International Standard 4185

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Measurement of liquid flow in closed conduits — Weighing method

Mesure de débit des liquides dans les conduites fermées — Méthode par pesée

First edition — 1980-12-15

UDC 532.575 : 531.753 **Ref. No. ISO 4185-1980 (E)**

Descriptors : flow measurement, liquid flow, pipe flow, measuring instruments, flowmeters, calibrating, weight measurement, error analysis.

Price based on 21 pages

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4185 was developed by Technical Committee ISO/TC 30, *Measurement of fluid flow in closed conduits*, and was circulated to the member bodies in August 1978.

It has been approved by the member bodies of the following countries :

Australia	Germany, F.R.	Poland
Belgium	India	Romania
Brazil	Italy	Spain
Chile	Korea, Rep. of	United Kingdom
Czechoslovakia	Mexico	USA
Egypt, Arab Rep. of	Netherlands	USSR
France	Norway	Yugoslavia

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Japan
South Africa, Rep. of

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Annexes

Measurement of liquid flow in closed conduits — Weighing method

1 General

1.1 Scope and field of application

This International Standard specifies a method of liquid flow-rate measurement in closed conduits by measuring the mass of liquid delivered into a weighing tank in a known time interval. It deals in particular with the measuring apparatus, the procedure, the method for calculating the flow-rate and the uncertainties associated with the measurement.

The method described may be applied to any liquid provided that its vapour pressure is such that any escape of liquid from the weighing tank by vaporization is not sufficient to affect the required measurement accuracy. Closed weighing tanks and their application to the flow measurement of liquids of high vapour pressure are not considered in this International Standard.

This International Standard does not cover the cases of corrosive or toxic liquids.

Theoretically, there is no limit to the application of this method which is used generally in fixed laboratory installations only. However, for economic reasons, usual hydraulic laboratories using this method can produce flow-rates of 1.5 m^3/s or less.

Owing to its high potential accuracy, this method is often used as a primary method for calibration of other methods or devices for mass flow-rate measurement or volume flow-rate measurement provided that the density of the liquid is known accurately. It must be ensured that the pipeline is running full with no air or vapour pockets present in the measuring section.

1.2 References

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

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

OIML, Recommendations Nos. 1, 2, 3, 20, 28, 33.

1.3 Definitions

Only terms which are used in a special sense or the meaning of which merits restatement are defined below.

1.3.1 static weighing : The method in which the net mass of liquid collected is deduced from tare and gross weighings made respectively before and after the liquid has been diverted for a measured time interval into the weighing tank.

1.3.2 dynamic weighing : The method in which the net mass of liquid collected is deduced from weighings made while fluid flow is being delivered into the weighing tank. (A diverter is not required with this method.)

1.3.3 diverter : A device which diverts the flow either to the weighing tank or to its by-pass without changing the flow-rate during the measurement interval.

1.3.4 flow stabilizer : A structure forming part of the measuring system, ensuring a stable flow-rate in the conduit being supplied with liquid; for example, a constant level head tank, the level of liquid in which is controlled by a weir of sufficient length.

1.3.5 buoyancy correction : The correction to be made to the readings of a weighing machine to take account of the difference between the upward thrust exerted by the atmosphere, on the liquid being weighed and on the reference weights used during the calibration of the weighing machine.

1.4 Units

The units used in this International Standard are the SI units, metre, kilogram, and second; the degree Celsius is used for convenience instead of the kelvin.

1.5 Notation

Symbol	Designation	Dimension	SI Units
q_m	Mass flow-rate	MT^{-1}	kg/s
q_V	Volume flow-rate	L^3T^{-1}	m^3/s
m	Mass	M	kg
V	Volume	L^3	m^3
t	Time	T	s
ϱ	Density of liquid	ML^{-3}	kg/m^3
ϱ_a	Density of air (at 20 °C and 1 bar*)	ML^{-3}	kg/m^3
ϱ_p	Density of standard weights	ML^{-3}	kg/m^3
s_x	Estimated standard deviation		
σ_x	Standard deviation of variable x		
e	Uncertainty of measurement		
e_s	Systematic uncertainty		
E_s	Percentage systematic uncertainty		
e_R	Random uncertainty		
E_R	Percentage random uncertainty		

* 1 bar = 10^5 Pa

1.6 Certification

If the installations for flow-rate measurement by the weighing method are used for purposes of legal metrology, they should be certified and registered by the national metrology service. Such installations are then subject to periodical inspection at stated intervals. If a national metrology service does not exist, a certified record of the basic measurement standards (weight and time), and error analysis in accordance with this International Standard and ISO 5168, shall also constitute certification for legal metrology purposes.

2 Principle

2.1 Statement of the principle

2.1.1 Static weighing

The principle of the flow-rate measurement method by static weighing (for schematic diagrams of typical installations, see figures 1A, 1B, 1C) is :

— to determine the initial mass of the tank plus any residual liquid;

— to divert the flow into the weighing tank (until it is considered to contain a sufficient quantity to attain the desired accuracy) by operation of the diverter, which actuates a timer to measure the filling time;

— to determine the final mass of the tank plus the liquid collected in it.

The flow-rate is then derived from the mass collected, the collection time and other data as discussed in clause 5 and annex A.

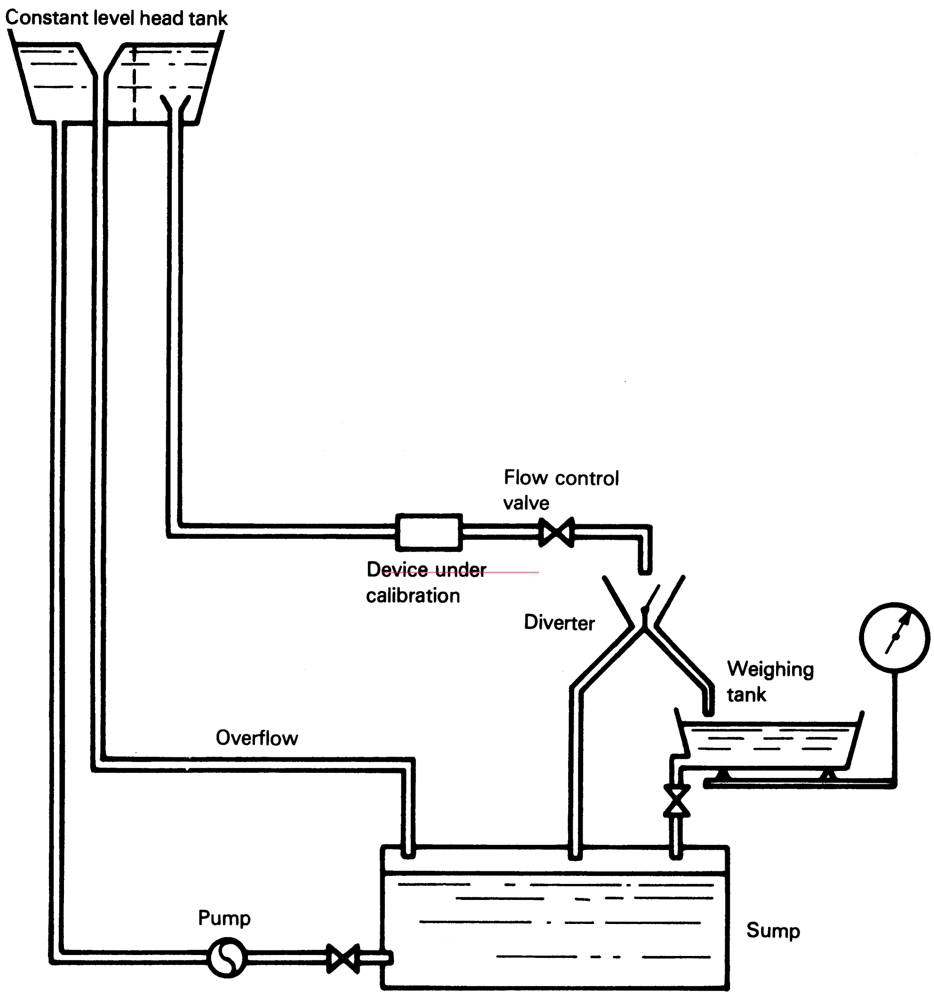

Figure 1A — Diagram of an installation for calibration by weighing (static method, supply by a constant level head tank)

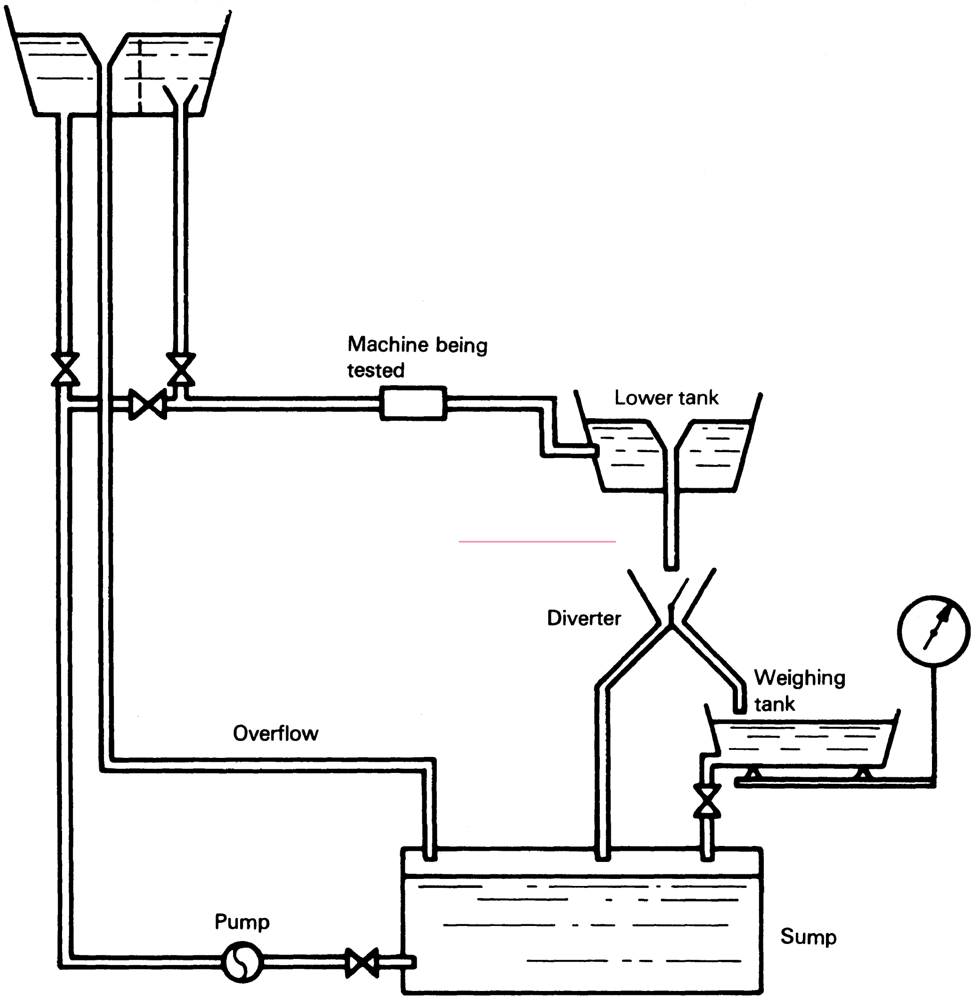

Figure 1B — Diagram of an installation for flow-rate measure by weighing (used for an hydraulic machine test; static method, supply by a constant level head tank)

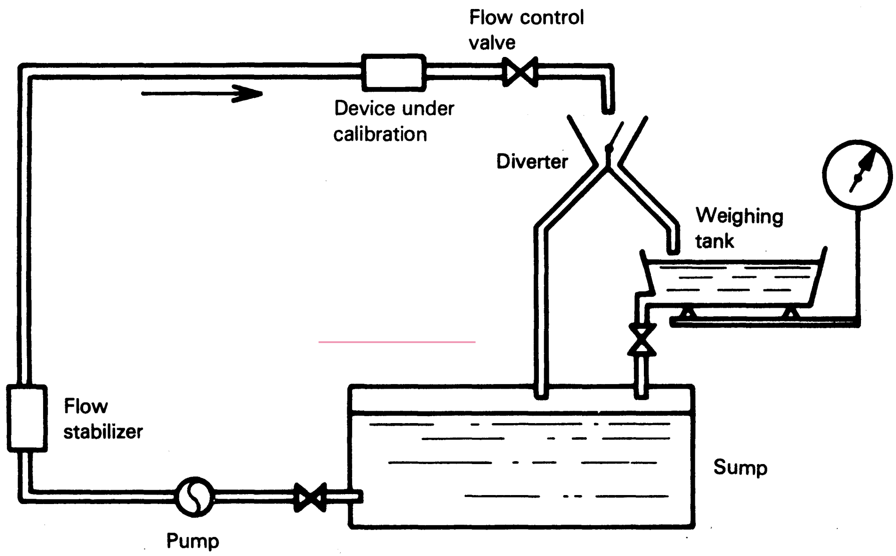

Figure 1C — Diagram of an installation for calibration by weighing (static method, direct pumping supply)

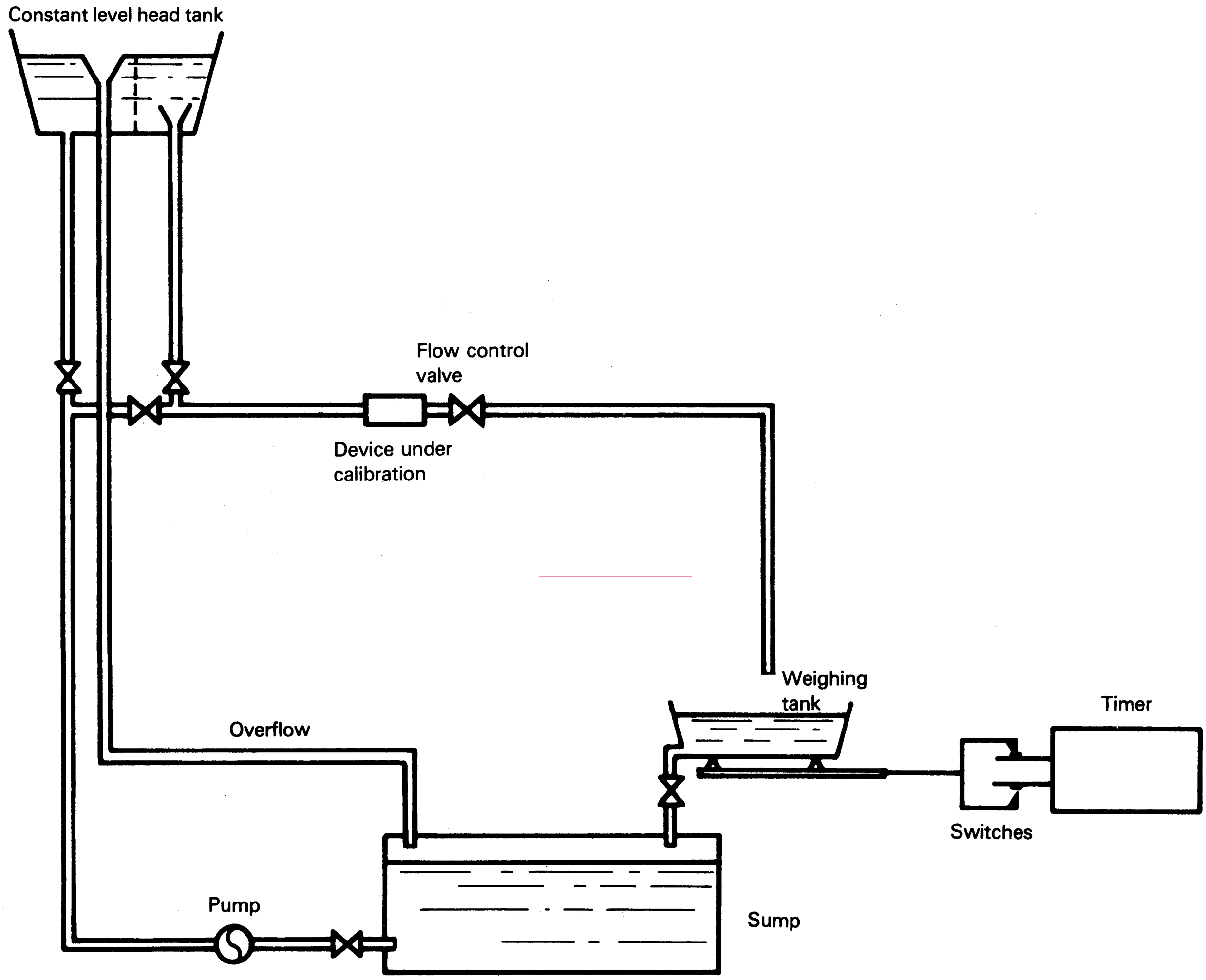

Figure 1D — Diagram of an installation for calibration by weighing (dynamic method, supply by a constant level head tank)

2.1.2 Dynamic weighing

The principle of the flow-rate measurement method by dynamic weighing (see figure 1D for a schematic diagram of a typical installation) is :

— to let the liquid collect in the tank to a predetermined initial mass, when the timer is then started;

— to stop the timer when a predetermined final mass of collected liquid is reached.

The flow-rate is then derived from the mass collected, the collection time and other data as discussed in clause 5 and annex A.

2.1.3 Comparison of instantaneous and mean flow-rate

It should, however, be emphasized that only the mean value of flow-rate for the filling is given by the weighing method. Instantaneous values of flow-rate as obtained on another instrument or meter in the flow circuit can be compared with the mean rate only if the flow is maintained stable during the measurement interval by a flow-stabilizing system, or if the instantaneous values are properly time-averaged during the whole filling period.

2.2 Accuracy of the method

2.2.1 Overall uncertainty on the weighing measurement

The weighing method gives an absolute measurement of flow which in principle requires only mass and time measurements. Provided that the precautions listed in 2.2.2 are taken, this method may be considered as one of the most accurate of all flow-rate measuring methods, and for this reason it is often used as a calibration method. When the installation is carefully constructed, maintained and used, an uncertainty of ± 0,1 % (with 95 % confidence limits for the random part of that uncertainty) can be achieved.

2.2.2 Requirements for accurate measurements

The weighing method gives an accurate measurement of flow rate provided that :

a) there is no leak in the flow circuit and there is no unmetered leakage flow across the diverter;

b) there is no accumulation (or depletion) of liquid in a part of the circuit by thermal contraction (or expansion) and there is no accumulation (or depletion) by change of vapour or gas volume contained unknowingly in the flow circuit;

c) necessary corrections for the influence of atmospheric buoyancy are made; this correction may be made when calibrating the weighing apparatus;

d) the weighing machine, the timer and means for starting and stopping it achieve the necessary accuracy;

e) the time required by the diverter for traversing is small with respect to the filling time, the timer being started and stopped while the diverter is crossing the hydraulic centre line;

f) in the case of the dynamic weighing method the effects of the dynamic phenomena are sufficiently small.

3 Apparatus

3.1 Diverter

The diverter is a moving device used to direct flow alternately along its normal course or towards the weighing tank. It can be made up of a conduit or moving gutter, or, better, by a baffle plate pivoting around a horizontal or vertical axis (see figure 2).

The motion of the diverter should be sufficiently fast (less than 0,1 s, for example) to reduce the possibility of a significant error occurring in the measurement of the filling time. This is accomplished by rapid diverter travel through a thin liquid sheet as formed by a nozzle slot. Generally, this liquid sheet has a length 15 to 50 times its width in the direction of diverter travel. The pressure drop across the nozzle slot should not exceed about 20 000 Pa to avoid splashing, air entrainment[1)] and flow across the diverter and turbulence in the weighing tank. This motion of the diverter can be generated by various electrical or mechanical devices, for example by a spring or torsion bar or by electrical or pneumatic actuators. The diverter should in no way influence the flow in the circuit during any phase of the measuring procedure.

1) In certain designs of nozzle slot, however, special vents to allow air ingress to the fluid jet may be necessary to ensure stable flow within the test circuit.