INTERNATIONAL STANDARD

ISO 8791-2

Second edition
2013-09-15

Paper and board — Determination of roughness/smoothness (air leak methods) —

Part 2: **Bendtsen method**

Papier et carton — Détermination de la rugosité/du lissé (méthodes du débit d'air) —

Partie 2: Méthode Bendtsen

Reference number
ISO 8791-2:2013(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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The committee responsible for this document is 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 8791-2:1990), which has been technically revised. In this second edition mainly editorial changes have been made to include the electronic version of the test apparatus and also precision data has been added as an informative Annex.

ISO 8791 consists of the following parts, under the general title *Paper and board — Determination of roughness/smoothness (air leak methods)*:

— *Part 1: General method*

— *Part 2: Bendtsen method*

— *Part 3: Sheffield method*

— *Part 4: Print-surf method*

NOTE *Part 1: General method* is considered to be redundant and will be withdrawn after Parts 2, 3 and 4 have been revised and published.

Paper and board — Determination of roughness/ smoothness (air leak methods) —

Part 2: Bendtsen method

1 Scope

This part of ISO 8791 specifies a method for the determination of the roughness of paper and board using the Bendtsen apparatus.

This part of ISO 8791 is applicable to paper and board which have Bendtsen roughness values between about 5 ml/min and 3 000 ml/min when measured with variable-area type testers and between about 50 ml/min and 5 000 ml/min when measured with electronic type testers. It is not suitable for soft papers which allow the land to make a significant impression on the surface or for high-air-permeance papers which allow a significant flow of air to pass through the sheet, or for papers which will not lie flat under the measuring head.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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*

3 Terms and definitions

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

3.1
Bendtsen roughness
a measure of the rate at which air will pass between a flat circular land and a sheet of paper or board when tested under specified conditions and at operating pressure

Note 1 to entry: Bendtsen roughness is expressed in millilitres per minute.

4 Principle

Clamping a test piece between a flat plate and a circular metal land. Supplying air at a nominal pressure of 1,47 kPa to the space enclosed inside the land and measuring the rate of air flow between the land and the test piece.

5 Apparatus

5.1 Bendtsen tester (two types)

Bendtsen tester, which operates according to one of the following principles of measurement of air flow rate:

— variable-area flowmeter type (see 5.2).

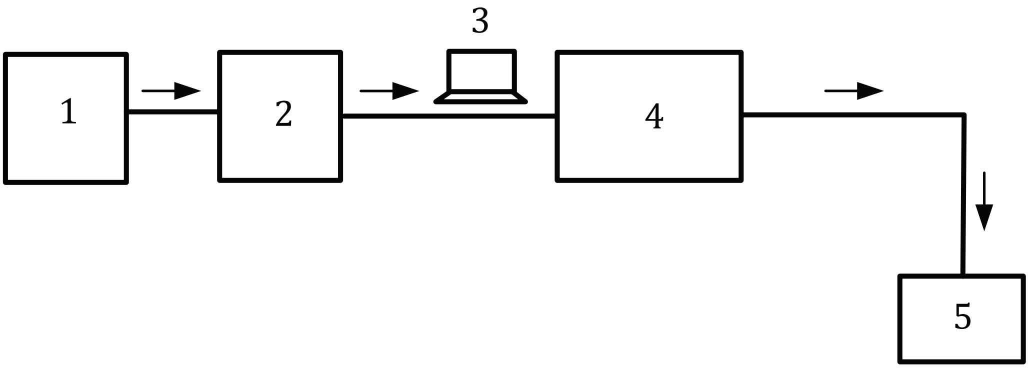
— electronic flowmeter type (see 5.3).

For variable-area flowmeter type testers, the pressure between the flowmeter and the measuring head is known to decrease at high air flow rates (see 10.2.2) which can reduce the accuracy of the flowmeter reading. For electronic flowmeter type testers, the pressure between the flowmeter and the measuring head is automatically controlled.

5.2 Variable-area flowmeter type

A standard pressure difference is created across the measuring land and the air flow rate is measured on a variable-area flowmeter. The apparatus, see Figure 1, consists of a compressor (5.2.1) and pressure stabilizing reservoir (5.2.2) to supply air, a flowmeter (5.2.4) with a pressure controlling device (5.2.3), and a measuring head (5.2.5).

Annex A gives details of care and maintenance of this type of Bendtsen tester.



Key

1 compressor

2 pressure stabilizing reservoir

3 pressure controlling device

4 flowmeter

5 measuring head

Figure 1 — Circuit diagram of variable-area flowmeter type test apparatus

5.2.1 Compressor, capable of generating air at a pressure of about 127 kPa. If necessary, filters shall be provided to ensure that the air is clean and free from oil.

NOTE It is advisable to have the compressor located in a laboratory having the standard atmosphere for conditioning and testing.

5.2.2 Pressure stabilizing reservoir, having a volume of not less than 10 litres, installed between the compressor and the pressure controlling device.

5.2.3 Pressure controlling device to control the air pressure at the inlet of the flowmeter. This shall comprise a manostat weight, a pressure regulator or some means of creating a steady nominal air pressure of (1,47 ± 0,02) kPa measured at the manostat.

NOTE Most Bendtsen apparatus are provided with three interchangeable manostat weights but only the 1,47 kPa manostat meets the requirement of this part of ISO 8791.

5.2.4 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 three variable-area flowmeters shall be capable of being read to within 2 ml/min, 5 ml/min and 20 ml/min respectively. The variable area flowmeter may be replaced by another kind of air flowmeter having a measuring range suitable for the material measured that allows the air flow to be determined with an error of less than ± 5 ml/min or ± 5 % whichever is greater.

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 (e.g. a soap-bubble meter) under the same pressure difference as that in the measuring head (Annex B gives details of the calibration of capillary tubes and variable-area flowmeters).

5.2.5 Measuring head, consisting of a circular land with an enclosed area preferably corrosion-resistant with an optically flat lower surface of 31,5 mm ± 0,2 mm internal diameter and 0,150 mm ± 0,002 mm width, and with a mass of 267 g ± 2 g. The tubing used to connect the head to the flowmeter shall be of rubber or plastic, 5 mm internal diameter and not more than 700 mm long.

NOTE 1 A longer length of tubing will result in a significant pressure drop between the flowmeter and the measuring head.

NOTE 2 On most commercial instruments the valve at the outlet of the flowmeter has two outlets. For roughness measurement the tubing is connected to the smaller diameter outlet.

Because the measuring head shall be placed on the test piece in such a manner as to avoid any indentation of the surface, it is advisable to provide a mechanical device to lower and raise the head.[1)]

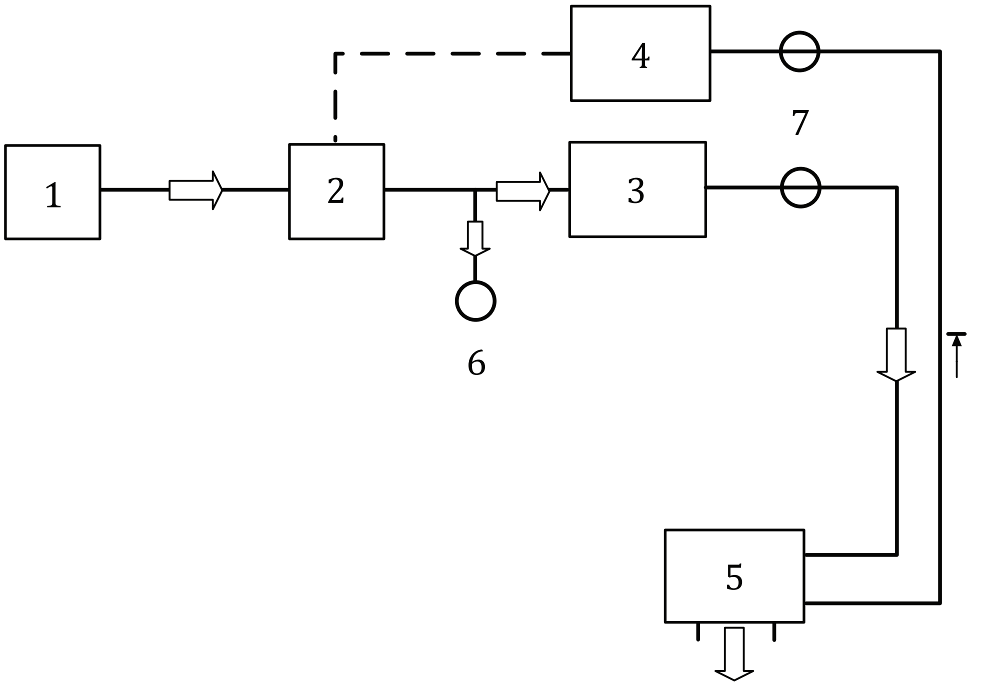
5.2.6 Flat plate, polished flat plate, preferably glass used to check for air leaks and upon which the test piece is placed for testing. The leakage between the measuring head land and the flat plate shall not exceed 5 ml/min.

5.2.7 Heavy metal weight, heavy metal annulus, or other suitably shaped weight, for keeping the test piece flat around the measuring head.

5.3 Electronic flowmeter type

A standard pressure difference is created across the measuring land and the air flow rate is measured on an electronic flowmeter. The apparatus, see Figure 2, consists of a compressed air supply system (5.3.1), a pressure regulator (5.3.2), an electronic flowmeter (5.3.3) with a pressure controlling device (5.3.4), and a measuring head (5.3.5).

1) A suitable device is described by Zubryn, E. And Hook, G.L. in Appita 23(4): 279-290 (January 1970).



Key

1 air supplying device

2 pressure controlling device

3 flow sensor

4 pressure sensor

5 measuring head

6 permanent air leak

7 connectors

Figure 2 — Circuit diagram of electronic flowmeter type test apparatus

5.3.1 Compressed air supply system, capable of generating air at a pressure of about 127 kPa. If necessary, filters shall be provided to ensure that the air is clean and free from oil.

NOTE It is advisable to have the compressor located in a laboratory having the standard atmosphere for conditioning and testing.

5.3.2 Pressure regulator, or other means of creating a steady nominal air pressure of 1,47 ± 0,02 kPa.

5.3.3 Flowmeter, having a measuring range of 50 ml/min to 5 000 ml/min that allows the air flow to be determined with an error of less than ± 5 ml/min or ± 5 % of actual value whichever is greater.

5.3.4 Differential air pressure meter, that allows the differential air pressure over the test piece to be determined with an error of less than 3 % of the actual pressure.

5.3.5 Measuring head, consisting of an enclosed metal land preferably corrosion-resistant with an optically flat lower surface of 31,5 mm ± 0,2 mm internal diameter and 0,150 mm ± 0,002 mm width, and with a mass of 267 g ± 2 g.

5.3.6 Flat plate, polished flat plate, preferably glass used to check for air leaks and upon which the test piece is placed for testing. The leakage between the measuring head land and the flat plate shall not exceed 5 ml/min.

5.3.7 Heavy metal weight, heavy metal annulus, or other suitably shaped weight, for keeping the test piece flat around the measuring head

6 Sampling

If the tests are being made to evaluate a lot, the sample shall be selected in accordance with ISO 186. If the tests are made on another type of sample, make sure that the specimens taken are representative of the sample received.

7 Conditioning

Samples shall be conditioned in accordance with ISO 187.

8 Preparation of test pieces

Cut at least 10 test pieces for each side to be tested. The minimum size of each test piece shall be 75 mm x 75 mm and its surfaces shall be identified, e.g. top side and wire side.

The test area shall be free from folds, wrinkles, holes, watermarks 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 Calibration and verification

9.1 Variable-area flowmeter type tester

Calibrate the instrument as described in 10.2.4 and Annex B.

9.2 Electronic flowmeter type tester

Calibrate the instrument as described in Annex B.2 (as well as according to the instructions of the manufacturer).

10 Procedure

10.1 Test atmosphere

Carry out the testing under the same atmospheric conditions as those used to condition the test pieces. Test each side of the test pieces separately.

10.2 Determination using variable-area flowmeter type tester

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

10.2.2 Decide which variable-area flowmeter will be used for the test, selecting, where possible, the variable-area flowmeter which will give a reading in the upper 80 % of the range with the 1,47 kPa manostat weight. 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. When the air flow has started, gently place the 1,47 kPa manostat weight on the shaft and start it spinning. It should continue to spin smoothly.

The manostat weight shall not be placed on the shaft until after the air flow has started and shall be removed before the air flow is stopped.

10.2.3 Set the valve at the outlet of the flowmeter so that air flows through the smaller (lower) outlet.

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

10.2.5 With the head connected to the flowmeter, lower the land on to the flat plate (5.2.6) and ensure that the float comes to rest at the bottom of the flowmeter. If not, check the system for air leaks as described in Annex A, Clause A.1.

10.2.6 Place the test piece on the flat plate, with the side to be tested uppermost. Gently lower the measuring head on to the test piece, taking particular care to ensure that the land does not make an impression on the surface of the test piece. If the test piece will not lie flat, use the metal annulus (5.2.7) to hold it down. Record the flowmeter reading at the top of the float at least 5 s after lowering the head, with the reading accuracy indicated in 5.2.4.

10.2.7 Repeat 10.2.6 for the remaining test pieces for each side to be tested.

10.2.8 After completing the tests, remove the manostat weight and then turn off the air supply.

10.3 Determination using electronic flowmeter type tester

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

10.3.2 Lower the land on to the flat plate (5.3.6) and check that the flowmeter reading does not exceed 5 ml/min.

10.3.3 Place the test piece on the flat plate, with the side to be tested uppermost and perform the test according to the instructions of the instrument manufacturer. If the test piece will not lie flat, use the metal annulus (5.3.7) to hold it down. Record the flowmeter reading of the instrument, with the reading accuracy indicated in 5.3.3.

10.3.4 Repeat 10.3.3 for the remaining test pieces for each side to be tested.

10.3.5 After completing the tests, turn off the air supply.

11 Expression of results

11.1 For each side tested, calculate and report the mean of the air flow readings, in ml/min, to three significant figures.

11.2 For each side tested, calculate the standard deviation or coefficient of variation to two significant figures for values less than 10 ml/min and to the nearest whole number for values equal to or greater than 10 ml/min.

12 Test report

The test report shall include the following information:

a) a reference to this part of ISO 8791;

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 pressure difference used, in kilopascals;

h) the flowmeter range used;

i) the mean Bendtsen roughness, in ml/min, as calculated in 11.1;

j) the standard deviation or coefficient of variation, as calculated in 11.2;

k) any deviations from the procedure described in this part of ISO 8791, that may have influenced the results.

Annex A
(normative)

Care and maintenance of variable-area flowmeter-type Bendtsen testers

A.1 Checking for air leaks

Check for air leaks by testing the circular land against the flat plate as described in 10.2.5, using the 5 ml/min to 150 ml/min flowmeter. If the rotor does not remain at rest at the bottom of the flowmeter, check the plate and the land surfaces for damage and imperfections, and check the condition of the tubing and the connections.

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.

Disconnect the measuring head and attach to that end of the tube a T-piece with a suitable capillary tube attached in the "straight-through" position and a water manometer attached to the side position. Check that the pressure at this point is within 5 % of the desired manometer reading when the air flow is as in Tables A.1 and A.2, and also as in the fourth last paragraph of this Clause.

Table A.1 — 5 ml/min to 150 ml/min variable-area flowmeter

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

Table A.2 — 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

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. Do not use air flows above 1 200 ml/min, see 10.2.2.

To ensure that the pressure drop between this point and the test piece is not significant, the connecting tube to the head shall be 5 mm in internal diameter and not more than 700 mm long.

The manostat weights shall not be lubricated.

A.3 Movement of floats

Check that the floats spin freely in the variable-area flowmeter tubes. Although a float which does not spin well may 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 tubes. Check the condition 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 condition of the top rim.

If a float becomes wedged in the spring at the bottom or 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 tube. A recurrence of sticking can be prevented by adjusting the shape of the springs. 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, remove the float from the tube, clean both with liquid detergent or a suitable solvent, then dry in the air stream. If liquid detergent is used, add to the tube, flush with water, reversing the flow several times, and use diluted aqueous solution (a volume fraction of about 10 %) to clean the float. Finally, rinse both with distilled water, and dry in an air stream.

Replace faulty tubes.

A.5 Air tubes

Tubing should be regularly inspected for signs of deterioration and replaced if necessary. All tubing should be replaced at least once a year, whether or not it appears defective.

A.6 Capillary tubes

Capillary tubes can become dirty rather easily and, therefore, should be inspected regularly and carefully with a magnifying glass and, if necessary, cleaned in accordance with the procedure in Clause A.4.

Annex B
(normative)

Calibration of capillary tubes and variable-area and electronic flowmeters

B.1 Checking variable-area flowmeters with capillary tubes

Flowmeter floats appear to be susceptible to wear. If a scale reading with the capillary tube connected differs by more than 5 % from the indicated value, the following procedure should be adopted:

a) Check the variable-area flowmeter against the capillary tube normally used for an adjacent variable-area flowmeter;

b) If both readings are high, check the variable-area flowmeter tube and float for cleanliness and clean if necessary;

c) If both readings are low, check for restrictions or leaks in the system, for example kinks or leaks in the plastics or rubber tube. Replace tubing if kinks or leaks occur.

d) If the two readings do not agree, or if the faults found in b) or c) cannot be identified, calibrate the variable-area flowmeter according to Clause B.2;

e) From the results of d), determine whether the variable-area flowmeter or capillary tube is at fault and replace if necessary.

B.2 Checking calibration of variable-area and electronic flowmeters

B.2.1 General

Variable-area flowmeters may be calibrated by a soap-bubble meter of which there are several designs. Figure B.1 shows a diagrammatic representation of a suitable meter.

NOTE Other calibration procedures are permitted provided they are at least as accurate as the procedure described in this annex.

This procedure describes the calibration of variable-area flowmeters, using a soap-bubble meter (Figure B.1). The method can also be used to calibrate electronic flow-measuring devices, provided a suitable attachment is available.

The principle of the method is that the movement of a soap bubble introduced into an air flow from the flow-measuring device being tested is timed between two marks in a volumeter representing an accurately known volume and the actual air-flow rate is calculated. This is repeated at other air flow rates until the whole flowmeter range of the instrument has been covered.

NOTE This method of calibration gives satisfactory accuracy if the test atmospheric conditions do not deviate appreciably from 101,3 kPa and 23 °C. For this reason, it is desirable, if possible, to choose a day for calibration when the meteorological conditions are favourable.

B.2.2 Apparatus and materials

B.2.2.1 Soap-bubble meter, consisting of:

— glass flask or bottle, capacity 1 litre;

— volumeter, with graduation marks indicating 100 ml, 250 ml and 1 500 ml; the different ranges may be achieved with replaceable volumeters (suitable designs are given in Reference [3] in the Bibliography);

— needle valve;

— glass and rubber tubing of as large an internal diameter as practicable to minimize pressure drop.

B.2.2.2 **Stop-watch**, capable of being read to 0,1 s.

B.2.2.3 **Soap solution:** 3 % to 5 % liquid detergent in distilled water.

B.2.2.4 **Barometer**, or other means of ascertaining the actual pressure.

B.2.3 Procedure

B.2.3.1 Make sure that the instrument is level on a surface free from variations. Make sure that the internal adjustment of the flowmeter has been carried out according to the instructions of the manufacturer.

B.2.3.2 To calibrate a variable-area flow-measuring device, disconnect the test assembly from the downstream end of the rubber or plastic tubing and connect in its place the soap-bubble meter. Set the valves to deliver air through the flowmeter to be calibrated and then through the soap-bubble meter at the connection point (3), see Figure B.1. Start the airflow, place the manostat weight corresponding to a pressure of 1,47 kPa on the shaft and start it spinning. Set the valves to deliver through the variable-area 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 remains 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 the time taken for the bubble to pass from the first to the second graduation is longer than 30 s.

Repeat the procedure at about six different air flow rates distributed over the flowmeter measurement range such that all readings are greater than 20 % of the scale range.

Record the atmospheric pressure.

NOTE At high air flows the pressure drop in the system can cause errors in calibration. To minimize these errors, the length and diameter of the tubing should be the same in calibration as in testing.

B.2.4 Calculation

Calculate the true air flow, in millilitres per minute, from each measured time and volume and check that the flowmeter reading is within 5 % of this flow. If not, check the operation of the flowmeter and if necessary construct a calibration graph.

If the actual atmospheric pressure differs by more than 5 % from 101,3 kPa, correct the air flow rates for pressure according to Equation (1):

$$q_0 = \frac{p \times V \times 60}{102,8 \times t} = \frac{0,548 pV}{t} \quad (1)$$

where

q_0 is the flow rate, in millilitres per minute, corrected to 102,8 kPa [normal atmospheric pressure (101,3 kPa) plus nominal operating pressure (1,47 kPa) at 23 ºC];

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

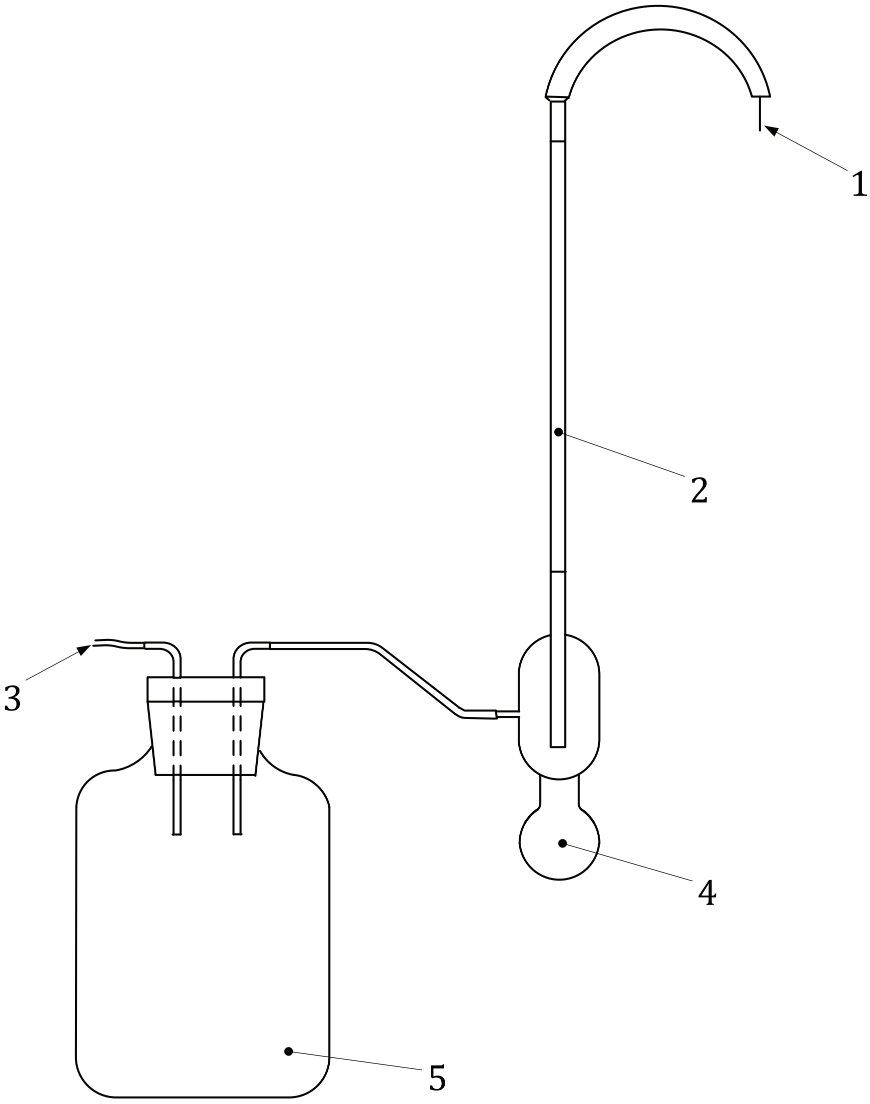
t is the time, in seconds;

p is the sum, in kilopascals, of the actual atmospheric pressure plus the nominal operating pressure (1,47 kPa).

B.3 Checking the calibration of capillary tubes

To calibrate a capillary tube, remove needle valve (1) and connect the tube in its place. Disconnect the measuring head and connect the instrument to the soap-bubble meter as described in B.2.2. Set the valves to deliver through the appropriate variable-area flowmeter. Rapidly squeeze the rubber bulb at the bottom of the volumeter and time the passage of a soap-bubble.

Calculate the air flow as described in B.2.3 and B.2.4.



Key

1 needle valve

2 volumeter

3 connection point

4 rubber bulb

5 glass flask, of capacity 1 litre

Figure B.1 — Soap-bubble meter

Annex C
(informative)

Precision

C.1 General

In early 2010, a round-robin was performed in which 14 laboratories participated. The round-robin included 6 variable-area flowmeter type testers and 8 electronic flowmeter type testers.

Three samples covering a range of roughness/smoothness were tested in accordance with this part of ISO 8791. The test results are shown in Tables C.1 and C.2.

C.2 Reproducibility

The reproducibility is the variation between individual results, independently obtained by two operators, working in different laboratories, on the same material.

The calculations have been made according to ISO/TR 24498 [1] and TAPPI Test method T 1200 sp-07 [2].

The reproducibility limits reported are estimates of the maximum difference which should be expected in 19 of 20 instances, when comparing two test results for material similar to those described under similar test conditions. These estimates may not be valid for different materials or different test conditions.

Reproducibility limits are calculated by multiplying the reproducibility standard deviations by 2,77.

NOTE 1 The *repeatability standard deviation* and the *within-laboratory standard deviation* are identical. However, the *reproducibility standard deviation* is NOT the same as *between-laboratories standard deviation*. The reproducibility standard deviation includes both the between-laboratories standard deviation and the standard deviation within a laboratory, viz.:

$$s_{\text{repeatability}}^2 = s_{\text{within lab}}^2 \quad \text{but} \quad s_{\text{reproducibility}}^2 = s_{\text{within lab}}^2 + s_{\text{between lab}}^2$$

NOTE 2 $2{,}77 = 1{,}96\sqrt{2}$, provided that the test results have a normal distribution and that the standard deviation *s* is based on a large number of tests.

Table C.1 — Results of an interlaboratory test for variable-area flowmeter type tester

Sample	Mean roughness/smoothness $\overline{X}$ ml/min	Standard deviation between laboratories s_R ml/min	Reproducibility coefficient of variation $C_{V,R}$ %	Reproducibility limit R ml/min
A	49,0	6,4	13	18
B	178	14	7,6	38
C	1 653	182	11	505

Table C.2 — Results of an interlaboratory test for electronic flowmeter type tester

Sample	Mean roughness/smoothness $\overline{X}$ ml/min	Standard deviation between laboratories s_R ml/min	Reproducibility coefficient of variation $C_{V,R}$ %	Reproducibility limit R ml/min
A	48,3	5,7	12	16
B	182	19	11	54
C	1 715	276	16	763

The difference in test results obtained between variable-area flowmeter type testers and electronic flowmeter type testers was found to be not statistically significant.

Bibliography

[1] ISO/TR 24498:2006, *Paper, board and pulps — Estimation of uncertainty for test methods*

[2] TAPPI Test method T 1200 sp-07, *Interlaboratory evaluation of test methods to determine TAPPI repeatability and reproducibility*

[3] GOODERHAM. *J.W.J. Soc. Chem. Ind.* 1944, **63** p. 351

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