INTERNATIONAL STANDARD

ISO 5636-4

Second edition
2005-02-01

Paper and board — Determination of air permeance (medium range) —

Part 4: Sheffield method

Papier et carton — Détermination de la perméance à l'air (valeur moyenne) —

Partie 4: Méthode Sheffield

Reference number
ISO 5636-4:2005(E)

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Published in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 5636-4 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*.

This second edition cancels and replaces the first edition (ISO 5636-4:1986), which has been technically revised.

ISO 5636 consists of the following parts, under the general title *Paper and board — Determination of air permeance (medium range)*:

— *Part 1: General method*

— *Part 2: Schopper method*

— *Part 3: Bendtsen method*

— *Part 4: Sheffield method*

— *Part 5: Gurley method*

Introduction

Basic requirements and general operating procedures for the determination of air permeance are given in ISO 5636-1 (see [1] in the Bibliography). Other parts of ISO 5636 specify detailed requirements and operating procedures applicable to other types of apparatus. Since all these methods determine the air flow rate through a specified area under a specified pressure difference when the test piece is clamped to avoid lateral surface leakage, they should in principle give the same result.

Paper and board — Determination of air permeance (medium range) —

Part 4:
Sheffield method

1 Scope

This part of ISO 5636 specifies a method of determining the air flow rate through unit area of a sheet of paper or board, under unit pressure difference using apparatus called the Sheffield instrument.

The method is applicable to papers and boards having air permeances between 0,02 µm/(Pa·s) and 25 µm/(Pa·s). The method is not suitable for papers and boards with a rough surface, such as crêpe paper and corrugated papers, which cannot be securely clamped to avoid surface leakage.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 186, *Paper and board — Sampling to determine average quality*

ISO 187, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples*

ISO 11605, *Paper and board — Calibration of variable-area flowmeters*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
air permeance
mean air flow rate through unit area under unit pressure difference in unit time, under specified conditions

NOTE 1 Air permeance is expressed in micrometres per pascal second [1 ml/(m^2·Pa·s) = 1 µm/(Pa·s)].

NOTE 2 This property is called air permeance, and not air permeability, because it is reported as a sheet property and is not normalized with respect to thickness to give a material property per unit thickness.

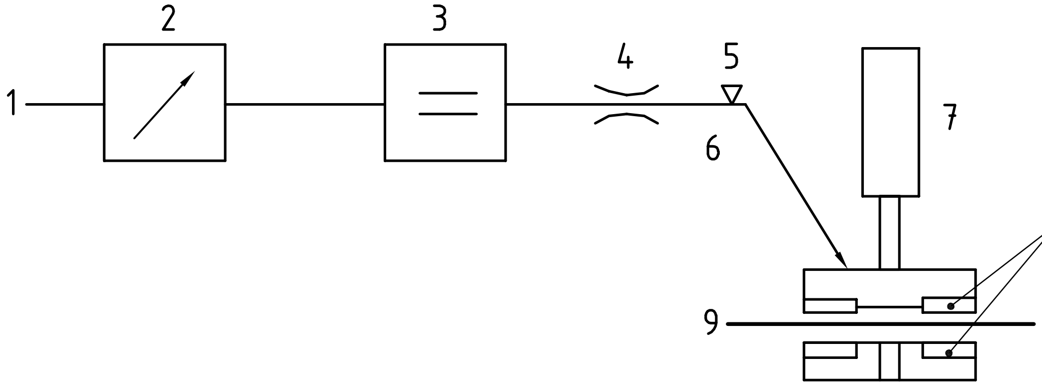
NOTE 3 The Sheffield unit is not defined, since it has been found that the scale units (Sheffield units) on different instruments can correspond to different air flows, and there is no precise physical definition. This part of ISO 5636 requires that the flowmeters be calibrated to give a flow rate in millilitres per minute.

4 Principle

A test piece is clamped between two rubber orifice plates of known dimensions, with the absolute air pressure on one side of the test piece equivalent to atmospheric pressure and the difference in pressure between the two sides of the piece maintained at a small but substantially constant value. The air flow rate through the test area is determined and the air permeance is calculated.

5 Apparatus

The apparatus, see Figure 1 for an example of one type of instrument, shall consist of an air supply, an air-pressure control and an air-flow-measuring device, and a test assembly which houses a measuring head in which the test piece can be securely clamped.



Key

1 air supply
2 pressure regulator
3 flow-measuring device
4 flow impedance
5 shut-off valve
6 measurement air
7 clamping air pressure
8 orifice plates
9 test piece

Figure 1 — Principles of operation of one type of apparatus

5.1 Air supply, free from water, oil and other contaminants, at a pressure of 420 kPa to 950 kPa. A small compressor using laboratory air is preferred to external compressed air.

5.2 Pressure-regulating device, to reduce the pressure to the nominal pressure at the measuring head of 10,3 kPa (variable-area flow-measuring devices) or 9,85 kPa (electronic flow-measuring devices).

5.3 Pressure manometer, with a suitable range to enable the air pressure at the measuring head to be set to the specified pressure within 2 % of the nominal value.

5.4 Flow-measuring device, of either a variable-area or an electronic type, for measuring the air flow rate to the measuring head. The air flow rate shall be measurable to an accuracy of ± 5 % of the measured value.

5.4.1 Variable-area flow-measuring device, consisting of three variable-area flowmeters each having a tapered glass column containing a metering float suspended by the air flow in the column (see ISO 5636-1[1]. The three columns shall be chosen with dimensions such that they enable measurements to be made on a continuous scale of flow rate from 10 ml/min to 3 000 ml/min, with some overlap of scales between columns. Each column shall be provided with a means of adjusting the flow rate (float-position knob) and a means of span calibration (calibrating knob). This type of instrument shall operate at a supply pressure of 10,3 kPa.

At air flow rates greater than 1 200 ml/min, the pressure drop in the Sheffield system is substantial. To ensure reproducibility of results, it is necessary that the tubing used to connect the flowmeter to the measuring head be carefully controlled with a length of 1,50 m ± 0,01 m and an internal diameter of 6,25 mm ± 0,25 mm. For the same reason, openings in valves and other fittings on the instrument must not be changed from those provided by the instrument manufacturer.

5.4.2 Electronic flow-measuring device, for measuring the air flow to the measuring head. The inlet pressure to the measurement device shall be controlled at 9,85 kPa.

NOTE The 9,85 kPa pressure is the typical pressure measured downstream of variable-area flow tubes that have been calibrated using the air bleeds (zero and span-adjustment) to the atmosphere.

5.5 Test piece clamping device (test assembly), incorporating a detachable measuring head with a set of rubber orifice plates to provide a test area of 283,5 mm^2 (19 mm diameter), constructed so that a test piece can be clamped between the orifice plates.

NOTE Additional sets of orifice plates may be available for the following four optional test areas:

— 71 mm^2 (9,5 mm diameter);

— 1 135 mm^2 (38 mm diameter);

— 2 550 mm^2 (57 mm diameter);

— 4 540 mm^2 (76 mm diameter);

but the use of these test areas is not in accordance with this part of ISO 5636. Doubling the test area does not necessarily double the air flow, since the specific design of the instrument means that the pressure difference is affected by the test area.

5.6 Flat non-porous plate, of approximate dimensions 100 mm × 100 mm, which can be clamped between the rubber orifice plates to check the zero reading.

5.7 Calibration plate device, to enable the test assembly to be connected to an external calibration system (see Clause 9 and Annex B).

6 Sampling

Sampling is not included in this part of ISO 5636. If the mean quality of a lot is to be determined, sampling shall be carried out in accordance with ISO 186. If the tests are made on another type of sample, make sure that the test pieces taken are representative of the sample received.

7 Conditioning

Condition the samples in accordance with ISO 187.

8 Preparation of test pieces

Prepare the test pieces in the same atmospheric conditions as were used to condition the samples.

Cut not less than ten test pieces, each at least 15 mm larger in both dimensions than the diameter of the circular orifice of the rubber plate to be used, and identify their two sides, for example top side and bottom side. The test area shall be free from folds, wrinkles, holes, watermarks or defects not inherent in the sample. Do not handle the part of the test piece which will become the test area.

9 Calibration

9.1 Variable-area flow-measuring device

Calibrate the instrument against an external flow-measuring device as described in B.1, and prepare a calibration graph or chart as described in B.2.

Calibrate the instrument sufficiently frequently to ensure that the reading does not deviate at any time by more than ± 5 % from the true value.

9.2 Electronic flow-measuring device

Carry out the internal adjustment of the flowmeter according to the manufacturer's instructions. Check the calibration of the instrument against an external flow-measuring device as described in B.1.

10 Procedure

10.1 Test atmosphere

Carry out all testing under the same atmospheric conditions as those used to condition the sample in accordance with ISO 187.

10.2 Determination of air flow rate

10.2.1 Make sure that the instrument is level on a surface free from vibrations. Check that the air pressure to the measuring head is correct (see 5.4.1 or 5.4.2). Check that the air flow reading obtained with the non-porous plate (see 5.6) clamped in the measurement gap is zero.

Apply the internal adjustment procedure described in the manufacturer's instructions frequently if the instrument is being used for long periods (at least twice in an 8 h day), and whenever the air supply to the instrument is interrupted.

NOTE For daily use, it is preferable to leave the air supply on in order to minimize the drifts in the regulator.

10.2.2 Place a test piece in the measuring gap and measure the air flow rate in accordance with the manufacturer's instructions. Record the result.

All papers are hygrosensitive to some degree, and readings should be taken at the initial stabilization point to avoid any possible effect of the incoming air adding moisture to, or extracting moisture from, the test piece.

10.2.3 Test the remaining test pieces by the same method, ensuring that, in half the tests, the top side of the test piece faces the direction of air flow, and in the other half, the bottom side of the test piece faces the direction of air flow.

11 Calculation and expression of results

11.1 If the instrument provides readings in “Sheffield units”, convert each reading to an air flow rate in millilitres per minute, using the calibration chart or graph prepared as described in B.2.

11.2 Calculation of air permeance

Calculate the mean air flow rate, q. Convert the results to give the air permeance, P, of the sample, in micrometres per pascal second, using the formula

$$P = 1{,}62 \times \frac{q}{A} \qquad (1)$$

where

q is the average air flow rate, expressed in millilitres per minute, to three significant figures;

A is the area, in square millimetres, of the test piece exposed by the rubber orifice plates.

NOTE The constant 1,62 in this equation is based on the supply pressure of 10,3 kPa used in the flow tube instruments.

If there is a difference of more than 10 % between mean results for the two directions of air flow through the test piece, calculate a separate result for each direction.

11.3 Standard deviation

Calculate the standard deviation or coefficient of variation of replicate tests.

12 Test report

The test report shall include the following information:

a) a reference to this part of ISO 5636;

b) date and place of testing;

c) all the information necessary for complete identification of the sample;

d) the make and model number of the instrument, and if appropriate, the flowmeter, used;

e) the number of test pieces tested,

f) the mean air permeance(s), in micrometres per pascal second, to three significant figures;

g) the standard deviation or coefficient of variation (as detailed in 11.2);

h) any deviation from the specified procedure which may have affected the result.

Annex A
(normative)

Care and maintenance of the test instrument using variable-area flowmeters

A.1 Weekly or more often if required, check the cleanness of the working orifices by testing against the spare calibration orifice manifold.

A.2 Check each orifice of the calibration orifice manifold for contamination. If necessary, clean with a suitable solvent, for example petroleum ether (boiling point 60 °C to 100 °C).

A.3 If the floats tend to stick in the air flowmeter columns, this may be due to dirt or static electrical charges. Clean as indicated in the instrument manual.

A.4 Rubber orifice plates in the hose quick-disconnect couplings shall be renewed at least once a year.

Annex B
(normative)

Calibration of flowmeters

B.1 Method

B.1.1 General

This procedure for calibrating variable-area flowmeters, using a soap-bubble meter (Figure B.1), is described in ISO 11605. The method can also be used to calibrate electronic flow-measuring devices, provided a suitable attachment is available.

The principle of the method is that the movement of a soap bubble introduced into an air flow from the flow-measuring device being tested is timed between two marks in a volumeter representing an accurately known volume and the actual air-flow rate is calculated. This is repeated at other air flow rates until the whole flowmeter range of the instrument has been covered.

NOTE This method of calibration gives satisfactory accuracy if the test atmospheric conditions do not deviate appreciably from 101,3 kPa and 23 °C. For this reason, it is desirable, if possible, to choose a day for calibration when the meteorological conditions are favourable.

B.1.2 Apparatus and materials

B.1.2.1 Soap-bubble meter, consisting of

— glass flask or bottle, of capacity 1 litre,

— volumetric tube, with graduation marks indicating 50 ml, 1 000 ml and 2 000 ml; the different ranges may be achieved with replaceable volumeters (suitable designs are given in [3] in the Bibliography),

— needle valve, and

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

B.1.2.2 **Stopwatch**, capable of being read to 0,1 s.

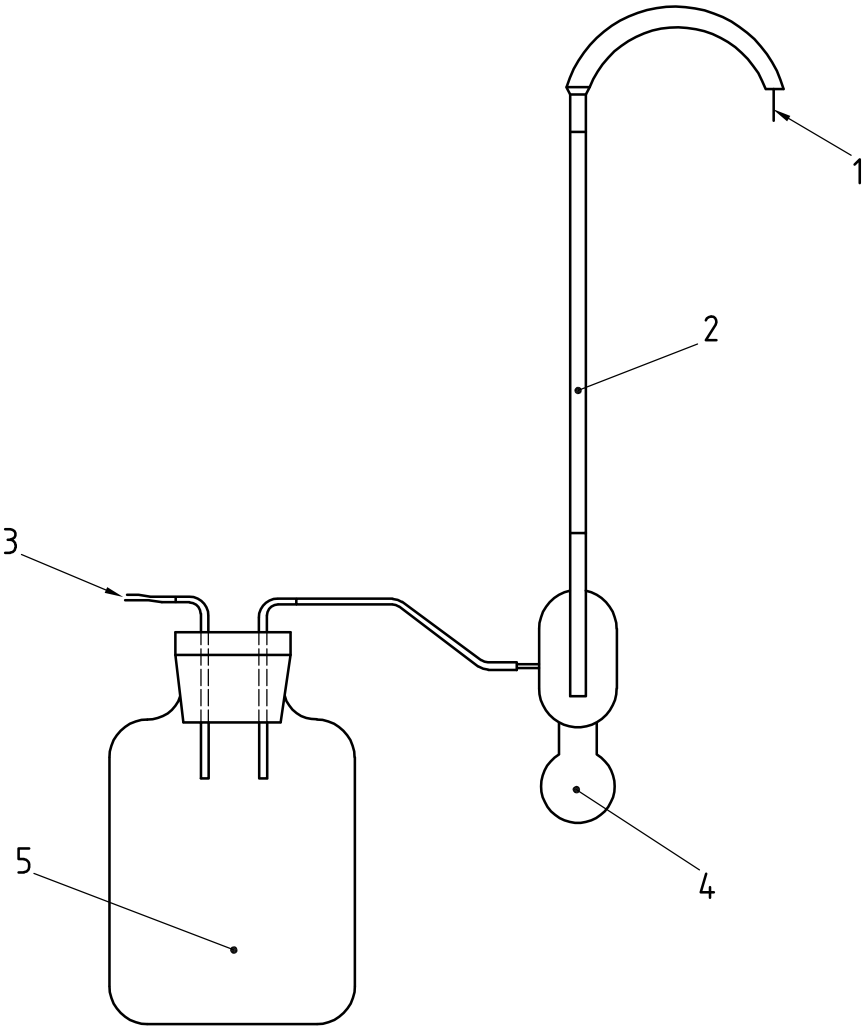
B.1.2.3 **Soap solution**, 3 % to 5 % liquid detergent in distilled water.

B.1.2.4 **Barometer**, or other means of ascertaining the actual atmospheric pressure.

NOTE It may be sufficient to contact a local meteorological station to obtain information about the atmospheric pressure.

B.1.3 Procedure

B.1.3.1 Make sure that the instrument is level on a surface free from vibrations. Make sure that the internal adjustment of the flowmeter has been carried out according to the manufacturer's instructions.



Key

1 needle valve

2 volumeter

3 connection point

4 rubber bulb

5 glass flask, of capacity 1 litre

Figure B.1 — Soap-bubble meter

B.1.3.2 Prior to performing the following calibration procedure, the variable-area flow tubes and the air-leak adjustment valves on the older-style instruments shall first be calibrated in Sheffield Units using calibration orifices provided by the manufacturer. In operation, the instrument shall always be checked against the manufacturer's calibration orifices prior to using the flow tube, to establish a calibration graph or chart (ml/min).

To calibrate a variable-area flow-measuring device, disconnect the test assembly from the downstream end of the rubber or plastic tubing and connect in its place the soap-bubble meter. Set the valves to deliver air through the flowmeter to be calibrated and then through the soap-bubble meter. Adjust the needle valve to give a conveniently measurable air flow and ensure that the flow rate remains constant. Rapidly squeeze the rubber bulb at the bottom of the volumeter so that a soap bubble enters the volumeter tube. The volumeter range should be chosen so that the time taken for the bubble to pass from the first to the second graduation is longer than 30 s.

Record the reading x on the flowmeter scale and record the time, t, in seconds, for the soap bubble to pass through the volume V.

Repeat the procedure at about six different air flow rates distributed over the upper 80 % of the flowmeter measurement range.

Record the atmospheric pressure p.

NOTE A better calibration may be achieved by leaving the measuring head in position and using a calibration plate device, such as that used with an electronic flow-measuring instrument, since this set-up includes the restriction within the measuring head.

B.1.3.3 To calibrate an electronic flow-measuring device, connect the soap-bubble meter to the calibration plate device (5.7) placed beneath the measuring head. Set the valves to deliver air through the flowmeter to be calibrated and then through the soap-bubble meter. Adjust the needle valve to give a conveniently measurable air flow and ensure that the flow rate remains constant. Rapidly squeeze the rubber bulb at the bottom of the volumeter, so that a soap bubble enters the volumeter tube. The volumeter range should be chosen so that the time taken for the bubble to pass from the first to the second graduation is longer than 30 s.

Record the reading x on the flowmeter scale and record the time, t, in seconds, for the soap bubble to pass through the volume V.

Repeat the procedure at about six different air flow rates distributed over the upper 80 % of the flowmeter measurement range.

Record the atmospheric pressure p.

B.1.4 Calculation

For each determination, calculate the flow rate q, in millilitres per minute, as

$$q = \frac{60 \times V}{t}$$

where

V is the known volume, in millilitres, between the two graduations on the volumeter;

t is the time, in seconds, taken for the soap bubble to go from the first to the second graduation.

If the actual atmospheric pressure differs by more than 5 % from the normal atmospheric pressure of 101,3 kPa, calculate the corrected flow rate q_0 as follows:

$$q_0 = q \frac{(p + 10{,}3)}{111{,}6} = 0{,}538\ (p + 10{,}3) \frac{V}{t}$$

where p is the actual atmospheric pressure.

NOTE 1 The pressure of 111,6 kPa is the sum of the normal atmospheric pressure, 101,3 kPa, and the nominal operating pressure,10,3 kPa, at 23 °C.

NOTE 2 The air passing through the apparatus may pick up moisture from the walls of the soap-bubble meter and the air flow may thus be over-estimated. The error is, however, appreciably less than the inherent errors associated with the Sheffield instrument and it may therefore be ignored.

B.2 Construction of calibration graph

Construct a graph by plotting the scale reading x against the calculated air flow q or q_0 for each flowmeter. The graph should be a straight line that can be represented by an equation of the form

$$q = A + Bx$$

where

A and B are constants;

x is the scale reading in Sheffield units.

This graph or equation can be used for conversion of the data to air flow rates, in millimetres per minute.

Annex C
(informative)

Conversion table

Table C.1 — Conversion of the traditional Sheffield units (SU) to SI units (derived from a survey of 12 instruments) (see [4] in the Bibliography)

Tube No. 3 SU	Air flow rate ml/min [a]	Tube No. 2 SU	Air flow rate ml/min [a]	Tube No. 1 SU	Air flow rate ml/min [a]
0	0	50	303	160	1 334
5	35	60	404	180	1 501
10	70	70	495	200	1 668
15	104	80	585	220	1 835
20	139	90	676	240	2 002
25	174	100	767	260	2 170
30	209	110	858	280	2 337
35	244	120	949	300	2 504
40	278	130	1 039	320	2 671
45	313	140	1 130	340	2 838
50	343	150	1 221	360	3 006
55	383	160	1 312	380	3 137
60	412	170	1 403	400	3 340
		180	1 493		
		190	1 584		

Sheffield tube No.	Recommended range Sheffield units, SU	Conversion to SI units ml/min [a]
3	0 to 56	ml/min = 6,96 SU
2	56 to 170	ml/min = 9,08 (SU) − 141
1	170 to 400	ml/min = 8,36 (SU) + 4

[a] Air flow rate is measured in millilitres per minute (ml/min), referenced to 21 °C and 101,3 kPa.

Bibliography

[1] ISO 5636-1, *Paper and board — Determination of air permeance (medium range) — Part 1: General method*

[2] LASHOF, T.W., MANDEL, J. and WORTHINGTON, W. *Tappi* **39**, pp.532-543 (1956)[1)]

[3] GOODERHAM, J.W.J. *Soc. Chem. Ind.*, **63**, p.351 (1944)

[4] TAPPI test method T 538 om-01, *Roughness of paper and paperboard (Sheffield method)*, Tappi Press, Atlanta, GA, USA

1) This publication includes reference to a device for overcoming the problem of tube No. 3.

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