

Measurement of flow of cold potable water in closed conduits —

**Part 3: Methods for determining
principal characteristics of single
mechanical water meters (including
test equipment)**

ICS 17.120.10

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

BSI
Documents

AVA

Document Sharing Hub

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee CPL/30, Measurement of fluid flow in closed conduits, upon which the following bodies were represented:

- British Compressed Air Society
- British Gas plc
- National Engineering Laboratory
- DTI — Gas and Oil Measuring Branch
- Electricity Association
- Energy Industries Council
- Engineering Equipment and Materials Users Association
- GAMBICA (BEAMA) Ltd.
- Institute of Measurement and Control
- Institute of Petroleum
- Institute of Trading Standards Administration
- Institution of Gas Engineers
- Institution of Mechanical Engineers
- Petrol Pump Manufacturers Association
- Society of British Gas Industries
- Water Services Association of England and Wales

The following bodies were also represented in the drafting of the standard through subcommittees and panels:

- Society of British Water Industries
- United Kingdom Automatic Meter Reading Association
- Water Research Centre

This British Standard, having been prepared under the direction of the Electrotechnical Sector Board, was published under the authority of the Standards Board and comes into effect on 15 October 1997

© BSI 10-1999

First published May 1984
Second edition October 1997

The following BSI references relate to the work on this standard:
Committee reference CPL/30
Draft for comment 95/210206 DC

ISBN 0 580 28320 8

Amendments issued since publication

Amd. No.	Date	Comments

Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
1 Scope	1
2 Normative references	1
3 Definitions	1
4 General considerations affecting all tests	1
5 Measurement error tests	2
6 Pressure tests	5
7 Pressure loss tests	8
8 Accelerated wear tests	16
9 Test report	17
Annex A (informative) Summary of requirements and permitted tolerances in the measurement of physical quantities associated with water meter test methods and equipment	20
Figure 1 — Pressure test manifold for concentric meters	6
Figure 2 — Example of plug for pressure test of concentric meters	7
Figure 3 — Layout of measuring section	8
Figure 4 — Example of drilled hole type of pressure tapping with ring chamber, suitable for small/medium diameter test sections	9
Figure 5 — Example of drilled hole type of pressure tapping with loop mean static pressure interconnections, suitable for medium/large diameter test sections	10
Figure 6 — Example of slit type of pressure tapping with ring chamber, suitable for small/medium diameter test sections	11
Figure 7 — Manifold caps	12
Figure 8 — Pressure loss measurement test procedure (in-line meters)	14
Figure 9 — Pressure loss measurement test procedure (concentric type meters)	15
Table 1 — Number of meters to be tested	1
Table 2 — Test programme for an accelerated wear test	17
Table 3 — Test procedure and test results. Information required	19
Table 4 — Test conclusions. Information required	19
Table A.1 — Summary of requirements and permitted tolerances	20
List of references	Inside back cover

Foreword

This Part of BS 5728 has been prepared by Technical Committee CPL/30. It supersedes BS 5728-3:1984 which is withdrawn.

This revision of BS 5728-3 was prepared in order to bring the techniques and equipment described up to date. Also, the scope has been extended to incorporate the testing of concentric meters, in addition to in-line meters.

The other Parts of BS 5728 on the measurement of flow of cold potable water, are as follows:

- *Part 1: Specification for single meters;*
- *Part 2: Specification for installation requirements for single meters;*
- *Part 4: Specification for combination meters;*
- *Part 5: Specification for installation requirements for combination meters;*
- *Part 6: Test methods for combination meters;*
- *Part 7: Specification for single mechanical type meters.*

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, and inside front cover, pages i and ii, pages 1 to 20, 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.

1 Scope

This Part of BS 5728 gives methods of test for single mechanical water meters conforming to BS 5728-7.

2 Normative references

This Part of BS 5728 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this Part of BS 5728 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

3 Definitions

For the purposes of this Part of BS 5728, the definitions given in BS 5728-7:1997 apply, together with the following.

3.1 measurement error

the difference between the indicated value of the volume and the conventional true value of the volume of water passed through the meter during a test

NOTE 1 Measurement errors are conventionally expressed as relative errors, calculated as a percentage, and equal to:

$$\frac{V_i - V_c}{V_c} \times 100$$

where

V_c is the value accepted as true of the volume passed;

V_i is the volume indicated by the water meter at the time of measurement of the same volume, both expressed in the same units.

NOTE 2 The values for maximum permissible errors (MPE) are specified in 5.1 of BS 5728-7:1997.

3.2 test flow-rate

the mean rate of flow of water through the meter under test during the period of a test

NOTE The test flow-rate is usually measured and indicated by a calibrated reference device (see 5.2 and 5.4).

4 General considerations affecting all tests

4.1 Test programme

NOTE Water meters are subject to a variety of different test programmes. For the purposes of pattern approval and initial verification, water meters are covered by the requirements of EC Directive 75/33/EEC of 17 November 1974.

4.1.1 Written test programme

Before starting testing, a written test programme shall be compiled, and shall include a description of the tests for the determination of measurement error, pressure loss and wear resistance.

4.1.2 Pattern approval

NOTE Pattern approval consists of verifying that the characteristics of one model of meter conform to the standards and regulations in force. This consequently requires that samples of the model fulfil the requirements of the test programme.

4.1.2.1 Number of meters to be tested

The pattern approval tests shall be carried out on a minimum number of water meters of each model as given in Table 1 as a function of the meter designation of the model submitted.

Table 1 — Number of meters to be tested

Meter designation	Number of meters
$N \leq 100$	3
$100 < N \leq 1\,000$	2
$1\,000 < N$	1

NOTE The number of water meters in Table 1 may be regarded as the minimum to be tested; the authority responsible for pattern approval may request additional water meters.

4.1.2.2 Pattern approval tests

Before tests commence, each water meter and accompanying certificates shall be inspected to check that the meter conforms to the regulations in force, and also to the specifications (e.g. model, identification, size and material) and drawings submitted when approval was requested.

The tests shall include the following, carried out in the order indicated:

- pressure tests (see 6.4);
- determination of the error curves as a function of flow-rate (see 5.9);
- pressure loss tests (see 7.5);
- accelerated wear tests (see 8.3).

4.1.3 Initial verification

NOTE Initial verification consists in verifying that all the water meters submitted conform to the approved model and to the standards and regulations in force. The initial verification programme may authorize total or partial statistical control procedures.

4.1.3.1 Check for conformity to the approved model

The meters shall be inspected to check that they have the same technical characteristics (dimensions of the constituent parts, materials, surface finish, etc.) as the approved model.

NOTE This check is normally carried out by sampling.

4.1.3.2 Initial verification tests

Initial verification tests shall include at least the following:

- a) in principle, on all meters:
 - pressure tests (see 6.5);
 - determination of the measurement errors (see 5.10);
- b) normally, by sampling, as required by the inspector:
 - a check that the meter conforms to the approved pattern (see 4.1.2.2);
 - pressure loss measurement (see 7.6).

4.2 Water quality

Water meter tests shall be made with water. The water shall be that of the public potable water supply or shall meet the same requirements. If water is being recycled, measures shall be taken to prevent residual water in the meter from becoming harmful to human beings.

The inclusion of air bubbles shall be avoided by the provision of suitably placed air bleeds in the test rigs (see 5.3.1 and 5.3.3) and particles of size greater than 100 µm shall be eliminated from the water by appropriate filtration.

4.3 Test rigs and their location

4.3.1 Freedom from spurious influences

Test rigs shall be so designed, constructed and used that the performance of the rig itself does not introduce significant errors into the measurement. To this end, high standards of rig maintenance and adequate supports and fittings, preventing vibration of the meter, the test rig and its accessories, shall be observed.

It shall be possible to perform tests rapidly and easily.

4.3.2 Group testing of meters

For the purposes of some tests, meters may be tested individually or in groups, depending on the purposes of the tests. When meters are tested in groups, the individual characteristics of each individual meter shall be precisely determined. Interaction between meters, and between test rigs, shall be eliminated by the use of suitable installation practices.

When meters are tested in series, the pressure at the outlet of each shall be sufficient to prevent cavitation.

4.3.3 Temperature of the water during the tests

The temperature of the water in the test section of the test rig shall be between 0 °C and 30 °C during a test. In no part of the test rig shall the temperature fall below 0 °C during a test.

NOTE Within this temperature range, temperature correction of the results is not required.

4.3.4 Location

The test rig shall be isolated from any other activity (for example, manufacture, repairs) and from environmental disturbances (for example, fluctuations in ambient temperature, vibration).

5 Measurement error tests

NOTE The method described in this Part of BS 5728 to determine measurement errors is the so-called “collection” method, in which the quantity of water passed through the water meter is collected in one or more collecting vessels, and the quantity determined volumetrically or by weighing. Other methods may be used, provided the accuracy levels stated in this Part of BS 5728 are attained.

5.1 Outline of test method

The checking of the measurement error consists of comparing the indications given by the meter under test against a calibrated reference device.

5.2 Description of the test rig

The test rig shall include:

- a) a water supply (mains, non-pressurized tank, pressurized tank, pump, etc.);
- b) pipework (see 5.3);
- c) a calibrated reference device (calibrated tank, reference meter, etc.) (see 5.4);
- d) means for measuring the duration of the test.

NOTE Devices for automating the testing of water meters are permissible.

5.3 Pipework

5.3.1 Description

Pipework shall include:

- a) a test section in which the meter(s) is (are) placed;
- b) means to establish the desired flow-rate;
- c) one or two isolating devices;
- d) means for determining the flow-rate; and, if necessary:
- e) one or more air bleeds;
- f) a non-return device;
- g) an air separator;
- h) a filter.

During the test, flow leakage, flow input and flow drainage shall not occur either between the meter(s) and the reference device or from the reference device.

The pipework shall be such that in the upper part of the meter a positive pressure exists of at least 0.05 bar (5 kPa) even at zero flow-rate.

5.3.2 Test section

The test section shall include, in addition to the meter(s):

- a) one or more pressure tapings for the measurement of pressure, of which one pressure tapping shall be situated upstream of, and close to, the (first) meter;
- b) if necessary, means for measuring the temperature of the water at the inlet of the (first) meter.

The different devices placed in the measuring section shall not cause cavitation or flow disturbances capable of altering the performance of the meters or causing measurement errors.

5.3.3 Precautions to be taken during tests

Make sure that there is no leakage in the pipework or fittings between the meter under test and the calibrated reference device.

Check that pipes (for example the swan neck in the outlet pipe) are filled to the same extent at the beginning and at the end of the test.

Bleed any air from the interconnecting pipework and the meter(s) (see 4.2).

Take precautions to avoid the effects of vibration and shock (see 4.3.4).

5.3.4 Installation of meter on test into the test rig

NOTE Volumetric water meters (that is, involving measuring chambers with mobile walls), such as oscillating piston meters, are considered insensitive to upstream installation conditions; hence no special recommendations are given for these types of meter.

5.3.4.1 Summary of test installation requirements

The meter on test shall be installed into the test rig such that:

- a) the hydrodynamic flow characteristics immediately upstream and downstream of the meter cause no discernible difference to the performance of the meter when compared with its performance under undisturbed conditions;
- b) the overall error of the method employed does not exceed the stipulated value (see 5.4.1).

5.3.4.2 Need for straight lengths of pipe or a flow straightener

NOTE 1 The accuracy of the water meter can be affected by upstream disturbance caused for example by the presence of bends, tees, valves or pumps.

NOTE 2 Certain velocity type water meters are sensitive to flow disturbance which can cause significant errors, but the way installation conditions affect their accuracy has not yet been clearly determined. It is simply recommended to avoid, as far as possible, the presence of bends, pumps, taper pieces and changes in diameter of pipework immediately upstream, and to position the meter to afford the maximum possible straight length of pipe upstream and downstream.

In order to counteract these effects, the meter shall be installed for test in a straight length of pipe. The connecting pipework shall have the same internal diameter as the bore of the meter inlet.

NOTE 3 It may also be necessary to put a flow straightener upstream of the straight length.

5.3.4.3 Common causes of flow disturbance

Flow can be subject to two types of disturbance: velocity profile distortion and swirl, both of which affect the accuracy of the water meter.

Velocity profile distortion is typically caused by an obstruction partially blocking the pipe, for instance the presence of a partly closed valve or a misaligned flange joint. This can easily be eliminated by removal of the obstruction or by opening the valve.

Swirl is caused mainly by two or more bends in different planes. This effect can be controlled either by ensuring an adequate length of straight pipe upstream of the water meter, or by installing a straightening device, or by a combination of the two.

5.3.5 Test commencement and termination errors

5.3.5.1 Principle

The magnitude of errors occurring at the beginning and end of a test, due to changing flow-rates, meter inertia, and timing errors are established and then reduced to a practical minimum.

5.3.5.2 Effects of meter inertia

Adequate precautions shall be taken to reduce the uncertainties resulting from the operation of the test rig components during the test.

NOTE Whilst flow is beginning and during the period of running at the specified constant flow-rate, the measurement error of the meter varies as a function of the changes in flow-rate (measurement error curve). Whilst flow is being stopped, the combination of inertia of the moving parts of the meter and the rotational movements of the water inside the meter may cause an appreciable error to be introduced in certain types of meter and for certain test flow-rates.

It has not been possible, in this case, to determine a simple empirical rule which lays down conditions so that this error may be discounted as negligible.

In case of doubt, it is advisable:

- a) to increase the volume and duration of the test;
- b) to compare the results with those obtained by one or more other methods, and in particular the method described in 5.5.2, which eliminates the causes of uncertainty given in the note.

Errors due to meter inertia may be assessed by procedure b), and may be minimized by procedure a).

5.4 Calibrated reference device

5.4.1 Overall error of the method employed

For pattern approval and initial verification, the total error in the method used for the determination of the volume of water passed through the water meter shall not exceed 1/10 of the relevant maximum permissible error.

5.4.2 Minimum volume of the calibrated vessel

Where a calibrated volumetric vessel is used, the minimum volume permitted depends on requirements determined by the test start and end effects and the design of the indicating device (verification scale division) (see BS 5728-7) of the meter under test.

5.5 Test methods

5.5.1 Standing start/stop test method

The flow is established by opening a valve, preferably situated downstream of the meter, and it is stopped by the closure of this valve. The meter is read whilst completely stationary.

Time is measured between the beginning of the movement of the valve at opening and at the beginning of closure.

5.5.2 Flow diversion method

The measurement is carried out when the flow conditions have stabilized.

A flow diverter switches the flow into a calibrated vessel at the beginning of the measurement and diverts it away at the end. The meter is read in motion.

The reading of the meter is synchronized with the movement of the flow diverter.

The volume collected in the vessel is the volume passed.

NOTE The volume collected may be determined by measuring its mass and converting this to volume from a knowledge of the water density.

The uncertainty introduced into the volumes measured shall be considered to be negligible if the time of motion of the flow diverter in each direction is identical within 5 % and if each time is not less than 1/50 of the total duration of the test.

5.6 Precautions to be taken when reading a meter

NOTE The maximum reading error of a scale does not exceed half a scale division per observation. Thus in the measurement of a volume of flow delivered by a water meter (consisting of two observations of the water meter) the total reading error can reach one scale division or, in the case of discontinuous movement of the control element, 2 digits.

During measurement error testing, the volume to be passed shall be chosen to be sufficiently large, so that the maximum error in the reading of the volume indicated by the meter does not exceed 0.5 % (see 4.5.4 of BS 5728-7:1997).

In the reading of a meter having circular scales with pointers, in order to avoid errors due to eccentricity or uneven scale graduations, the volume to be passed shall be chosen such that whole revolutions of the pointer or scale are used.

5.7 Major factors affecting measurement error checks

NOTE Variations in the pressure, flow-rate, and temperature in the test rig, and uncertainties in the precision of measurement of these physical quantities, are the principal factors affecting the measurement error test results.

5.7.1 Pressure

The pressure shall be maintained at a constant value throughout the test at the chosen flow-rate.

For testing water meters of N10 or smaller, at test flow-rates $\leq 1 \text{ m}^3/\text{h}$, constant pressure at the inlet of the meter (or at the inlet of the first meter of a series being tested) can be achieved if the test rig is supplied through a pipe from a constant head tank.

Any other methods of supply which can be shown not to cause pressure pulsations exceeding those of a constant head tank may be used.

For all other tests the pressure upstream of the meter shall not vary by more than 10 %.

The maximum uncertainty in the measurement of pressure shall be 5 % of the measured value. Pressure at the inlet to the meter shall not exceed the nominal pressure for the meter.

5.7.2 Flow-rate

The flow-rate shall be maintained constant throughout the test at the chosen value.

The relative variation in the flow-rate during each test (not including starting and stopping) shall not exceed:

- $\pm 2.5 \%$ from $q_{\min}$ to q_t (not inclusive);
- $\pm 5.0 \%$ from q_t (inclusive) to q_s .

The flow-rate value used in plotting the error curve shall be the volume passed during the test divided by the duration of the test.

The relative pressure variation (in flow to free air) or the relative variation in pressure loss (in closed circuits) shall not exceed:

- $\pm 5 \%$ from $q_{\min}$ to q_t (not inclusive);
- $\pm 10 \%$ from q_t (inclusive) to q_s .

5.7.3 Temperature

During a test the temperature of the water shall not change by more than 5 °C.