INTERNATIONAL STANDARD

ISO 5636-3

Second edition
1992-09-15

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

Part 3: Bendtsen method

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

Partie 3: Méthode Bendtsen

Reference number
ISO 5636-3:1992(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 5636-3 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Sub-Committee SC 2, *Test methods and quality specifications for paper and board*.

This second edition cancels and replaces the first edition (ISO 5636-3:1984), of which it constitutes a technical revision.

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*

Annexes A and B form an integral part of this part of ISO 5636.

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

Introduction

ISO 5636 specifies methods 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 requirements given in ISO 5636.

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

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

Part 3:
Bendtsen method

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 Bendtsen apparatus.

NOTE 1 The instrument can also be used to measure roughness [see ISO 8791-2:1990, *Paper and board — Determination of roughness/smoothness (air leak methods) — Part 2: Bendtsen method*].

The method is applicable to papers and boards having air permeances between 0,35 µm/(Pa·s) and 15 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.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 5636. 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 5636 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 186:1985, *Paper and board — Sampling to determine average quality.*

ISO 187:1990, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples.*

ISO 5636-1:1984, *Paper and board — Determination of air permeance (medium range) — Part 1: General method.*

3 Definition

For the purposes of this part of ISO 5636, the following definition applies.

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

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

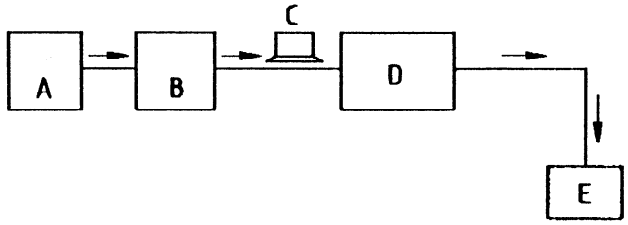
4 Principle

Clamping a test piece between a circular gasket and an annular flat surface of known dimensions. The absolute air pressure on one side of the test area of the test piece is equivalent to atmospheric pressure and the difference in pressure between the two sides of the test 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.

5 Apparatus

The apparatus consists of a compressor (A) and pressure stabilizing reservoir (B) to supply air, a flowmeter (D) with a pressure controlling device (C) and a measuring head (E) (see figure 1).

Annex A gives details of the maintenance of Bendtsen testers.



A: Compressor
B: Pressure stabilizing reservoir
C: Pressure controlling device
D: Central unit
E: Sample clamping device

Figure 1 — Flow diagram of test apparatus

5.1 Compressor.

The compressor shall generate air at a pressure of about 127 kPa. If necessary, filters shall be provided to ensure that the air is clean and free of oil.

5.2 Pressure stabilizing reservoir.

The pressure stabilizing reservoir shall have a volume of about 10 litres and shall be installed between the compressor and the flowmeter.

NOTE 2 This item is not normally supplied with the apparatus. Its provision, or some other means of providing a stable air flow, is the user's responsibility.

5.3 Pressure controlling device.

The air pressure shall be controlled by a pressure controlling device at the inlet of the flowmeter. Most Bendtsen instruments are provided with three interchangeable manostat weights which control the air pressure at 0,74 kPa ± 0,01 kPa, 1,47 kPa ± 0,02 kPa and 2,20 kPa ± 0,03 kPa. The nominal air pressure should be marked on each weight. However, the standard pressure is 1,47 kPa and this manostat weight shall be used when testing in accordance with this part of ISO 5636.

5.4 Flowmeter.

The flow rate shall be measured by variable area flowmeters which offer optional flow rate measurements in the ranges 5 ml/min to 150 ml/min, 50 ml/min to 500 ml/min and, on some instruments, 300 ml/min to 3 000 ml/min. These variable area flowmeters shall be capable of being read to within 2 ml/min, 5 ml/min and 20 ml/min respectively.

NOTE 3 Other methods of measuring flow rate are permitted provided they can be read to at least the accuracy given in the previous paragraph. If such a method is used, it should be described in the test report.

One capillary tube shall be provided for verifying the calibration of each variable area flowmeter. The capillary tubes shall be within the working range of the relevant flowmeter and shall themselves be accurately calibrated against a reliable standard (for example a soap-bubble meter) under the same pressure difference as that in the measuring head (annex B gives details of calibration of capillary tubes and variable area flowmeters).

5.5 Measuring head.

The measuring head consists of a device in which the test piece is clamped between an annular flat surface and a circular rubber gasket. Both the annular ring and the gasket shall be of such dimensions that the test area of the test piece enclosed by either of them is 10 cm^2 ± 0,2 cm^2. The tubing used to connect the head to the flowmeter shall be made of rubber or plastics material, 7 mm ± 0,5 mm in internal diameter, 9 mm in external diameter and 690 mm ± 10 mm long.

NOTES

4 A longer length of tubing results in a significant pressure drop between the flowmeter and the measuring head.

5 The valve at the outlet of the flowmeter has two outlets. For air permeance measurement the tubing is connected to the larger diameter outlet.

6 Sampling

Sampling shall be carried out in accordance with ISO 186.

7 Conditioning

Unless otherwise specified, samples shall be conditioned in accordance with ISO 187.

8 Preparation of test pieces

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

Not less than 10 test pieces shall be cut and their two surfaces identified, for example top side and wire side. The minimum size of the test piece shall be 50 mm × 50 mm. The test area shall be free from folds, wrinkles, holes or defects normally not inherent in the paper or board.

Do not handle that part of the test piece which will become part of the test area.

9 Procedure

9.1 Test atmosphere

Testing shall be carried out under the same atmospheric conditions as those used to condition the samples.

9.2 Determination

9.2.1 Place the instrument on a rigid level bench. Level the instrument and turn on the air supply and ensure that no vibration can cause erroneous readings.

9.2.2 Decide which variable area flowmeter will be used for the test, selecting, where possible, the variable area flowmeter which will give readings greater than 20 % of the scale range with 1,47 kPa.

NOTE 6 Readings on variable area flowmeters are unreliable at the low end of the scale range.

Do not use air flows above 1 200 ml/min, because at high air flows the pressure drop between the flowmeter and the measuring head can be sufficient to render the calibration of the variable area flowmeter invalid.

Set the valves at the bottom of the variable area flowmeters so that air flows through the selected variable area flowmeter. Start the air flow and gently place the manostat weight corresponding to a pressure of 1,47 kPa on the shaft and start it spinning. It should continue to spin smoothly.

NOTE 7 The manostat weight should not be placed on the shaft until the air flow has started and should be removed before the air flow has stopped.

9.2.3 Set the valve at the outlet of the flowmeter so that air flows through the appropriate outlet.

9.2.4 Verify the calibration of the variable area flowmeter by temporarily replacing the measuring head with the appropriate calibrated capillary tube. The air flow reading should agree with the correct reading for that capillary to within 5 %.

9.2.5 With the measuring head connected to the flowmeter, clamp a smooth non-metallic rigid plate against the gasket and check that the rotor of the variable area flowmeter comes to rest at the bottom of the variable area flowmeter. If not, check the measuring head for leaks as described in A.1.

9.2.6 Clamp the test piece in the measuring head and record the variable area flowmeter reading at least 5 s after clamping, with the reading accuracy indicated in 5.4.

NOTE 8 If a high clamping pressure is used, the gasket can be deformed.

9.2.7 Test the remaining test pieces by the same method, ensuring that in half the tests one face of the test piece is in contact with the gasket and in the other half the other face of the test piece is in contact with the gasket.

9.2.8 After completing the tests, remove the manostat weight and then switch off air supply.

10 Expression of results

10.1 Calculation of air permeance (P)

Convert the result obtained to give the air permeance (P) of each test piece, in micrometres per pascal second, by means of the formula:

$$P = 0{,}011\ 3\ q$$

where q is the rate of flow of air, expressed in millilitres per minute, passing through the test area.

10.2 Arithmetic mean

Calculate the arithmetic mean of the air permeance, in micrometres per pascal second, to two significant figures. If there is evidence of a significant difference between the results for each direction of air flow through the test piece, a separate mean for each shall be calculated.

10.3 Standard deviation

Calculate the standard deviation or coefficient of variation of the air permeance for all replicate test results to two significant figures.

11 Precision

No statement on the precision of the method can be made at present but it is intended to provide this information in a future revision of this part of ISO 5636.

12 Test report

The test report shall include the following information:

a) a reference to this part of ISO 5636;

b) the date and place of testing;

c) all the information necessary for the 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 manostat weight used if different from that corresponding to a pressure of 1,47 kPa;

h) the flowmeter range used;

i) the arithmetic mean or means (see 10.2);

j) the standard deviation or coefficient of variation (see 10.3);

k) any deviation from the procedure specified.

Annex A
(normative)

Maintenance of Bendtsen testers

A.1 Checking for air leaks

Check for air leaks in the head by clamping a smooth, rigid, hard plastics plate against the gasket as described in clause 9, using the 5 ml/min to 150 ml/min variable area flowmeter. If the rotor does not remain at rest at the bottom of the variable area flowmeter, inspect the plate for damage or imperfections, making sure the rubber gasket is protruding sufficiently to contact the plate firmly and ensuring that it is in good condition. Check air lines and fittings for leaks.

A.2 Manostat weight

Care shall be taken when handling the manostat weight to avoid damage to the rim. In particular, it shall not be placed on the shaft until the air flow has been started and shall be removed before it has stopped.

Check that the axial hole through the weight is clean. Using a junction piece, connect a water manometer and a suitable capillary to the outlet of the flowmeter and check that the pressure at this point is within 5 % of the desired manometer reading when the air flow is as follows.

a) 5 ml/min to 150 ml/min variable area flowmeter

Air flow (ml/min)	10	100	150
Desired manometer reading (mm)	152	150	148

b) 50 ml/min to 500 ml/min variable area flowmeter

Air flow (ml/min)	50	100	300	500
Desired manometer reading (mm)	152	151	149	146

c) 300 ml/min to 3 000 ml/min variable area flowmeter

Desired manometer reading (mm): 150 ± 10 at all flow rates, up to 1 200 ml/min.

To ensure that the pressure drop between this point and the test piece is not significant, the connecting tube to the head shall be 7 mm ± 0,5 mm in internal diameter and 690 mm ± 10 mm long.

The manostat weight shall not be lubricated.

A.3 Movement of floats

Check that the floats spin freely in the variable area flowmeter tubes (a float which does not spin well can give stable readings). A spinning float has a self-cleaning action and is less likely to give errors by sticking to the walls of the variable area flowmeter tubes. Check the conditions of the flutes as this mainly determines whether it will spin properly, especially at low flow rates. Other factors important for good spinning are mechanical symmetry and the condition of the top rim.

If a float becomes wedged in the spring at the bottom or the top of a variable area flowmeter tube, tap the instrument lightly while passing air through the tube. If this fails to free the float, loosen the bottom and top bushings around the tubes with a special spanner, take off the metal block at the top of the variable area flowmeter and remove the variable area flowmeter tube. A recurrence of sticking can be prevented by adjusting the shape of the spring. The bottom spring should terminate in a horizontal loop centred in the variable area flowmeter. The top spring should terminate in a vertical loop centred in the variable area flowmeter.

A.4 Cleaning variable area flowmeters

If a variable area flowmeter tube or float is dirty, giving high readings, a liquid detergent may be used to clean the tube. If so, add the detergent to the tube, flush with water, reversing the flow several times, and use diluted aqueous solution [about 10 % (V/V)] to clean the float. Finally, rinse both with distilled water, and dry in a stream of air.

A solvent, such as carbon tetrachloride or similar may be used as an alternative to the detergent provided that adequate safety precautions for the selected solvent are applied.

Replace faulty tubes.