INTERNATIONAL STANDARD

ISO 5636-5

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

Part 5: Gurley method

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

Partie 5: Méthode Gurley

Reference number
ISO 5636-5:2003(E)

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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 5636-5 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 5636-5:1986), which has been technically revised.

In this edition, the factor to be used for the calculation of air permeance (10.1) has been changed to 135,3 (from calculation factor 127 in the first edition). The new factor for calculation of air permeance will cause an increase in the level of the result of approximately 7 %. To avoid confusion in trade due to the fact that some laboratories are not aware of this new edition and thus will still use the factor 127, it is important to report the calculation factor used.

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

— *Part 1: General method*

— *Part 2: Schopper method*

— *Part 3: Bendtsen method*

— *Part 4: Sheffield method*

— *Part 5: Gurley method*

Introduction

This part of ISO 5636 describes a method for measuring the air permeance or, if required, the air resistance of paper and board using the measurement principle known as “Gurley”. The air pressure within the cylinder varies slightly according to the displacement of the cylinder, but it has been shown that the variation is about 1,2 % of the mean pressure for 100 ml of displacement and about 4 % for a cylinder with a displacement of 400 ml. Because these variations are within the 5 % limit specified in ISO 5636-1, the apparatus complies with the general requirements detailed in ISO 5636-1 and the air-permeance results may be expressed in micrometres per pascal second [μm/(Pa·s)].

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

Part 5:
Gurley method

1 Scope

This part of ISO 5636 specifies the Gurley method of determining the air permeance of paper and board. It is applicable to papers and boards which have air permeances between 0,1 µm/(Pa·s) and 100 µm/(Pa·s). It is unsuitable for rough-surfaced materials, which cannot be securely clamped to avoid leakage.

This method may also be used to determine the air resistance of paper and board.

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 48, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD*

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 385-1, *Laboratory glassware — Burettes — Part 1: General requirements*

ISO 3104, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*

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

3 Terms and definitions

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

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

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

3.2
air resistance
time required for a specific volume of air under unit pressure to pass through unit area

NOTE Air resistance is expressed in seconds per 100 millilitres [s/(100 ml)].

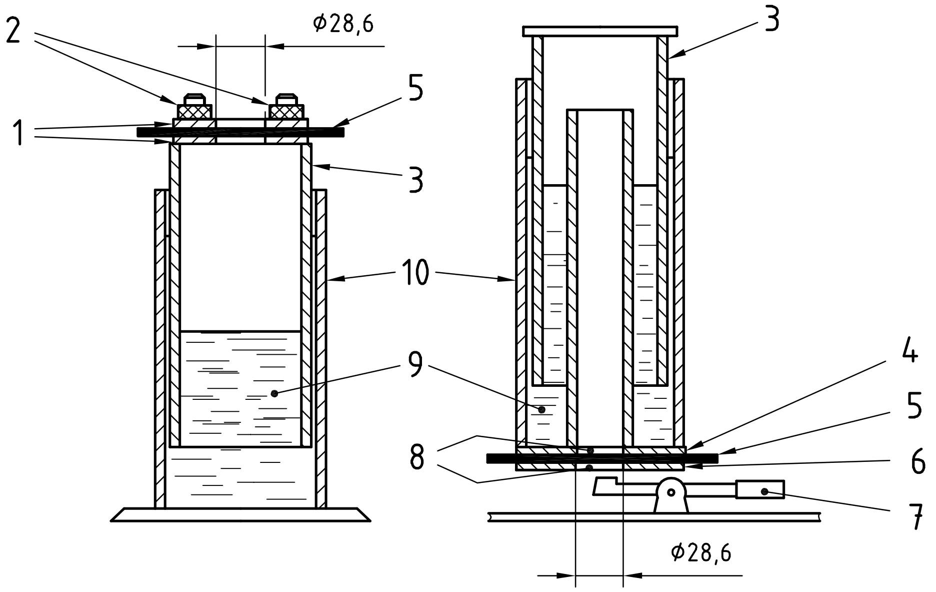
4 Principle

Air is compressed by the weight of a vertical cylinder floating in a liquid. A test piece is in contact with the compressed air and the cylinder falls steadily as air passes through the test piece. The time for a given volume of air to pass through the test piece is measured and from this the air permeance is calculated.

5 Apparatus and materials

5.1 Air-resistance apparatus (Gurley tester), a diagrammatic sketch of which is shown in Figure 1, consisting of an outer cylinder partly filled with sealing fluid, and an inner cylinder, having an open or closed top, sliding freely in the outer cylinder. Air pressure, provided by the weight of the inner cylinder, is applied to the test piece held between clamping plates in a circular orifice. The clamping plates are at the top if the inner cylinder is open, or at the base of the apparatus if the top of the cylinder is closed. The latter arrangement is preferred (see Annex A). An elastic gasket attached to the clamping plate on the side exposed to the air pressure prevents leakage of air between the surface of the paper and the clamping plate.

Dimensions in millimetres



Key

1 clamping plates and gasket
2 knurled nuts
3 inner cylinder mass 567 g
4 gasket
5 test piece
6 clamping plate
7 loading lever
8 holes for egress of air
9 oil
10 outer cylinder

Figure 1 — Diagrammatic sketch of air-resistance (Gurley) apparatus

The gasket consists of a thin, elastic, oil-resistant, non-oxidizing material, having a smooth surface, a thickness of 0,7 mm to 1,0 mm and a hardness of 50 IRHD to 60 IRHD (International Rubber Hardness Degrees) in accordance with ISO 48. The inside diameter of the gasket is about 28,6 mm and the outside diameter is about 34,9 mm. The aperture of the gasket is concentrically aligned with the aperture in the clamping plates. To align and protect the gasket in use, it is cemented to a groove machined in the inner clamping plate. The groove is concentric with the aperture in the opposing plate. Its internal diameter is 28,50 mm ± 0,15 mm and its depth 0,45 mm ± 0,05 mm. Its outside diameter is 35,2 mm ± 0,1 mm for convenience in inserting and attaching the gasket. The gasket when mounted inside the concentric groove defines the measurement area and shall have an inside diameter of 28,6 mm ± 0,1 mm (6,42 cm^2 area). The gasket should be changed at regular intervals.

The outer cylinder has a height of 254 mm and an internal diameter of 82,6 mm. The inner surface has three or four bars, not less than 190 mm and not greater than 245,5 mm in length, and 2,4 mm square or 2,4 mm diameter, spaced equidistantly to serve as guides for the inner cylinder.

The inner cylinder is made of aluminium alloy, is graduated in units of 50 ml and has a full-scale reading of at least 300 ml. Some cylinders may have 25 ml graduations between 0 ml and 100 ml markings. The scale markings represent true volumes enclosed within the inner cylinder and, in most instruments, are accurate to within 0,5 %. The exact volume of the inner cylinder may be checked by means of the procedure given in Annex B. The cylinder has a height of 254 mm ± 0,5 mm, an external diameter of 76,2 mm ± 0,5 mm and an internal diameter about 74 mm such that the mass of the cylinder assembly is 567 g ± 0,5 g.

The volumes referred to are nominal volumes and should, in principle, be increased by the volume of fluid displaced by the walls of the inner cylinder during the test; in practice, since this error is common to all instruments of this type, it is ignored. For one instrument, the actual volume delivered between the 100 ml and 200 ml marks was measured to be 106 ml.

5.2 Sealing fluid, oil having a density of 860 kg/m^3 ± 30 kg/m^3 (0,86 g/cm^3 ± 0,03 g/cm^3), a viscosity of 16 cP to 19 cP at 20 °C in accordance with ISO 3104, and a flash point of at least 135 °C. (The change in specification of the oil viscosity from that of a kinematic viscosity of 10 mm^2/s to 13 mm^2/s at 38 °C is based on the typical physical properties of lightweight paraffin oils.)

5.3 Ancillary equipment, stopwatch, or electric timer to be accurate to within 0,5 % at all levels and capable of being read to the nearest 0,2 s.

6 Sampling

Sampling is not included in this International Standard. If the mean quality of a lot is to be determined, sampling shall be 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 sample in accordance with ISO 187.

8 Preparation of test pieces

One test piece cut from each of ten specimens is normally sufficient (but see 10.3).

Where the clamping plates of the apparatus are at the top of the inner cylinder, a convenient test-piece size is 50 mm × 120 mm; for apparatus having the clamp in the base, a 50 mm square is adequate.

9 Procedure

9.1 Determination

Carry out the test in the same atmospheric conditions as used to condition the sample.

Place the instrument on a level surface so that the cylinders are vertical. Check the oil level in the outer cylinder to make certain it is at a depth of about 120 mm as indicated by a ring marked on the inner surface of the cylinder.

For an instrument having the clamp in the base, raise the inner cylinder until its rim is supported by the catch, clamp the test piece between the clamping plates, release the catch and then lower the inner cylinder until it floats.

For instruments with the clamp in the base; and, for those papers where surface air leakage or leakage through the sheet may be a problem, the clamping force should be controlled to ensure repeatability. The clamping force should be repeatable and set at a minimum force of 150 N.

For an instrument having the clamp in the top of the inner cylinder, raise the inner cylinder with one hand, clamp the test piece with the other, then lower the inner cylinder and allow it to float in the oil. Alternatively, see hereafter, the inner cylinder may be removed, the test piece clamped, and the inner cylinder lowered gently into the outer cylinder.

NOTE The proper procedure is to tighten the knurled nuts alternately so that the clamping pressure will be the same on both sides. If only one nut at a time is tightened, the clamp will not bear evenly on the test piece and air leakage will probably occur.

If the alternative procedure is used, it should be carried out very carefully to avoid spillage of oil on the test piece, reduction in volume of oil and contamination of the oil.

Once the cylinder attains steady movement, measure the time, in seconds, required for the first two consecutive 50 ml scale markings to pass the rim of the outer cylinder. The time shall be measured with the following precision:

— up to 60 s: to the nearest 0,2 s;

— greater than 60 s: to the nearest 1 s.

For relatively impermeable papers and boards, the reading may be taken at the end of the first 50 ml interval. With very open or porous papers, a larger volume of air may be timed. If a steady movement of the inner cylinder is not attained before the zero mark is reached, timing may be started at the 50 ml mark.

If a volume other than 100 ml is measured, calculate the time t based on 100 ml.

It is essential to avoid vibration of the apparatus, as this increases the rate of air displacement.

9.2 Number of tests

Test a minimum of ten specimens, five with the top side up and five with the top side down.

10 Expression of results

10.1 Calculate the air permeance, to two significant figures, from the formula:

$$P = \frac{135{,}3}{t}$$

where

P is the air permeance, in micrometres per pascal second;

t is the mean time, in seconds, for the passage of 100 ml of air (as measured on the volume marks on the cylinder).

This formula is based on a mean pressure difference of 1,22 kPa and a test area of 6,42 cm^2 and an actual volume of 106 ml of air passing through the test specimen measured at room pressure.

NOTE Due to the testing principle of this method, the actual pressure in the instrument decreases as the cylinder descents into the oil and the actual volumes passing through the test piece are slightly greater than the scale volumes. In practice, since these errors are common to all instruments of this type, they are ignored.

It should be observed that there is a systematic error of around 6 % when comparisons are made with results achieved by other methods described in ISO 5636-1.

10.2 If the standard deviation is required, calculate this from the replicate time measurements and correct to micrometres per pascal second using the formula in 10.1.

10.3 If the mean air permeances measured on the two sides are significantly different and if this difference is required to be shown in the test report, ten tests are required for each face. The results shall then be reported separately.

10.4 If the air resistance is required, this shall be reported as “Air resistance (Gurley)” in seconds and is the time, t, obtained in 10.1. Report values to two significant figures.

11 Precision

When two sets of test pieces from the same sample are tested in the same laboratory by the same operator, the two average test results can be expected to agree, 95 % of the time, within 10 %.

No information is available for reproducibility.

12 Test report

The test report shall include 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 conditioning atmosphere used;

f) the number of test pieces tested;

g) the air permeance, in micrometres per pascal second, to two significant figures or, if required, the air resistance, in seconds per 100 millilitres, to two significant figures;

h) the standard deviation or coefficient of variation, if required;

i) any deviations from the specified procedure.

Annex A
(informative)

Variations in apparatus

Reference was made in 5.1 to the existence of two versions of the apparatus. In one version, the clamping plates are mounted on top of the floating inner cylinder. In the other version, the plates are mounted in the fixed base portion of the apparatus, and all the dimensions quoted relate to the current model of this version.

Many examples of earlier models of this instrument also exist. The earliest models were not fitted with gaskets, although it is believed that all of those made since the end of 1945 are so fitted. In these, the dimensions are slightly different, but no significant difference in the results is to be expected. It appears that the inside diameter of the gasket and the groove have been varied slightly so that, at times, it has been necessary to stretch the gasket slightly to fix it into the groove. The effective test area, however, always seems to have been within 1 % of the original 6,452 cm^2 (1 in^2).

Some of the inner cylinders are also graduated in units of 25 ml for the first 100 ml and may have a graduation at the 400 ml interval. On some cylinders, the engraved graduations are replaced by an adhesive graduation label.

Alternative inner cylinders with a mass of 142 g are available. Air flows obtained with these cylinders are approximately 1/4 of those obtained with the 567 g cylinders.

Alternative clamps to expose 1,61 cm^2 (diameter 14,3 mm) or 0,64 cm^2 (diameter 9,0 mm) are available and these give air flows about 1/4 and 1/10 of normal.

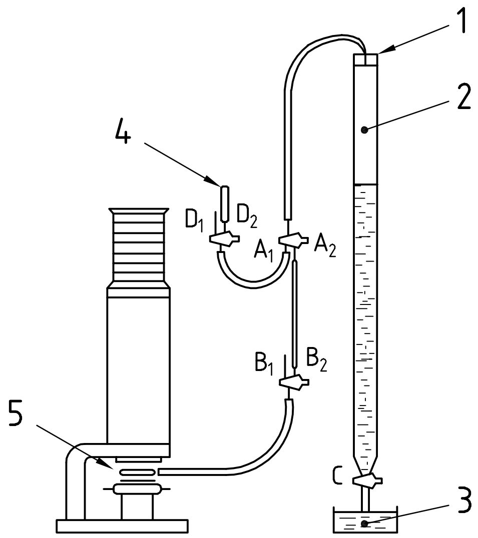
The use of the alternative cylinders or clamps referred to above shall be reported because the results can be converted only approximately to those which would be obtained with the standard apparatus.

Annex B
(normative)

Volume calibration

Check the apparatus for air leakage by clamping a thin sheet of smooth, rigid, impermeable metal or plastic between the orifice plates. Using the procedure in 9.1, the leakage shall not exceed 50 ml in 5 h. If there is a leak exceeding 50 ml in 5 h, repeat the check with a sheet of soft rubber in place of the hard-surfaced material. No air will then escape at the clamping plates and leaks elsewhere can be detected. Seal any leaks with neoprene or another suitable adhesive.

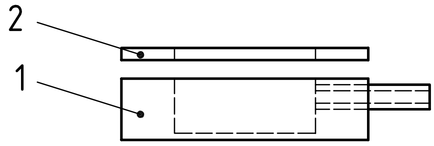
Check the volume of the inner cylinder with the apparatus shown in Figure B.1. By means of a special adaptor plate (Figure B.2), connect the Gurley apparatus to a 100 ml class A burette, in accordance with ISO 385-1, graduated in 0,2 ml through two glass stopcocks A and B. Connect another stopcock D to a vacuum line and to stopcock A. For all connections use rubber pressure tubing.



Key

1 rubber stopper
2 100 ml burette
3 water collected
4 connection to vacuum
5 adaptor plate
A to D stopcocks

Figure B.1 — Calibration apparatus



Key

1 brass
2 rubber

Figure B.2 — Adaptor plate

Fill the burette with water by opening stopcocks A_2, D_2 and C, in that order, until the water level is above the 35 ml mark. Restore atmospheric pressure in the burette by opening D_1. Open B_1, and raise the inner cylinder above the oil level so that its zero mark is about 1,5 mm above a reference point on the outer cylinder. Open A_2 and B_2 and bring the zero mark exactly to the reference point by running water from the burette. Check for air leaks by allowing the apparatus to stand for 15 min. If the cylinder has moved, check all connections for leakage.

Adjust the zero mark exactly to the reference point and read the burette to the nearest 0,1 ml. Run water from the burette until the first 50 ml mark on the inner cylinder coincides with the reference point and read the burette again to the nearest 0,1 ml. The difference between the readings gives the volume of air delivered by the Gurley apparatus for the first 50 ml interval.

Perform three measurements for each 50 ml interval from zero to full scale and calculate the mean of each set of three. If the three measurements are not within 1,0 ml of the mean, repeat the measurements. Subtract 5,7 % from each mean value to compensate for the volume of fluid displaced by the walls of the inner cylinder, change in oil levels between the cylinders, and the change of pressure within the inner cylinder. If the error is more than 3 %, compile a correction table for the graduation of the inner cylinder.

An alternative procedure that does not require the use of a calibrated 100 ml burette is to weigh the volume of water collected to the nearest 0,1 g and determine the volume by calculation using the density of water.

ICS 85.060

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