International Standard 5636/4

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Paper and board — Determination of air permeance (medium range) — Part 4: Sheffield method

Papier et carton — Détermination de la perméabilité à l'air (valeur moyenne) — Partie 4: Méthode Sheffield

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Foreword

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International Standard ISO 5636/4 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Paper and board — Determination of air permeance (medium range) — Part 4: Sheffield method

0 Introduction

This part of ISO 5636 specifies a method of measuring the rate of flow of air through unit area of a sheet of paper or board, under unit pressure difference. The measurements may be made with any apparatus which complies with the specifications given in this part of ISO 5636.

ISO 5636/1 specifies basic requirements for the apparatus and general operating procedures. Other parts specify detailed requirements and operating procedures applicable to specific types of apparatus.

1 Scope

This part of ISO 5636 specifies the method of determining the air permeance of paper and board in the medium air permeance range using the Sheffield apparatus.

2 Field of application

The method is applicable to papers and boards having air permeance between 0,02 and 25 µm/(Pa·s). The method is unsuitable for rough surfaced papers and boards, such as creped and corrugated papers, which cannot be securely clamped to avoid leakage.

3 References

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

ISO 187, *Paper and board — Conditioning of samples.*

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

4 Definition

For the purpose of ISO 5636, the following definition applies.

air permeance: The mean flow of air through unit area under unit pressure difference in unit time, under specified conditions.

It is expressed in micrometers per pascal second
[1 ml/(m^2·Pa·s) = 1 µm/(Pa·s)].

5 Principle

Clamping a test piece between two rubber orifice plates of known dimensions, with the absolute air pressure on one side of the test area 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 during the test. Determination of the flow of air through the test area in a specified time and calculation of the air permeance.

6 Apparatus

6.1 Air supply, free from water, oil and other contaminants, at 420 to 950 kPa.

Pressure regulation down to the working level specified in this part of ISO 5636 is an integral part of the instrument.

6.2 Test instrument (see figure 1).

A copy of the instrument manual as a guide for maintenance shall accompany the instrument (see also annex A). The instrument shall be checked periodically against an external flow measurement device such as that described in annex B, clause B.2.

The instrument consists of the following elements.

6.2.1 Flow measuring device, consisting of three variable-area flowmeters each of which consists of a tapered glass column containing a metering float suspended by the air flow in the column. The three columns represent one continuous scale of flow with some overlap of scale between columns. Each is provided with adjustment for flow rate (float position knob) and span calibration (calibrating knob) (items 9 and 10 on figure 1). On some instruments the float position knob is located above the relevant flowmeter tube.

Flowmeters shall be calibrated frequently if the instrument is being used for long periods, at least twice in an 8 h day. The necessary calibration procedure is described in annex B, clause B.1.

6.2.2 Test piece clamping device, with a set of rubber orifice plates to provide a test area of 283,5 mm^2 (19 mm diameter). Additional sets of orifice plates are 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)

NOTE — Doubling the test area does not necessarily double the air flow.

A plastic hose 1,50 ± 0,15 m long and 6,25 ± 0,25 mm in internal diameter connects the device to the flowmeter.

6.2.3 Calibration orifice manifold, consisting of three standard orifices for calibrating the flowmeters. A spare orifice manifold should be kept as a master for checking the working orifices.

6.2.4 Flat, non-porous plate, of approximate dimensions 100 mm × 100 mm, which can be clamped between the rubber orifice plates.

7 Sampling

Sampling shall be carried out in accordance with ISO 186.

8 Conditioning

Conditioning shall be carried out in accordance with ISO 187.

9 Preparation of test pieces

Not less than ten test pieces shall be cut and their two sides identified, for example top side and bottom side.

Each side of the test piece shall be at least 15 mm larger than the diameter of the orifice to be used. The test area shall be free from folds, wrinkles, holes, watermarks or defects not inherent in the sample. Do not handle that part of the test piece which will become the test area.

10 Procedure

10.1 Test atmosphere

Testing shall be carried out under the same atmospheric conditions as used to condition test pieces (see clause 8).

10.2 Determination

10.2.1 Place the instrument on a surface free from vibration and level the instrument. Fit the 283,5 mm^2 area (19 mm diameter) rubber orifice plates to the clamping device. If the system is pneumatic, supply air at 420 to 800 kPa to the clamping device via the foot-pedal valve.

10.2.2 Connect the air hose between the clamping device and whichever of the three couplings feeding the three flowmeter columns will give a reading closest to mid-scale. The three scales represent one continuous scale from 0 to 400 units. If readings with the 283,5 mm^2 orifice are outside the range of the flowmeters, fit one of the other orifice plates and record the area of the plate used.

10.2.3 Clamp a test piece between the rubber orifice plates. If the test piece has a tendency to crease during clamping, clamp it with the bypass switch closed, then re-open the shut-off valve to take the reading.

10.2.4 When the metering float in the appropriate flowmeter first reaches a point of relative stability, record the reading corresponding to the top of the float.

The point of stability in No. 3 column can be difficult to judge because of the low air flow rate and hence the longer time the float takes to settle[1]. Some degree of care is required to obtain reliable readings.

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

10.2.5 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.

1) A device for overcoming this problem is referenced in the following publication:

LASHOF, T.W., MANDEL, J. and WORTHINGTON, W. *Tappi* **39**, pp. 532-542 (1956).

11 Expression of results

11.1 Calculation of air permeance

Calculate the mean scale reading and determine the air flow rate from the calibration graph (see annex B, clause B.3). Convert the results to give the air permeance (P) of the sample, in micrometres per pascal second, using the formula

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

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.

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

11.2 Standard deviation

Calculate the standard deviation or coefficient of variation of replicate tests for each test result reported.

12 Test report

The test report shall give the following information:

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 type of instrument used;

e) the temperature and relative humidity during the test;

f) the number of test pieces tested;

g) the pressure difference used, in kilopascals;

h) the flowmeter range used;

i) the test results;

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

k) any deviations from the specified procedure.

Annex A

Care and maintenance of the test instrument

(This annex forms part of the standard.)

A.1 Weekly, or more often if required, check the cleanness of the working orifices by testing against the spare calibration orifice manifold. Clean the inside of the glass column in the mercury manometer as required, as outlined in the instrument manual.

A.2 If the floats tend to stick in the air flowmeter columns, this may be due to dirt or static charges and cleaning should be carried out as outlined in the instrument manual.

A.3 Rubber gaskets in the hose quick-disconnect couplings shall be renewed at least once a year.

A.4 Check each orifice of the calibration orifice manifold for contamination. If necessary, clean with a suitable solvent, for example petroleum ether (boiling point 60 to 100 °C).

Annex B

Calibration of flowmeters

(This annex forms part of the standard.)

B.1 Internal calibration

B.1.1 General

Flowmeters shall be calibrated frequently if the instrument is being used for long periods. Should the air supply to the instrument be interrupted for any reason, the filter drain cock shall be opened and blown clear and the flowmeters shall be calibrated before testing is resumed. For daily use it is preferable to leave the air supply on to minimize drifts in the regulator.

During the initial calibration (steps B.1.2.5 to B.1.2.9), the top of the float shall be positioned precisely on the appropriate red lines. In the cross-calibration (steps B.1.2.10 to B.1.2.14), the top of the float shall be within plus or minus one scale division at each of the check points.

B.1.2 Procedure

B.1.2.1 Check zero on the mercury manometer.

B.1.2.2 Set the primary air regulator so that the air pressure to the instrument is 205 to 210 kPa.

NOTE — Although SI units are used throughout this International Standard, the pressure scales of some instruments are graduated in pounds-force per square inch (1 lbf/in^2 = 6,89 kPa).

B.1.2.3 Fit the 283,5 mm^2 area (19 mm diameter) orifice plates to the clamping device (see 10.2.1).

B.1.2.4 Fully open the bypass switch and adjust the mercury manometer *upward* to a pressure of 10,3 kPa by turning the pressure regulator (5 on figure 1) located at the back of the tester, making sure that the top of the meniscus is within an estimated 0,1 scale division (± 0,07 kPa) of the line.

B.1.2.5 Connect the air hose between the coupling on No. 3 column and the coupling on No. 3 orifice on the orifice manifold (15 on figure 1).

B.1.2.6 Close the air valve (16 on figure 1) on the orifice manifold and adjust the float position knob (10 on figure 1) until the top of the float is opposite the lower red line on the scale. Open the air valve on the orifice and observe the position of the float relative to the upper red line on the scale. If the top of the float is *above* the red line, adjust its position by turning the calibrating knob (9 on figure 1), counterclockwise until the float falls an equal distance *below* the red line on the scale. If the top of the float is *below* the red line, adjust its position by turning the calibrating knob clockwise until the float is positioned an equal distance *above* the red line on the scale. Then adjust the float position knob until the top of the float is opposite the upper red line on the scale.

B.1.2.7 Close the air valve and check the float position relative to the lower red line on the scale. The top of the float should be opposite the lower red line when the valve is closed and opposite the upper red line when the valve is open. If not, repeat step B.1.2.6 until the desired calibration is obtained.

B.1.2.8 Connect the air hose between No. 2 column and No. 2 orifice. Repeat steps B.1.2.6 and B.1.2.7.

B.1.2.9 Connect the air hose between No. 1 column and No. 1 orifice and repeat steps B.1.2.6 and B.1.2.7.

B.1.2.10 Connect the air hose between No. 3 column and the clamping device. Clamp the non-porous plate between the rubber orifice plates and check that the clamping pressure is at least 400 kPa. This operation should result in a zero (lower red line) reading in No. 3 column.

B.1.2.11 Connect the air hose between No. 3 column and No. 2 orifice and close the air valve on No. 2 orifice. The top of the float should be opposite the upper red line in No. 3 column.

B.1.2.12 Connect the air hose between No. 2 column and No. 3 orifice and open the air valve on No. 3 orifice. The top of the float should be opposite the lower red line in No. 2 column.

B.1.2.13 Connect the air hose between No. 2 column and No. 1 orifice and close the air valve on No. 1 orifice. The top of the float should be opposite the upper red line in No. 2 column.

B.1.2.14 Connect the air hose between No. 1 column and No. 2 orifice and open the air valve on No. 2 orifice. The top of the float should be opposite the lower red line in No. 1 column.

B.1.2.15 Connect the air hose between the clamping device and the appropriate column and check zero as in B.1.2.10.

B.2 Calibration against an external flow measurement device

B.2.1 General

If a Sheffield smoothness instrument is available, it may be used with master calibration plates to calibrate the flowmeter tubes.

Variable-area flowmeters may be calibrated by a soap-bubble meter of which there are several designs. Figure 2 is a diagrammatic representation of a suitable meter.

B.2.2 Apparatus and products

B.2.2.1 Soap-bubble meter consisting of:

- glass flask or bottle, capacity 1 litre;
- water manometer, graduated in millimetres;
- thermometer, graduated in degrees Celsius;
- volumeter, with graduating marks indicating 500 ml, 1 000 ml and 2 000 ml; the different ranges may be achieved with replaceable volumeters;
- needle valve;
- glass and rubber tubing of as large an internal diameter as practicable to minimize pressure drop.

B.2.2.2 Stop-watch.

B.2.2.3 Soap solution: 3 to 5 % liquid detergent in water is satisfactory.

B.2.3 Procedure

Conduct the internal calibration of the flowmeter as described in clause B.1.

To calibrate the flowmeter tubes, disconnect the measuring head from the downstream end of the rubber or plastic tubing and connect in its place the soap-bubble meter at C. Set the valves to deliver through the flowmeter to be calibrated to the soap-bubble meter. Adjust the needle valve to give a conveniently measurable air flow and ensure that the flow rate and manometer reading remain constant. Rapidly squeeze the rubber bulb at the bottom of the volumeter so that a soap bubble enters the volumeter tube. Note the time, in seconds, for it to move between marks representing a known volume. 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 range. Note also the temperature, atmospheric pressure and the manometer reading at each air flow.

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

B.2.4 Calculation

At each calibration point, calculate a flow rate corrected for temperature and pressure from the equation

$$q_0 = \frac{pV \times 296 \times 60}{111{,}6 \times Tt}$$

$$= \frac{159{,}1\, pV}{Tt}$$

where

q_0 is the flow rate, expressed in millilitres per minute, corrected to 111,6 kPa [normal atmospheric pressure (101,3 kPa) plus nominal operating pressure (10,3 kPa)] and 23 °C;

p is the sum, in kilopascals, of actual atmospheric pressure plus pressure differential indicated by the manometer (a manometer reading of 1 mm = 9,78 Pa at 23 °C);

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

T is the temperature reading, in kelvins ($T = 273 + \theta$, where θ is the temperature reading in degrees Celsius);

t is the time, in seconds.

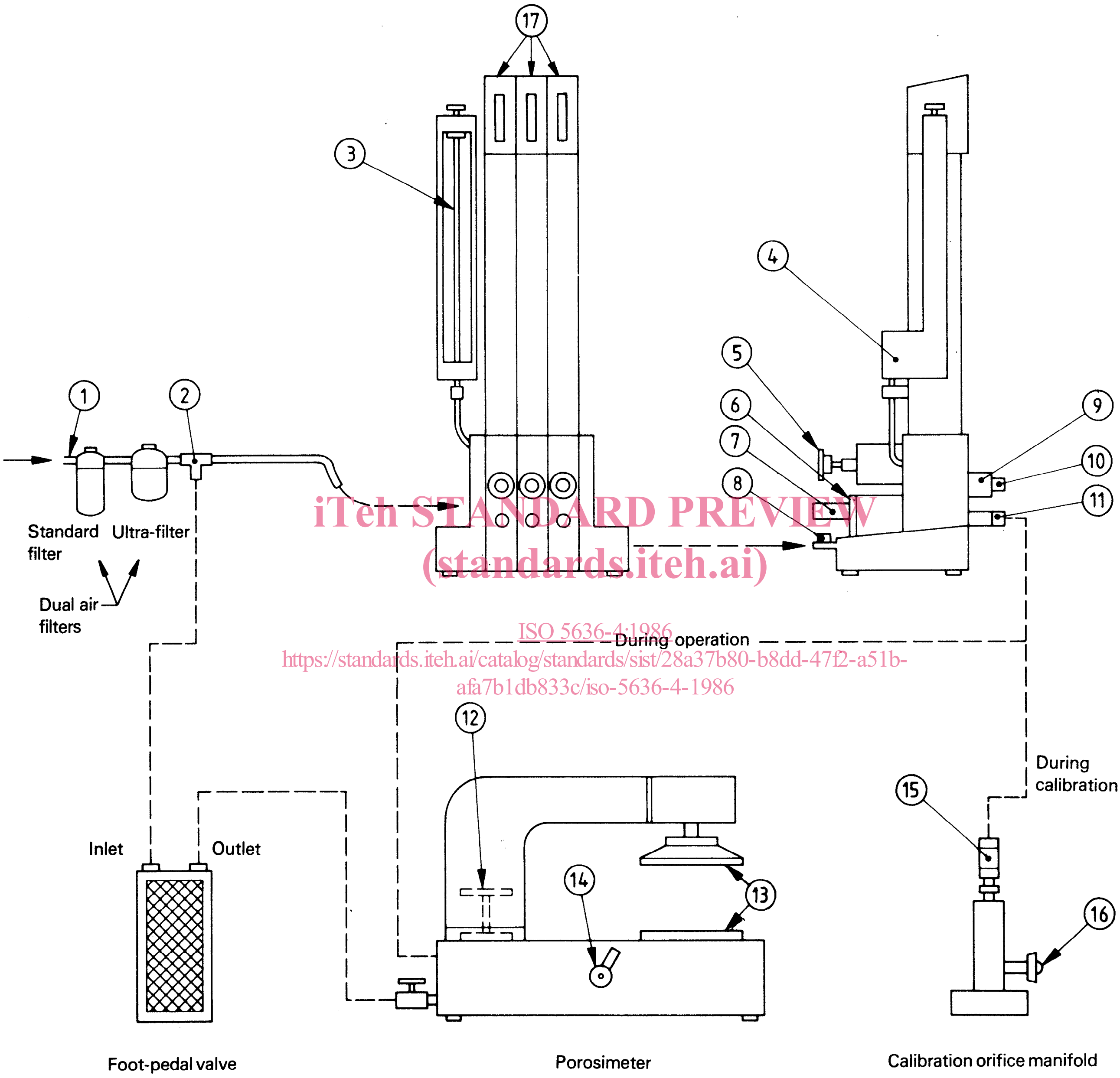
B.2.5 Precision

This method of calibration gives satisfactory accuracy for atmospheric conditions of test which do not deviate appreciably from 101,3 kPa and 23 °C.

B.3 Construction of calibration graph

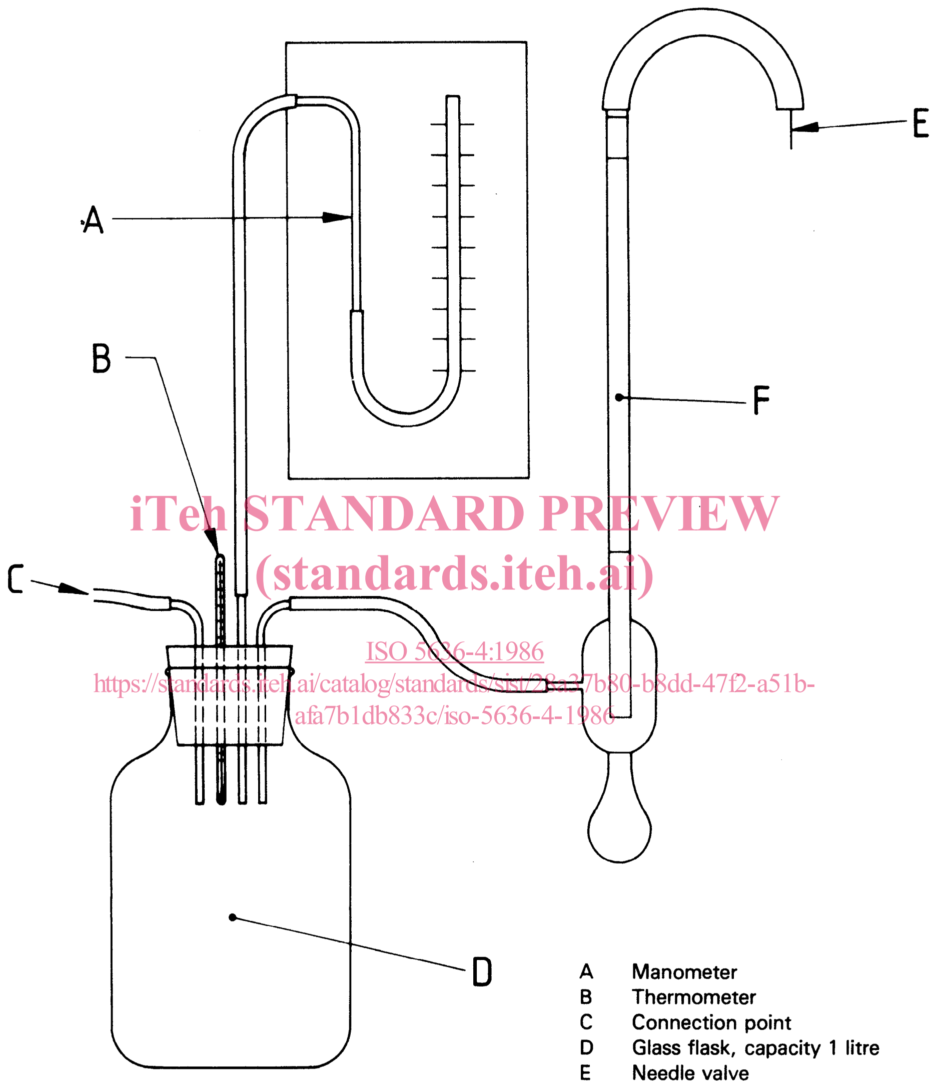
Construct a graph of scale reading against true air flow rate for each flowmeter. The graph should be a straight line and the results from the three flowmeters should all lie on the same line. If not, there is a defect in either the flowmeter tubes or the standard orifice manifold.

It is convenient to indicate on the flow rate axis values for the calculation in clause 11 for any particular test area which is frequently used. The calibration graph can then be used to convert scale reading directly into air permeance.



1 Air supply
2 "Tee" fitting
3 Manometer 10,3 kPa
4 Mercury reservoir
5 Regulator 10,3 kPa, with knob
6 Pressure indicator
7 Primary regulator
8 Shut-off valve
9 Calibrating knob
10 Float position knob
11 Quick-disconnect coupling
12 Clamp pressure regulator
13 Rubber orifice plates
14 Bypass switch
15 Calibration orifice manifold
16 Orifice air valve
17 Flowmeters

Figure 1 — Sheffield porosity tester



A Manometer
B Thermometer
C Connection point
D Glass flask, capacity 1 litre
E Needle valve
F Volumeter

Figure 2 — Soap-bubble meter