

Measurement of

Liquid flow in closed conduits using weighing and volumetric methods —

Part 1: Weighing method —

Section 1.2 Procedures for checking
static weighing systems

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Industrial-process Measurement and Control Standards Policy Committee (PCL/-) to Technical Committee PCL/2, upon which the following bodies were represented:

- British Compressed Air Society
- British Gas plc
- Department of Energy (Gas and Oil Measurement Branch)
- Department of Trade and Industry (National Engineering Laboratory)
- Electricity Industry in United Kingdom
- Energy Industries Council
- GAMBICA (BEAMA Ltd.)
- Institute of Measurement and Control
- Institute of Petroleum
- Institute of Trading Standards Administration
- Institution of Gas Engineers
- Institution of Mechanical Engineers
- Society of British Gas Industries
- Water Services Association of England and Wales

The following body was also represented in the drafting of the standard, through subcommittees and panels:

University of Surrey

This British Standard, having been prepared under the direction of the Industrial-process Measurement and Control Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 31 October 1991

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The following BSI references relate to the work on this standard:
Committee reference PCL/2
Draft for comment 89/20801 DC

ISBN 0 580 20133 3

Amendments issued since publication

Amd. No.	Date	Comments

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National foreword

This Section of BS 6199 has been prepared under the direction of the Industrial-process Measurement and Control Standards Policy Committee. It is identical with ISO 9368-1:1990 “*Measurement of liquid flow in closed conduits by the weighing method — Procedures for checking installations — Part 1: Static weighing systems*”, published by the International Organization for Standardization (ISO).

This is Section 1.2 of a series of Parts and Sections of BS 6199 on weighing and volumetric methods, as follows.

— *Part 1: Weighing method;*

(It is intended to renumber Part 1 as Section 1.1 when it is next reviewed.)

— *Part 2: Method for measurement by collection of the liquid in a volumetric tank.*

It is envisaged that a further Part of BS 6199 will be published in due course that will be identical with ISO 9368-2 “*Measurement of liquid flow in closed conduits by the weighing method — Procedures for checking installations — Dynamic weighing methods*”.

Cross-references

International Standard	Corresponding British Standard
ISO 3354:1988	BS 1042 <i>Measurement of fluid flow in closed conduits</i> Section 2.4:1989 <i>Method of measurement of clean water flow using current meters in full conduits and under regular flow conditions</i> (Identical)
ISO 3966:1977	Section 2.1:1983 <i>Method using Pitot static tubes</i> (Identical)
ISO 4006:1991 ^a	BS 5875:1991 <i>Glossary of terms and symbols for measurement of fluid flow in closed conduits</i> (Identical)
ISO 4185:1980	BS 6199 <i>Measurement of liquid flow in closed conduits using weighing and volumetric methods</i> Part 1:1981 <i>Weighing method</i> (Identical)
ISO 5168:1978	BS 5844:1980 <i>Methods of measurement of fluid flow: estimation of uncertainty of a flow-rate measurement</i> (Identical) BS 7118 <i>Measurement of fluid flow: assessment of uncertainty in the calibration and use of flow measurement devices</i>
ISO 7066-1:1989	Part 1:1990 <i>Linear calibration relationships</i> (Identical)
ISO 7066-2:1988	Part 2:1989 <i>Non-linear calibration relationships</i> (Identical)
ISO 7194:1983	BS 1042 <i>Measurement of fluid flow in closed conduits</i> Section 2.3:1984 <i>Methods of flow measurement in swirling or asymmetric flow conditions in circular ducts by means of current-meters or Pitot static tubes</i> (Identical)
ISO 7278-3:1986	BS 6866 <i>Proving systems for meters used in dynamic measurement of liquid hydrocarbons</i> Part 3: 1987 <i>Methods for pulse interpolation</i> (Identical)

^a The reference in the text is to an undated standard which has now been published.

The Technical Committee has reviewed the provisions of OIML International Recommendation 33, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

There is no related British Standard to OIML International Recommendation 33. 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 16, 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.

Introduction

The weighing method of liquid flowrate measurement, as described in ISO 4185, is one of the basic methods of measurement, it is widely used in hydraulic research, in the testing of pumps and turbines and for flowmeter calibration.

To obtain comparative results when such measurements are carried out in various installations, it is necessary to standardize the procedures for carrying out the measurements and the tests.

1 Scope

This part of ISO 9368 specifies methods of testing installations for flowrate measurement by the static weighing method. Methods of testing by dynamic weighing are given in ISO 9368-2.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 9368. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9368 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 4006:—, *Measurement of fluid flow in closed conduits — Vocabulary and symbols*¹⁾.

ISO 4185:1980, *Measurement of liquid flow in closed conduits — Weighing method*.

ISO 5168:1978, *Measurement of fluid flow — Estimation of uncertainty of a flow-rate measurement*.

OIML — International Recommendation 33:1973, *Conventional values of the result of weighing in air*.

3 Definitions and symbols

3.1 Definitions

For the purposes of this part of ISO 9368, the definitions given in ISO 4006 apply.

3.2 Symbols

The symbols used in this part of ISO 9368 are given in Table 1.

Table 1 — Symbols

Symbol	Quantity	Dimension ^a	SI unit
E_R	Random uncertainty, relative value	Dimensionless	—
e_R	Random uncertainty, absolute value	^b	^b
E_s	Systematic uncertainty, relative value	Dimensionless	—
e_s	Systematic uncertainty, absolute value	^b	^b
m	Mass	M	kg
q_v	Volumetric flowrate	$L^3 T^{-1}$	m^3/s
q_m	Mass flowrate	$M T^{-1}$	kg/s
S	Standard deviation, relative value	dimensionless	—
s	Standard deviation, absolute value	^b	^b
t	Time	T	s
V	Volume	L^3	m^3
ρ	Liquid density	$M L^{-3}$	kg/m^3

^a M = mass; L = length; T = time.
^b The dimensions and units are those of the quantity for which the uncertainty is stated.

4 Certification

If the installation for flowrate measurement by the weighing method is used for purposes of legal metrology, it shall be certified and registered by the national metrology service. Such installations are then subject to periodic inspection at stated intervals, if a national metrology service does not exist, a certified record of the basic measurement standards (length, mass, time and temperature), and error analysis in accordance with this part of ISO 9368 and ISO 5168, may also constitute certification for legal metrology purposes.

The person responsible for carrying out the checks shall evaluate the results in accordance with this part of ISO 9368 and shall issue and sign a written report on the results.

¹⁾ To be published. (Revision of ISO 4006:1977.)

5 General principles

5.1 Main items of installation

Static weighing installations generally comprise the following main items:

- sump,
- test section,
- diverter,
- weight tank,
- weighing device,
- receiving tank,
- timer,
- one or more pumps.

The requirements for these main items are specified in ISO 4185.

5.2 Test liquid

Clean water is generally used as the test liquid when verifying installations for flowrate measurement by the weighing method.

Other liquids may be employed provided that the liquid vapour pressure is low enough to make vaporization effects negligible. For practical reasons (particularly to limit the drainage time of the weight tank) it is recommended that the kinematic viscosity of the liquid does not exceed about $35 \times 10^{-6} \text{ m}^2/\text{s}$.

5.3 Principle of verification

Following the construction of a system, tests are carried out to assess the systematic and random errors.

Further tests are conducted at regularly established intervals to determine the errors and to compare them with the previous results to determine the required intervals between successive checks.

The general principle of the verification of flow calibration systems is to check separately the errors for each item of the installation and to combine them to determine the overall uncertainty of the whole installation.

ISO 4185:1980, subclause 6.2, covers methods for assessing the weighing device and diverter errors. This part of ISO 9368 amplifies certain aspects of verification and testing of the system. In particular, alternative procedures are given for checking the weighing device (see 6.1 and Annex A), checking the diverter (see 6.2 and Annex B), checking the timer (see 6.3), checking the density measurement system (see 6.4), assessment of flowrate stability (see 6.5 and Annex C and Annex D), study of flow characteristics (see 6.6 and Annex E), and calculating the overall measurement uncertainty (see clause 7).

5.4 Preliminary operations

Before undertaking the detailed checks the following preliminary operations shall be carried out:

- a) examine the technical description and written procedures for operating the installation;
- b) check the characteristics of the main and auxiliary instrumentation and equipment, and verify that it conforms with the characteristics given in the documentation;
- c) check the operation of the hydraulic system in order to establish any additional sources of error;
- d) determine the operational flow range of the installation.

The maximum operational flowrate of an installation shall be the lower of the following two values:

- a) the maximum flowrate which can be produced by the flow supply system when operating in a flow circuit with minimum hydraulic resistance;
- b) the flowrate corresponding to the minimum allowable time for filling the weight tank up to its maximum level, the minimum time having to satisfy the requirements given in ISO 4185:1980, subclause 3.3, i.e. 30 s.

6 Procedures for checking operations

6.1 Checking the weighing device

The mass of liquid collected is determined by weighing the weight tank before and after the diversion period (double weighing) and the tare is then subtracted from the gross weight.

Checking of the weighing device used with the double weighing method shall allow the determination of the corrections to be applied and the systematic and random uncertainties due to the weighing device. Procedures for assessing these uncertainties are given in detail in ISO 4185 and Annex A of this part of ISO 9368.

6.1.1 Checking by means of standard weights

In order to check the weighing device, standard weights of a total mass not less than the maximum possible mass of liquid collected shall be used whenever possible. The maximum permissible error of the standard weights shall be 20 % or less of the expected uncertainty of the weighing device.