SCAN-P 85:02
Accepted 2002

SCANDINAVIAN PULP, PAPER AND BOARD
TESTING COMMITTEE

Paper and board

Air permeance

Bendtsen method with pressure correction

0 Introduction

This SCAN-test Method specifies a modified procedure for determining the air permeance of paper and board using a Bendtsen tester. This Method specifies a compensation for the pressure drop to the measuring head and it thus gives a more accurate but significantly higher value than that obtained according to SCAN-P 60 (12.1).

Note – Traditional Bendtsen testers with variable area flow meters can be used provided they are equipped with an additional pressure meter.

1 Scope

This Method is applicable to all kinds of paper and board having an air permeance between 0,35 µm/Pa s and 50 µm/Pa s, determined under the conditions specified.

The Method is not applicable to papers having such a rough surface that leakage occurs when the sample is clamped in the instrument specified.

2 Reference

ISO 187 Paper, board and pulps – Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples (EN 20187)

Note – SCAN-test has withdrawn a number of test methods and refers instead to the corresponding ISO and/or EN Standards.

3 Definition

For the purpose of this Method, the following definition applies:

3.1 *Air permeance* – The mean flow of air through unit area under unit air-pressure difference in unit time under specified conditions.

Note – The property is called “air permeance” and not “air permeability”, because it is presented as a sheet property and is not normalised with respect to the thickness of the material. It is expressed in micrometres per Pascal second (µm/Pa s).

4 Principle

A test piece is clamped as a partition between a rubber gasket and an annular flat surface leaving a test area of 10 cm^2. One side of the test piece is exposed to air at atmospheric pressure and the other to air at a higher pressure, the pressure difference being maintained at a constant value during the test. The air flow through the test area is measured with an air-flow meter and the air permeance is calculated.

5 Apparatus

5.1 *A Bendtsen air permeance tester, Figure 1,* including:

5.1.1 *A compressed-air-supply system,* that is capable of delivering a sufficient amount of compressed air (depending on the type of instrument used) at a sufficient nominal pressure.

5.1.2 *A pressure regulator* or other means of creating a steady and repeatable nominal measuring pressure of (1,47 ± 0,3) kPa in the measuring head.

> *Note 1* – Alternative pressures (e.g. 0,74 kPa and 2,20 kPa) are often available and can be used to further increase the working range of the instrument. Their use is not, however, in accordance with this Method.

5.1.3 *An air permeance measuring head, Figure 2*, in which the test piece is clamped between a metal ring and a rubber gasket. The rubber gasket shall have a hardness of between 60 Shore A and 70 Shore A. The inner diameter of the gasket shall be (35,68 ± 0,36) mm (corresponding to an area of 10,0 ± 0,2 cm^2). The inner diameter of the metal ring shall have a diameter of (35,84 ± 0,16) mm. The outer diameter of the metal ring shall be 3 mm larger.

> *Note 2* – It has recently been established that it is the inner diameter of the metal ring and not the inner diameter of the gasket which determines the measurement area (12.2). The tolerances given here thus mean that the true measurement area is (10,1 ± 0,1) cm^2. This is, however, within the traditional tolerance of (10,0 ± 0,2) cm^2, and it has therefore been decided not to change the nominal area, but to keep the value of 10,0 cm^2 to which SCAN-P 60 referred.

To clamp the test piece against the gasket, the metal ring is pressed against the paper with a force of not less than 14 N and not more than 22 N, to give a contact pressure of between 80 kPa and 125 kPa.

The metal ring shall be constructed so that the air, which passes through the sample during the test has a free outlet to the atmosphere.

5.1.4 *An air-flow meter,* having a measuring range from 20 ml/min to 3000 ml/min that allows the air flow to be determined with an error of less than ±5 ml/min or ±5 % of the reading whichever is greater.

5.1.5 *A pressure meter* that allows the air pressure in the measuring head to be determined with an error of less than 50 Pa.

6 Calibration and adjustment of apparatus

Place the Bendtsen tester (5.1) in a vibration-free environment or use a vibration-damping foundation. Variable area flow meters must be level. Use a precision spirit level and adjust the instrument, or the table, if necessary. Check and, if necessary, calibrate the tester in accordance with the manufacturer's instruction.

> *Note* – The readings from the instrument are strongly influenced by vibrations. It is therefore important to eliminate this source of error as far as possible.

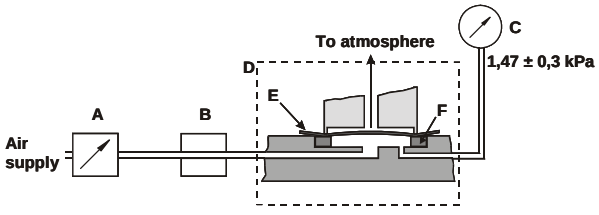

Figure 1. Principle of the Bendtsen tester

A Pressure regulator
B Flow meter
C Pressure meter for measuring the pressure in the measuring head
D Permeance measuring head
E Paper
F Rubber gasket

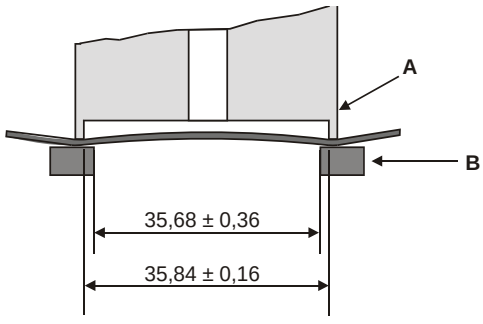

Figure 2. Dimensions of the measuring head (dimensions in millimetres)

A Metal ring
B Rubber gasket

7 Preparation of test pieces

Condition the specimens as specified in ISO 187 and keep them in the conditioning atmosphere throughout the test. Select test pieces from undamaged paper, free from watermarks and from folds, wrinkles or other defects not normally inherent in the paper.

Cut test pieces, at least 10 test pieces, having a minimum size of 50 mm × 50 mm. Mark the test pieces to identify the two sides. Do not handle that part of the test piece, which will become the test area.

8 Procedure

Make the instrument ready for use and select, if applicable, the measuring range for the flow meter. Check for leakage in the system by inserting an impermeable sheet material into the measuring head and ensuring that there is no airflow, and check that the pressure is (1,47 ± 0,3) kPa.

Clamp a test piece in the measuring head (5.1.3). Record the air flow, u, and, if applicable, the corresponding measuring pressure, P_m , in the air permeance head after (4 ± 1) s.

Repeat the test, with the remaining test pieces until in total 10 approved results are obtained. In half of the tests, the top side of the test pieces shall face the gasket; in the other half, the top side shall face the ring.

9 Calculation

Note – If the results are measured in an instrument without compensation for the pressure drop out to the measuring head and without a pressure meter connected to the measuring head, only readings of 1200 ml/min and below are in accordance with this Method. In such instruments and in instruments that automatically compensate for the pressure drop to the measuring head, use the values as reported**.**

If no correction is made in the instrument, calculate the air permeance from the expression:

$$X = \frac{0{,}01667 \cdot u}{P_m} \qquad [1]$$

where

X is the air permeance, in micrometer per Pascal second (µm/Pa s);

u is the air flow, in millilitres per minute;

P_m is the measured pressure at the measuring head, in kilopascal (kPa).

Calculate and report the mean air permeance with two significant figures. If there is evidence of a significant difference between the results for the two directions of air flow through the test piece, calculate a separate mean for each direction.

Calculate and report the standard deviation or coefficient of variation for the replicate tests.

10 Report

The test report shall include reference to this SCAN-test Method and the following particulars:

(a) date and place of testing;
(b) description and identification of the material tested;
(c) if relevant, the side of paper tested;
(d) the test results as specified above;
(e) the standard deviation or coefficient of variation;
(f) any departure from the procedure described in this Method and any other circumstances that may have affected the results.

11 Precision

Sets of test pieces taken from the same gross samples of five different paper grades were tested at five different laboratories. Each test result is based on 20 test pieces. The results are presented in *Table 1*, the papers being presented in order of increasing mean air permeance.

Table 1.

Sample	Air permeance, µm/Pa s	Within-test CV, %	CV between labs, %
Newsprint 1, 45 g/m^2	2,3	12	15
Newsprint 2, 45 g/m^2	2,6	6	13
Sack paper 1, 70 g/m^2	6	5	6
Fine paper, 100 g/m^2	7,4	7	2
Sack paper 2, 70 g/m^2	10	8	5
Mean	5,7	7,6	8,2

CV is the Coefficient of Variation, i.e. the standard deviation expressed as a percentage of the mean. CV is fairly constant among the samples, and mean coefficients of variation have thus been calculated as the root mean squares of the coefficients for the different materials. The reproducibility limit, R, calculated as $R = t\sqrt{2}\,s$ where $t_{(n=5)}$=2,776, is thus 32,2 %. This means that there is a 95 % probability that the means of measurements made at two different laboratories will not differ by more than this amount.

12 Literature

12.1 SCAN-P 60 Paper and board – Air permeance – Bendtsen method

12.2 Unpublished test results, Lorentzen & Wettre

13 Additional information

The Bendtsen tester, but not the measuring head, is the same as that described in SCAN-P 84 Paper and board – Surface roughness – Bendtsen method with pressure correction.

SCAN-test Methods are issued and recommended by KCL, PFI and STFI-Packforsk for the pulp, paper and board industries in Finland, Norway and Sweden.
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SE-114 86 Stockholm, Sweden.