy ingots and castings.*

BS 1501, *Specification for steels for fired and unfired pressure vessels. Plates.*

BS 1503, *Specification for steel forgings (including semi-finished forged products) for pressure purposes.*

BS 1504, *Specification for steel castings for pressure purposes.*

BS 1560, *Specification for steel pipe flanges (nominal size ½ in to 24 in) for the petroleum industry.*

BS 1560-2, *Metric dimensions.*

BS 2782, *Methods of testing plastics.*

BS 2782:Method 140E, *Flammability of a small, inclined test piece exposed to an ethanol flame (laboratory method).*

BS 2789, *Specification for spheroidal graphite or nodular graphite cast iron.*

BS 3293, *Specification for carbon steel pipe flanges (over 24 inches nominal size) for the petroleum industry.*

BS 3600, *Specification for dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes.*

BS 4161, *Gas meters*[7)].

BS 4161-1, *Meters of plate construction up to 1 000 cubic feet per hour rating (obsolescent).*

BS 4161-2, *Meters of plate construction above 1 000 cubic feet (28 cubic metres) per hour rating (obsolescent).*

BS 4161-3, *Unit construction meters of 6 cubic metres (or 212 cubic feet) per hour rating.*

BS 4161-4, *Plate constructed positive displacement diaphragm meters for a pressure of 350 mbar (5 lb/in^2) and up to 170 cubic metres (6 000 cubic feet) per hour rating (obsolescent).*

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

BS 4161-7, *Mechanical volume correctors.*

BS 4161-8, *Specification for electronic volume correctors.*

BS 4231, *Classification for viscosity grades for industrial liquid lubricants.*

BS 4504, *Specification for flanges and bolting for pipes, valves and fittings. Metric series.*

BS 4504-1, *Ferrous.*

BS 5150, *Specification for cast iron wedge and double disk gate valves for general purposes.*

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 5500, *Specification for unfired fusion welded pressure vessels.*

BS 6400, *Specification for installation of domestic gas meters (2nd family gases).*

ASTM A105, *Forgings, carbon steel, for piping components.*

[7)] Referred to in the foreword only.

ASTM A216, *Specification for carbon-steel casting suitable for fusion welding for high-temperature service.*
ASTM A352, *Specification for ferritic steel castings for pressure-containing parts suitable for low-temperature service.*
Recommendations on gas measurement practice IGE/GM/1 Installation of high-pressure gas meters[8)].

[8)] Published by the Institution of Gas Engineers, 17 Grosvenor Crescent, London SW1 7GSO.

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