INTERNATIONAL STANDARD

ISO 11605

First edition
1995-03-01

Paper and board — Calibration of variable-area flowmeters

Papier et carton — Étalonnage des débitmètres à section variable

Reference number
ISO 11605:1995(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11605 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*.

Annexes A and B of this International Standard are for information only.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Paper and board — Calibration of variable-area flowmeters

1 Scope

This International Standard specifies a method for the calibration of variable-area flowmeters as used in instruments for the determination of air permeance and the roughness/smoothness of paper and board. Other meters, such as an electronic mass flowmeter may be used, provided their accuracy is at least as good as that of the specified method.

NOTE 1 This procedure may also be used for calibrating the capillary tubes used to check the Bendtsen apparatus.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard 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 187:1990, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples.*

ISO 5636-3:1992, *Paper and board — Determination of air permeance (medium range) — Part 3: Bendtsen method.*

ISO 5636-4:1986, *Paper and board — Determination of air permeance (medium range) — Part 4: Sheffield method.*

ISO 8791-2:1990, *Paper and board — Determination of roughness/smoothness (air leak methods) — Part 2: Bendtsen method.*

ISO 8791-3:1990, *Paper and board — Determination of roughness/smoothness (air leak methods) — Part 3: Sheffield method.*

ISO 8791-4:1992, *Paper and board — Determination of roughness/smoothness (air leak methods) — Part 4: Print-surf method.*

ISO 11004:1992, *Paper and board — Determination of air permeance — Low range.*

3 Principle

A soap bubble, introduced into an air flow from the variable-area flowmeter under test, is timed between two marks in a volumeter representing an accurately known volume and the actual air flow is calculated. This is repeated at other air flows until the flowmeter range has been covered.

4 Apparatus

4.1 Soap bubble meter (see figure 1) consisting of:

— glass flask or bottle, of capacity 1 litre;

— volumeter, calibrated at graduation marks appropriate to the flowmeter to be calibrated, for example, marks approximating 100 ml, 250 ml, 500 ml, 1 000 ml, 1 500 ml and 2 000 ml. The different ranges may be achieved with replaceable volumeters (additional designs are discussed by Gooderham [1]);

— needle valve[1];

1) The needle valve has to be removed for calibration of the Print-surf apparatus.

— glass and rubber tubing of as large an internal diameter and as short as is practicable to minimize pressure drop.

4.2 Stopwatch, capable of being read to 0,1 s.

4.3 Soap solution, comprising, for example, 3 % to 5 % liquid detergent in distilled water.

5 Procedure

5.1 General

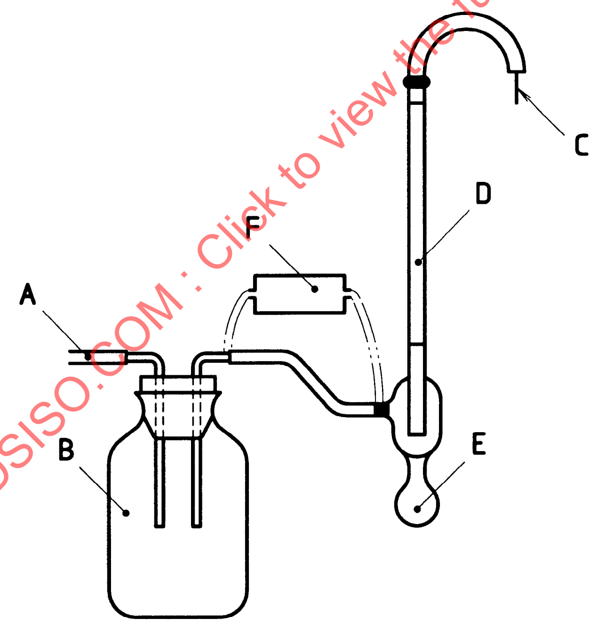
Carry out the calibration procedure in the same atmosphere as normally used for testing (see ISO 187).

5.2 Bendtsen apparatus (for description of the apparatus, see ISO 5636-3 or ISO 8791-2)

5.2.1 Disconnect the measuring head from the downstream end of the rubber or plastics tubing and connect in its place the soap bubble meter at A (see note 2). Start the air flow, place the manostat which corresponds to a pressure of 1,47 kPa on the shaft and start it spinning. Set the valves to deliver to the soap bubble meter through the flowmeter being calibrated.

NOTE 2 The internal diameters of the tubing connecting the flowmeter to the air permeance measuring head or the roughness head are different. Consequently, the pressure drop and therefore the calibration can change between these configurations. Therefore, it is advisable to verify periodically that both calibrations are within 5 % of the true air flow (see 6.1).

5.2.2 Adjust the needle valve C to give a conveniently measurable air flow and ensure that the flowrate remains constant. Rapidly squeeze the rubber bulb E at the bottom of the volumeter D so that a soap bubble enters the volumeter tube. Note the time, in seconds to the nearest 0,1 s, for it to move



Key

A Connection point
B Glass flask, of capacity 1 litre
C Needle valve[1)]
D Volumeter
E Rubber bulb
F Saturator

1) Removed for calibration of Print-surf apparatus.

Figure 1 — Soap bubble meter

between marks representing a known volume, and record the flowmeter reading. The volumeter range should be chosen so that time measurements are in excess of 30 s. Repeat the procedure at about six air flows distributed over the upper 80 % of the flowmeter working range.

NOTES

3 Squeezing the bulb creates a pressure fluctuation which may take the manostat several seconds to stabilize. This can cause the indicated flow to be seriously in error and it is therefore important to allow the flowmeter float to stabilize before the soap film passes the lower timing mark.

4 At air flows above 1 200 ml/min, the pressure drop in the system is substantial and to ensure reproducibility of results it is necessary to ensure that the length and diameter of the tubing used in calibration to connect the flowmeter outlet to A are the same as those used in normal testing.

5.3 Sheffield apparatus

Conduct the internal calibration of the flowmeter as described in ISO 5636-4 or ISO 8791-3. Disconnect the measuring head from the downstream end of the rubber or plastics tubing and connect in its place the soap bubble meter at A. Set the valves to deliver through the flowmeter being calibrated and continue the procedure as described in 5.2.2 (see also notes 3 and 4).

5.4 Print-surf apparatus (non-impedance type)

Remove needle valve C and connect the inlet (A) of the soap bubble meter to the outlet of the flowmeter being calibrated. Operate the instrument according to the procedure described in subclauses 9.1 to 9.6.1 inclusive of ISO 8791-4:1992, using a test piece of suitable roughness (see note 4). Rapidly squeeze the rubber bulb E at the bottom of the volumeter D so that a soap bubble enters the volumeter tube. Note the time, in seconds to the nearest 0,1 s, for the bubble to move between marks representing a known volume, and record the flowmeter reading. Repeat the procedure using test pieces of appropriate roughness to provide about six air flows distributed over the upper 80 % of the flowmeter working range.

NOTE 5 Some paper test pieces may not give stable scale readings during the calibration procedure due to the effect of moisture change during the test. Do not use material which behaves in this way. Materials other than paper may be used, providing they give readings at appropriate intervals over the range of the flowmeter being calibrated.

5.5 Low-permeance apparatus
(see ISO 11004)

Connect the upper part (open end) of the largest flowmeter to the soap bubble meter at A. Start the compressor and continue the procedure as described in 5.2.2 (see also notes 3 and 4).

6 Calculation

6.1 Bendtsen apparatus

Calculate the true air flow, in millilitres per minute, from each measured time and volume and check that the flowmeter reading is within 5 % of this flow. If not, examine the flowmeter tubes and rotor for dirt and/or damage and replace if necessary. As a temporary measure, a calibration graph may be constructed.

NOTE 6 If extreme accuracy is required, it may be necessary to correct for temperature, pressure and the water vapour picked up from the soap solution, but the precision of the respective test method in other respects does not warrant the application of this correction.

6.2 Sheffield apparatus

Calculate the true air flow, in millilitres per minute, from each measured time and volume and construct a calibration graph for each flowmeter. The three graphs for a single instrument should constitute a straight line and if they do not there is a defect in the flowmeter tubes or the orifice manifold. The equation to the graph is of the form

$$\text{air flow (ml/min)} = A + B \cdot X$$

where

A is a constant (usually between − 500 and + 150);

B is a constant (usually between 8 and 9,5);

X is the scale reading, in Sheffield units.

(See also note 6.)

6.3 Print-surf apparatus

Calculate the true air flow, in cubic metres per second, for each measured time and volume and convert each air flow to roughness R, in micrometres, by means of the equation

$$R = \left(\frac{12\, \mu b\, q_V}{l\, \Delta p} \right)^{1/3} \times 10^{-6}$$

where

μ is the viscosity of air at room temperature, in pascal seconds;

b is the width of the metering land, in metres;

q_V is the true air flow in unit time, in cubic metres per second;

l is the effective length of the metering land, in metres;

Δp is the pressure difference across the metering land, in pascals.

Compare the calculated values with the actual scale readings. If the instrument reading is more than 0,05 µm from the calculated value at any point, construct a calibration graph.

NOTE 7 For very accurate calibration, it is desirable to allow for the water vapour picked up from the soap solution. A means of carrying out this determination is given, for information, in annex A.

6.4 Low-permeance apparatus

Calculate the true air flow, in millilitres per second, from each measured time and volume and compare with the flowmeter reading. If the flowmeter readings differ from the flowrate by more than 2 % of the full scale value, examine the flowmeter tubes and rotors for dirt and/or damage and replace if necessary. As a temporary measure, a correction chart of air flow versus flowmeter readings may be constructed.

Annex A
(informative)

Compensation for the relative humidity of the air

In the course of carrying out the calibration procedure, the air passing through the apparatus may pick up moisture from the walls of the soap bubble meter or the vicinity of the bubble itself. This will result in an increase in volume and so the air flow will be overestimated. The increase in volume is small, being of the order of 1 % to 2 % depending on the initial relative humidity and the rate of flow, and the error in calibration induced by such a change is appreciably less than inherent errors associated with instruments such as the Bendtsen and Sheffield and may therefore be ignored. The same is not necessarily true for instruments which operate on the Print-surf principle and, for very accurate calibration, a saturator should be interposed between flask B and volumeter D as shown in figure 1. A suitable saturator consists of a glass absorption column packed with wetted porous beads. Air passing through such a column will become close to saturated with water vapour.

NOTE 8 During calibration, it is essential that the pressure drop through the instrument be as close to zero as possible. It is therefore important that the inclusion of a saturator should have a negligible effect on the pressure drop.

The true air flow q_V, in cubic metres per second, is calculated from the following equation

$$q_V = \frac{q_{Vs}\,(p_3 - p_{V2})}{(p_2 - p_{V1})} \times \frac{p_2}{p_1} \times \frac{T_1}{T_2}$$

where

q_{Vs} is the volume of saturated air passing through the volumeter in unit time, in cubic metres per second;

p_1 is the absolute air pressure into the flowmeter on test, in pascals;

p_2 is the absolute air pressure into the saturator, in pascals;

p_3 is the absolute air pressure into the volumeter, in pascals;

p_{V1} is the water vapour pressure of air into the saturator, in pascals;

p_{V2} is the water vapour pressure of air into the volumeter, in pascals;

T_1 is the absolute temperature, in kelvins, of the air into the saturator;

T_2 is the absolute temperature, in kelvins, of the air exiting the volumeter.

Annex B
(informative)

Bibliography

[1] GOODERHAM, J.W. *J. Soc. Chem. Ind.*, **63**, 1944, p. 351.

This page intentionally left blank