



BSI Standards Publication

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

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Part 4: Print-surf method

## National foreword

This British Standard is the UK implementation of ISO 8791-4:2021. It supersedes BS ISO 8791-4:2007, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PAI/11, Methods of test for paper, board and pulps.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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

Part 4:

**Print-surf method**

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

*Partie 4: Méthode Print-surf*



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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 (see [www.iso.org/directives](http://www.iso.org/directives)).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document 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 third edition cancels and replaces the second edition ([ISO 8791-4:2007](http://www.iso.org/iso/8791-4:2007)), which has been technically revised.

The main changes compared to the previous edition are as follows:

- Annex D and Annex E describing the calibration of Print-surf instruments have been removed;
- some minor editorial changes have been made.

A list of all parts in the ISO 8791 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

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

## Part 4: Print-surf method

### 1 Scope

This document specifies a method for determining the roughness of paper and board using an apparatus which conforms to the Print-surf method, as defined in this document. It is applicable to all printing papers and boards with which it is possible to form a substantially airtight seal against the guard lands of the measuring head.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 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.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

#### 3.1

##### **print-surf roughness**

mean gap between a sheet of paper or board and a flat circular land pressed against it under specified conditions

Note 1 to entry: The mean gap is expressed as the cube root mean cube gap calculated as specified in [Annex A](#). The Print-surf roughness is expressed directly as the average value of roughness, in micrometres.

#### 3.2

##### **print-surf compressibility**

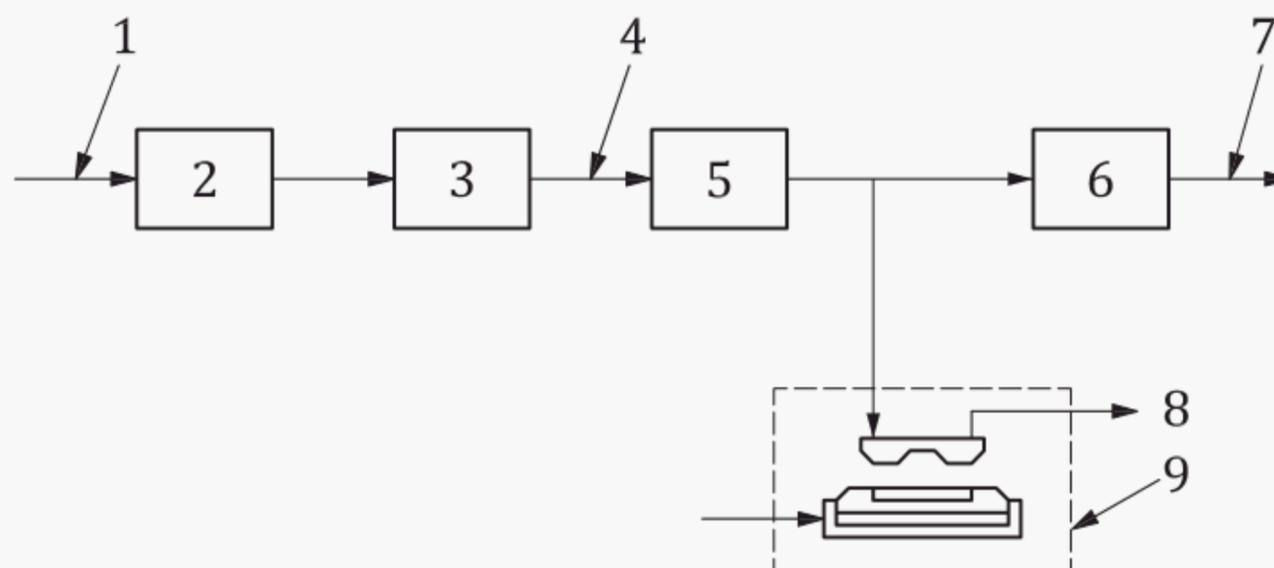
***K***

percentage decrease in surface roughness when measurements are made consecutively at the two standard clamping pressures specified in this document

### 4 Principle

The test piece is placed between a circular flat metal sensing surface and a resilient backing, and inner and outer circular lands form a seal with the test piece. Under the influence of a pressure difference,

transducer. These pressure differences vary with roughness and the signals are converted to roughness, in micrometres. The flow diagram for this type of instrument is shown in [Figure 2](#).



**Key**

- 1 incoming air — 300 kPa to 600 kPa
- 2 filter
- 3 pressure-regulator valve
- 4 19,6 kPa
- 5 fluidic impedance
- 6 pressure transducer
- 7 analogue signal
- 8 to atmosphere
- 9 sensing head and clamping device

**Figure 2 — Flow diagram for impedance instrument type**

5.1.2 The procedures for maintaining these testers in good working order given in [Annex B](#) apply.

**5.2 Principal components of the system**

5.2.1 Air supply, in which the air from the controlled pressure source passes first through a fluidic impedance and then through a pressure transducer.

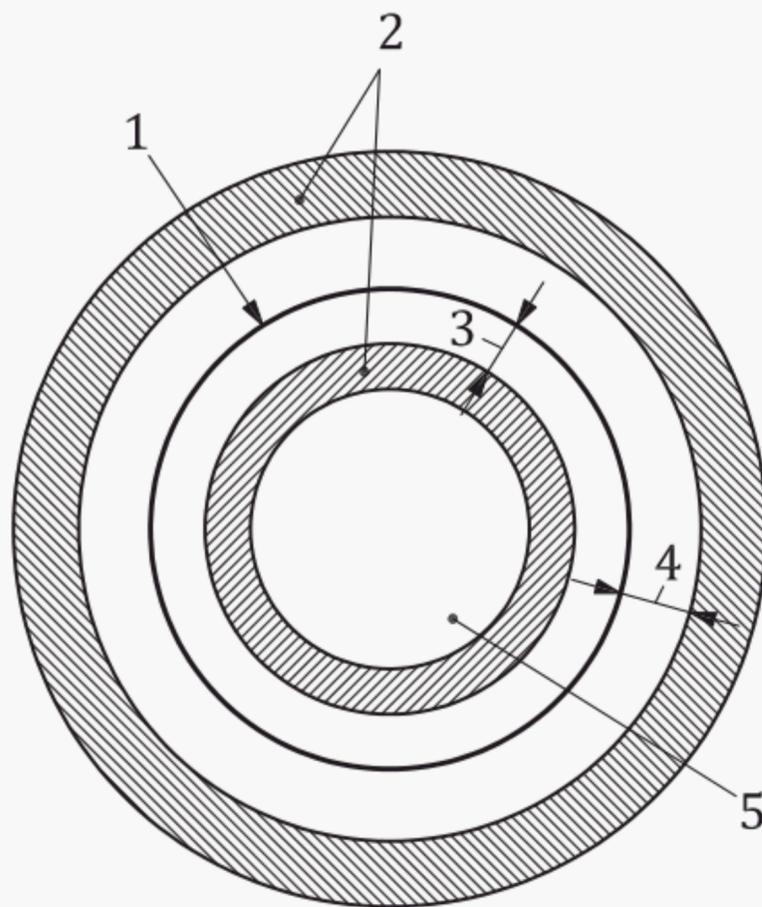
5.2.2 Sensing-head pressure regulator, allowing setting of the sensing-head differential pressure to 19,6 kPa ± 0,1 kPa or, on variable-area flowmeter instruments only, to either 6,2 kPa ± 0,1 kPa or 19,6 kPa ± 0,1 kPa.

5.2.3 Sensing head, (see [Figures 3](#) and [4](#)), consisting of three concentric, annular lands composed of suitable material which have coplanar, polished surfaces. The centre or measuring land shall be 51,0 µm ± 1,5 µm wide and have an effective length of 98,0 mm ± 0,5 mm. The two guard lands shall each be at least 1 000 µm wide at any point, and the radial distance between them at any point shall be 152 µm ± 10 µm. The measuring land shall be centred between them to within ±10 µm.

The lands shall be mounted in an airtight mounting, constructed so that air can be passed into the gap between one guard land and the measuring land, and exhausted from the gap between the measuring land and the other guard land. The back of the mounting shall be flat and form a ground mating surface with the flat surface of a manifold fitted with air inlet and outlet ports.

A spring-loaded protective collar may be fitted outside the guard lands. If such a protective collar is fitted, the force exerted by the loading spring shall be taken into account when setting the clamping pressure.

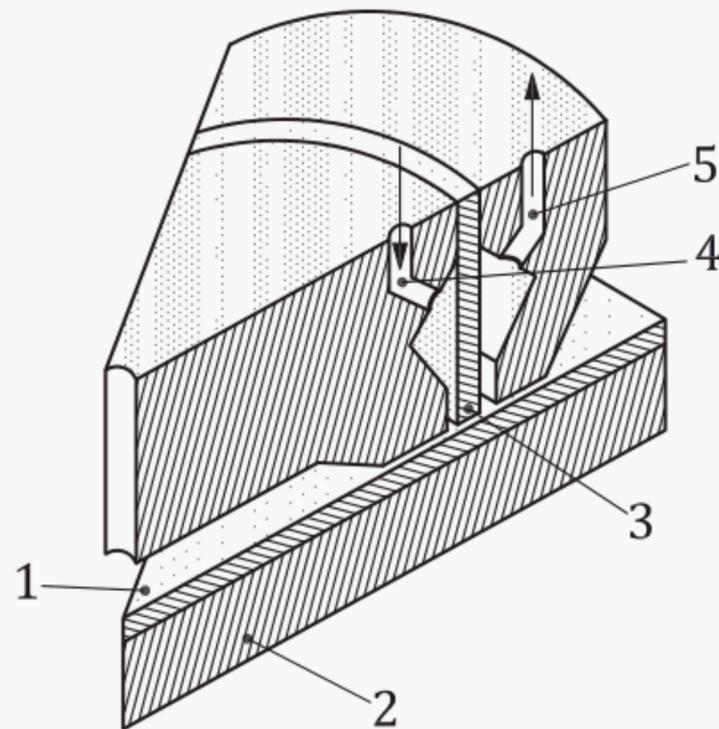
NOTE In many instruments fitted with the protective collar, the force exerted by the loading spring is 9,8 N.



**Key**

- 1 measuring land
- 2 guard lands
- 3 passage air connected to air supply
- 4 passage leading to flowmeters or atmosphere
- 5 fluidic impedance

**Figure 3 — Plan of the measuring and guard lands of the sensing head**



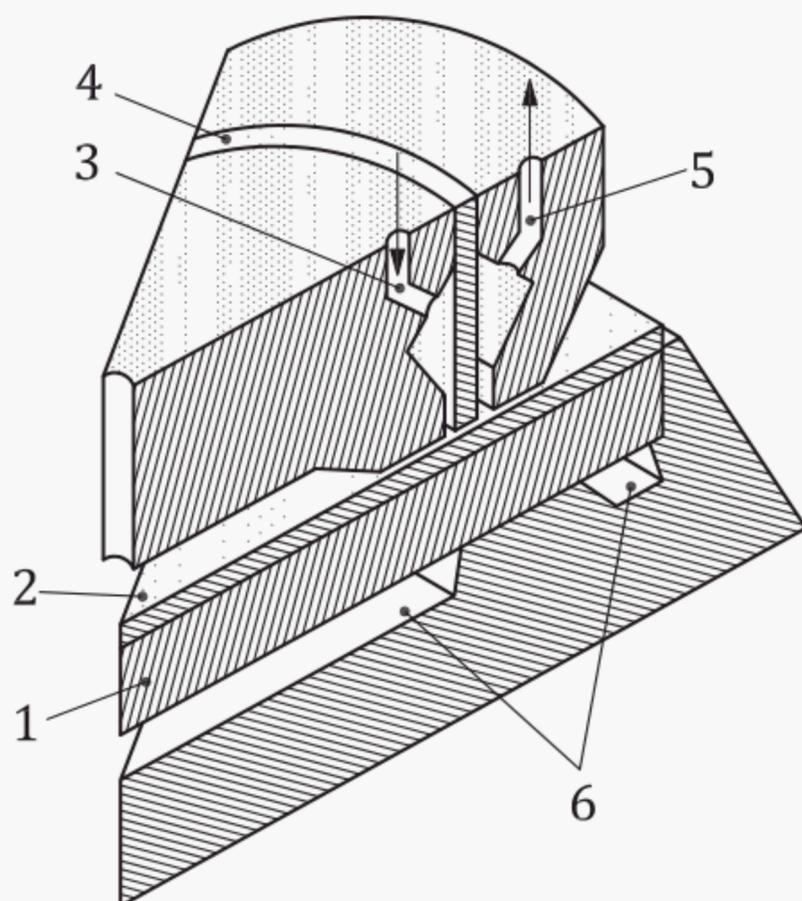
**Key**

- 1 paper
- 2 resilient backing
- 3 measuring land
- 4 regulated low-pressure air
- 5 to flowmeters or atmosphere

**Figure 4 — The sensing head sectioned on two radii**

5.2.4 Backing holders, consisting of rigid metal discs of known mass, each recessed to accommodate a resilient backing at least 10 mm greater in diameter than the outside diameter of the outer guard land. The mass of both the resilient backing and the holder shall be allowed for in the initial adjustment of the clamping pressure.

It has been observed that high-stiffness papers and boards can interact negatively with the flat metal backing holder and cause erroneously high roughness results. This problem can be solved by using a modified backing holder which relieves those areas of the backing holder not directly below the measuring land, as shown in [Figure 5](#).



**Key**

- 1 resilient backing
- 2 paper
- 3 regulated low-pressure air
- 4 measuring lands
- 5 to flowmeters or atmosphere
- 6 new modified clamp platen showing machined cut-away

**Figure 5 — The sensing head sectioned on two radii showing cut-away platen**

5.2.5 Two resilient backings, of different types, which can be held in the recessed holders by means of double-sided adhesive tape:

5.2.5.1 Soft backing, resilient, consisting of an offset printing blanket composed of a layer of synthetic rubber, at least 600  $\mu\text{m}$  thick, bonded to a fabric backing giving an overall thickness of 2 000  $\mu\text{m} \pm 200 \mu\text{m}$ . The apparent hardness of the complete backing shall be 83 IRHD  $\pm 6$  IRHD (International Rubber Hardness Degrees).

5.2.5.2 Hard backing, resilient, usually made from a polyester film bonded at its periphery to cork, offset blanket or similar material. A small exhaust hole shall be provided to prevent air being trapped between the film and the backing. The apparent hardness of the assembly shall be 95 IRHD  $\pm 2$  IRHD.

5.2.6 Clamping mechanism, allowing clamping of the resilient backing at pressures of either 980 kPa  $\pm 30$  kPa or 1960 kPa  $\pm 30$  kPa, the pressure being calculated from the total area of the measuring and guard lands.

NOTE 1 On some earlier instruments, these values can be displayed on the gauge as 10 kgf/cm<sup>2</sup> and 20 kgf/cm<sup>2</sup>.

Note that the spring loading in the protective collar (5.2.3) and the weight of the backing and its holder need to be taken into account. The rate of clamping shall be such that the pressure reaches 90 % of its final value in about 0,4 s, and 99 % of its final value in about 0,8 s.

NOTE 2 A third pressure of 490 kPa (5 kgf/cm<sup>2</sup>) is available on most instruments, but is not acceptable for use with this part document because of a tendency for air to leak under the guard lands.



— Soft backing letterpress  $1\,960\text{ kPa} \pm 30\text{ kPa}$

— Soft backing offset  $980\text{ kPa} \pm 30\text{ kPa}$

9.5 For a tester of the variable-area flowmeter type, select the lowest-range flowmeter which will give a reading greater than 20 % of the scale range.

Always start with the highest-range flowmeter and turn the flow range selector switch successively to a flowmeter of lower range, in order to avoid subjecting the low-range flowmeters to a high air flow.

9.6 Test the first test piece by the following procedure.

#### 9.6.1 Variable-area flowmeter type

Set the sensing-head differential pressure to  $6,2\text{ kPa} \pm 0,1\text{ kPa}$  by adjusting the pressure from the low side.

NOTE 1 If the pressure gauge indicates differential pressure in metres of water gauge, 0,63 m is equivalent to 6,18 kPa.

NOTE 2 The pressure gauge on some instruments has been found to be sensitive to jolts and, if the adjustment is made downwards from a higher pressure, the resulting pressure for a given scale reading will be higher than if the adjustment is made upwards from a lower pressure.

Clamp the first test piece under the sensing head, with the side to be tested uppermost. This operation can cause the reading on the sensing-head pressure gauge to change, but such a change may be ignored. Record the reading on the flowmeter to the nearest  $0,05\text{ }\mu\text{m}$ , 3 s to 5 s after application of clamping pressure. Readings shall be taken level with the top of the flowmeter float. Select the lowest-range flowmeter which gives results greater than 20 % of the scale range.

If the reading obtained is less than 20 % of the range of the lowest-range flowmeter, increase the sensing-head pressure to  $19,6\text{ kPa} \pm 0,5\text{ kPa}$  (2,0 m water gauge). All readings taken at this pressure shall be multiplied by 0,667 (for the background of this factor, see [Annex A, Formula \[A.1\]](#)) to give the roughness, in micrometres, unless the flowmeters are calibrated for this pressure.

#### 9.6.2 Impedance type

Place a test piece under the head with the side to be tested uppermost. Clamp the test piece either automatically or manually. Record the reading, 3 s to 5 s after application of clamping pressure.

9.7 Repeat step [9.6](#) for the other test pieces and calculate the arithmetic mean and standard deviation or coefficient of variation for the side tested. For variable-area flowmeter-type instruments, do not repeat the procedure for selection of the appropriate flowmeter and sensing-head pressure.

9.8 If a result is required for the roughness of the other side, take a second set of test pieces and repeat steps [9.6](#) and [9.7](#).

9.9 If Print-surf compressibility is to be determined, the lower of the two clamping pressures shall be selected and adjusted first. Follow step [9.6](#) and record the result and, without unclamping the test piece, next select and adjust the higher clamping pressure and again record the result. Repeat this sequence for the other test pieces. Calculate Print-surf compressibility using the [Formula \(1\)](#) in [Clause 10](#).

## 10 Calculation

The Print-surf compressibility,  $K$ , can be defined mathematically by [Formula \(1\)](#):

$$K = \frac{100(G_1 - G_2)}{G_1} \quad (1)$$

where

- $G_1$  is the surface roughness value obtained at a nominal clamping pressure of 980 kPa;
- $G_2$  is the surface roughness value obtained at a nominal clamping pressure of 1960 kPa.

## 11 Precision

The repeatability and reproducibility can be calculated as outlined in [Annex D](#).

## 12 Test report

The test report shall include the following information:

- a reference to this document, i.e. ISO 8791-4:2021;
- date and place of testing;
- all the information necessary for complete identification of the sample;
- the type of instrument used;
- the backing and type of backing holder used;
- the number of test pieces tested;
- the sensing-head differential pressure, in kilopascals;
- the clamping pressure, in kilopascals;
- the mean of the test results for each side tested;
- the standard deviation or coefficient of variation for each side tested;
- any deviation from this procedure which can have affected the results.

## Annex A

### Calculation of roughness in micrometres

For the purposes of this document the cube root mean cube gap,  $G_3$ , in metres, in the direction of the air flow between the measuring land and the test piece is calculated from [Formula \(A.1\)](#):

$$G_3 = \left( \frac{12 \times \eta \times b \times q_v}{l \times \Delta p} \right)^{\frac{1}{3}} \quad (\text{A.1})$$

where

- $\eta$  is the viscosity, in pascal seconds, of air at room temperature;
- $b$  is the width, in metres, of the measuring land;
- $q_v$  is the volume of air flowing in unit time, in cubic metres per second;
- $l$  is the median length, in metres, of the measuring land;
- $\Delta p$  is the pressure difference, in pascals, across the measuring land.

The roughness, in micrometres, is then equal to  $G_3 \times 10^6$ .

If the differential pressure exceeds 1 % of the absolute pressure then  $\Delta p$  should be calculated as in [Formula \(A.2\)](#) to correct for the compressibility of air:

$$\Delta p = \frac{p_u^2 - p_d^2}{2p_m} \quad (\text{A.2})$$

where

- $p_u$  is the absolute upstream pressure;
- $p_d$  is the absolute downstream pressure;
- $p_m$  is the pressure at which the flow  $q_v$  is measured.

[Formula \(A.2\)](#) is derived on the assumption that the gap between the measuring land and the test piece is uniform across the width of the land, but that it varies along its length.

[Formula \(A.1\)](#) is subject to the assumptions that the flow is laminar, that the temperature is constant throughout, and that the kinetic energy changes per unit volume of air are negligible compared with  $\Delta p$ . The flow conditions are normally well within the laminar range, but the kinetic energy can be important when rough papers are measured, unless the differential pressure is restricted. To estimate the extent of the error, the full equation for flow over the measuring land may be used:

$$\Delta p = \frac{12 \times \eta \times b \times q_v}{l \times G_3^3} + \frac{C \times \rho \times q_v^2}{2 \times l^2 \times G_3^2} \quad (\text{A.3})$$

where

- $\rho$  is the density of air measured at pressure  $p_m$ ;
- $C$  is a coefficient found by experiment for a number of papers, and is approximately equal to 2,5.

Additional information about the background of [Formulae \(A.1\)](#), [\(A.2\)](#) and [\(A.3\)](#) can be found in a paper published in Paper Technology<sup>[1]</sup>.

## Annex B (normative)

### Maintenance of Print-surf roughness testers

#### B.1 Leakage

B.1.1 The apparatus shall be maintained free of leakage, visible surface irregularities of the backings and pressure gauge error, as detailed in [B.1.2](#), [B.1.3](#) and [B.3](#). Check for leakage at the lowest clamping pressure available and a sensing-head differential pressure of 19,6 kPa.

B.1.2 Leakage between the back of the sensing head and its supporting manifold is indicated by a measurable air flow when the soft backing is clamped directly against the head. Such leakage can be corrected by a thin smear of petroleum jelly on the mating surfaces.

B.1.3 Damage to the sensing head is detected as follows:

- a) Carefully wipe the face of the sensing head with a lint- and oil-free, soft clean material.
- b) Clamp a smooth scratch-free piece of 125 µm thick film, such as cellulose acetate, between the sensing head and the hard backing. Measure the air flow.
- c) This test is very sensitive to dust, due to static charges and even to fingerprints. If a measurable flow is found, carefully wipe the surface of the film and repeat the test.
- d) It is recommended that a suitable film be obtained from the instrument manufacturer/supplier.
- e) If it is impossible to obtain a zero reading on the lowest range flowmeter, confirm damage by inspecting the measuring surface at a magnification of about  $\times 50$  with a stereoscopic microscope. On impedance instruments, a reading greater than 0,8 µm indicates the possibility of damage.
- f) If pits or scratches are apparent, replace the sensing head.

#### B.2 Sensing head

At frequent intervals, inspect the head, preferably with a stereoscopic microscope, to ensure that the gaps between the measuring land and guard lands are free from debris. If necessary, clean as advised by the instrument manufacturer.

#### B.3 Pressure gauges

Whenever the instrument is used, check that both gauges register zero when the air supply is disconnected.

At least once a year, check the accuracy of pressure gauges and transducers by connecting in parallel a manometer or transducer, the latter having been calibrated against dead weights. Operate the instrument normally and record the actual static pressures achieved.

Convert the clamping pressure reading to force per unit area of guard plus measuring land surface. Correct for the weight of the resilient backing plus holder and for the force exerted by the spring-loaded protective collar. Compare the corrected clamping pressure and the measured head pressure to the gauge readings and pressure settings specified in [5.2.2](#) and [5.2.6](#).

Replace defective gauges or repair faulty control systems.

#### **B.4 Resilient backing**

Inspect the clamping surfaces daily and, as soon as any visible damage occurs, replace the backing using the procedure in the instrument manual. It is advisable to replace the backing on a regular basis and also if a zero reading cannot be obtained.

#### **B.5 Evenness of clamping**

Place a sheet of high-quality white paper on the hard backing, cover it with a piece of carbon paper, place the “sandwich” in the measuring gap and apply the clamping pressure. An uneven print indicates uneven clamping which shall be corrected by referring to the manufacturer.

## Annex C (normative)

### Calibration of variable-area flowmeters

#### C.1 General

The variable-area flowmeters may be calibrated individually using a soap-bubble meter such as that shown in [Figure C.1](#) or they may be calibrated against international reference standards provided by the instrument manufacturers.

#### C.2 Apparatus and product

C.2.1 Soap-bubble meter, consisting of:

- glass flask or bottle, of at least 1 l capacity;
- volumeter, of 500 ml capacity;
- rubber bulb and soap reservoir;
- glass and rubber tubing of as large an internal diameter as practicable to minimize pressure drop.

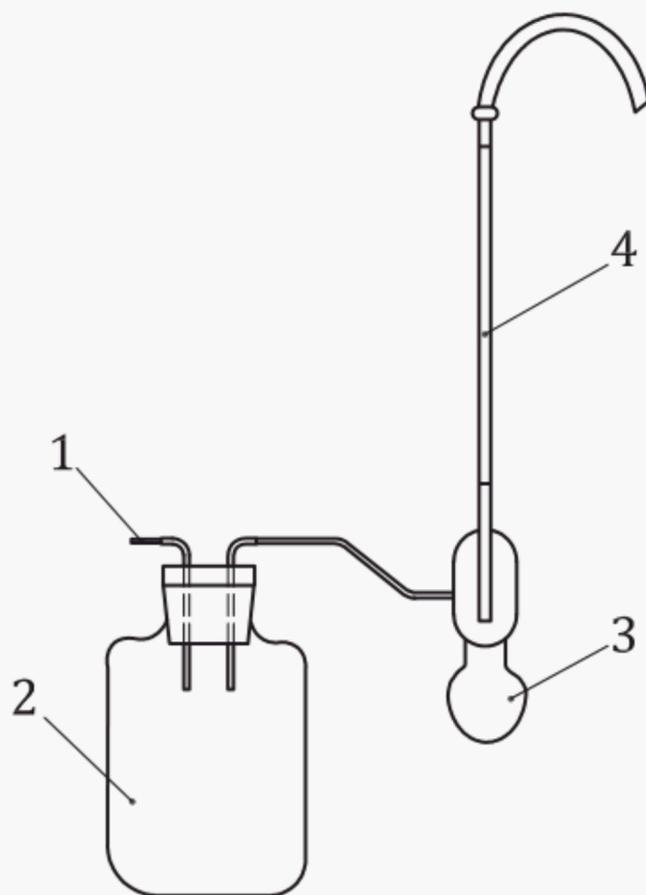
C.2.2 **Stopwatch.**

C.2.3 **Soap solution, for example, a 3 % to 5 % liquid detergent in distilled water.**

#### C.3 Procedure

Connect the inlet of the soap bubble meter to the outlet of the flowmeter. Operate the instrument according to the procedure described in [9.1](#) to [9.6.1](#) inclusive, using a test piece of suitable roughness (see note below). 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 the soap bubble to move between marks representing a known volume, such that the time measurements are in excess of 30 s. Note also the corresponding scale reading. Using test pieces of appropriate roughness, repeat the procedure for about six air flows over the range of the flowmeter.

NOTE Some paper test pieces can fail to give stable scale readings during the calibration procedure, due to the effect of moisture change during the test. Do not use material which behaves in this way. Materials other than paper can be used, providing they give readings at appropriate intervals over the range of the flowmeter being calibrated.



**Key**

- 1 inlet
- 2 glass flask
- 3 rubber bulb
- 4 volumeter

**Figure C.1 — Soap-bubble meter**

**C.4 Calculation**

At each calibration point, calculate the flow rate and using [Formula \(A.1\)](#) convert the flow rate to a roughness, in micrometres. Compare the calculated values with the actual scale readings. For very accurate calibration, it is desirable to allow for the water vapour picked up from the soap solution. If the instrument reading is more than 0,05  $\mu\text{m}$  from the correct value at any point, construct a calibration graph for use in normal testing.

## Annex D (informative)

### Precision

#### D.1 Precision

The following estimates of repeatability and reproducibility shown in [Table D.1](#), calculated according to TAPPI Test Method T 1200 and published in TAPPI Test Method T 555, are based on data taken from the CTS-TAPPI Interlaboratory Program for Paper and Paperboard and are reprinted and used by permission of TAPPI. Testing is based on 10 determinations per test result and 1 result per laboratory, per material. The estimates were determined prior to the availability and use of standard reference materials. The reproducibility is expected to improve with the introduction of a reference standard system.

**Table D.1 — Roughness measurements in  $\mu\text{m}$**

Material description	Grand mean	Range	Repeatability <i>r</i> and % <i>r</i>		Reproducibility <i>R</i> and % <i>R</i>		Number of laboratories
Coated cover, gloss	0,824	0,590 – 1,192	0,026	3,2 %	0,368	44,7 %	67
Coated face stock	1,125	0,887 – 1,390	0,030	2,6 %	0,320	28,4 %	71
Coated offset	1,193	0,984 – 1,420	0,043	3,6 %	0,291	24,4 %	67
Coated offset	1,255	1,049 – 1,500	0,045	3,6 %	0,281	22,4 %	67
Speciality paper	2,701	2,358 – 3,031	0,106	3,6 %	0,410	15,2 %	71
Laser bond, uncoated	3,511	3,031 – 3,965	0,172	4,9 %	0,580	16,5 %	33
Offset	4,602	4,000 – 5,141	0,145	3,2 %	0,772	16,8 %	30
Offset	5,415	4,680 – 6,117	0,167	3,1 %	1,049	19,4 %	30

## Bibliography

- [1] PARKER J.R. An air leak instrument to measure printing roughness of paper and board, Paper Tech. **6** (2): T32 ( 1965)



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## BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK