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International Standard



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**Paper and board — Determination of air permeance  
(medium range) —  
Part 5: Gurley method**

*Papier et carton — Détermination de la perméabilité à l'air (valeur moyenne) — Partie 5: Méthode Gurley*

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## Foreword

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International Standard ISO 5636/5 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*.

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# Paper and board — Determination of air permeance (medium range) — Part 5: Gurley method

## 0 Introduction

This part of ISO 5636 describes a method for measuring the air permeance 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 1,2 % of mean pressure for 100 ml of displacement and 3,3 % for the full scale displacement of 350 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 results may be expressed in micrometres per pascal second [ $\mu\text{m}/(\text{Pa}\cdot\text{s})$ ].

## 1 Scope and field of application

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 and 100  $\mu\text{m}/(\text{Pa}\cdot\text{s})$ . It is unsuitable for rough surfaced materials, such as creped or corrugated papers, which cannot be securely clamped to avoid leakage.

## 2 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*.

## 3 Definition

For the purpose of this International Standard, 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 micrometres per pascal second [ $1 \text{ ml}/(\text{m}^2\cdot\text{Pa}\cdot\text{s}) = 1 \mu\text{m}/(\text{Pa}\cdot\text{s})$ ].

## 4 Principle

Compression of air 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 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 of diameter 28,66 mm. The clamping plates are at the top if the inner cylinder is open, or at the base of the apparatus if the top is closed. The latter arrangement is preferred (see annex A). An elastic gasket which is 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.

The gasket consists of a thin, elastic, oil-resistant, non-oxidizing material, having a smooth surface, a thickness of 0,7 to 1 mm and a hardness of 50 to 60 IRHD. The inside diameter of the gasket is  $28,6 \pm 0,1$  mm (area 6,42 cm<sup>2</sup>) and the outside diameter  $34,9 \pm 0,1$  mm. The aperture of the gasket is accurately 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 clamping plate. The groove is concentric with the aperture in the opposing plate. Its internal diameter is  $28,41 \pm 0,04$  mm and its depth  $0,45 \pm 0,05$  mm. Its outside diameter is  $35,2 \pm 0,1$  mm for convenience in inserting and attaching the gasket.

NOTE — Some instruments have a groove of 28,65 mm internal diameter which requires the gasket to be stretched slightly to fit.

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 total range of 350 ml. The volume tolerance is 0,5 %. It has a height of 254 mm, an external diameter of 76,2 mm and an internal diameter of 74,1 mm. Its mass is  $567 \pm 0,5$  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 from the normal source, it is ignored.

The volume of the inner cylinder may be checked by means of the procedure given in annex B.

**5.2 Sealing fluid:** oil having a density of approximately 860 kg/m<sup>3</sup> (0,86 g/ml), a kinematic viscosity of 10 to 13 mm<sup>2</sup>/s (60 to 70 s Saybolt) at 38 °C and a flashpoint of at least 135 °C.

**5.3 Ancillary equipment:** stopwatch, or electric timer capable of recording time to the nearest 0,2 s.

## 6 Sampling

Sampling shall be carried out in accordance with ISO 186.

## 7 Conditioning

Conditioning shall be carried out in accordance with ISO 187.

## 8 Preparation of test pieces

One test piece cut from each of ten selected 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 Checking

Test 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 9.3, the leakage shall not exceed 50 ml in 5 h.

### 9.2 Test atmosphere

Testing shall be carried out under the same atmospheric conditions as used to condition the test pieces.

### 9.3 Determination

Place the instrument on a level surface so that the cylinders are vertical. Fill the outer cylinder with oil to 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 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, the inner cylinder may be removed, the test piece clamped, and the inner cylinder lowered gently into the outer cylinder.

## NOTES

1 The proper procedure is to tighten the knurled nuts alternately so that the clamping pressure will be equal 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.

2 The alternative procedure 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.

Measure the time, in seconds, required for the first two consecutive 50 ml intervals to pass the rim of the outer cylinder, starting at zero point. The time shall be measured with the following precision:

- < 60 s to the nearest 0,2 s
- > 60 s to < 180 s to the nearest 1 s
- > 180 s to the nearest 5 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.

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

## 9.4 Number of tests

Five test pieces shall be tested with the top side up and five with the bottom side up.

## 10 Expression of results

**10.1** Calculate the air permeance to two significant figures from the formula

$$P = \frac{127}{t}$$

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.

This formula is based on a mean pressure difference of 1,23 kPa and a test area of 6,42 cm<sup>2</sup>.

If a volume other than 100 ml is timed, calculate the result from the formula

$$P = \frac{1,27 V}{t}$$

where  $V$  is the volume timed.

**10.2** If 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 in the two directions through the sheet are significantly different and if this difference is required to be shown in the test report, ten tests are required in each direction. 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 below 10 s to the first decimal place, otherwise 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 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 used for conditioning and testing;
- f) the number of test pieces tested;
- g) the test results;
- h) the standard deviation or coefficient of variation, if required;
- i) any deviations from the specified procedure.

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## Annex A

### Variations in apparatus

(This annex forms part of the standard.)

Reference has been 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 thought 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  $1 \text{ in}^2$  ( $6,452 \text{ cm}^2$ ).

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  $1,61 \text{ cm}^2$  (diameter 14,3 mm) or  $0,645 \text{ cm}^2$  (diameter 9,05 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

### Volume calibration

(This annex forms part of the standard.)

Check the apparatus for air leakage as described in 9.1. 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 other suitable adhesive.

Check the volume of the inner cylinder with the apparatus shown in figure 2. By means of a special adaptor plate (figure 3) connect the Gurley apparatus to a 100 ml burette, graduated in 0,1 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.

Fill the burette with water by opening  $A_1$ ,  $D_2$  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 0 to 350 ml 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 5,4 % from each mean value to compensate for the volume of fluid displaced by the walls of the inner cylinder. If the error is more than 3 %, compile a correction table for the graduation of the inner cylinder.