INTERNATIONAL STANDARD

ISO 8791-3

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

Part 3:
Sheffield method

Papier et carton — Détermination de la rugosité/du lissé (méthodes du débit d'air) —
Partie 3: Méthode Sheffield

Reference number
ISO 8791-3:1990(E)

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.

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.

International Standard ISO 8791-3 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*.

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*

Parts 2 and 3 together cancel and replace ISO 2494:1974, which formerly dealt both with the Bendtsen method and with the Sheffield method.

Annexes A and B form an integral part of this part of ISO 8791. Annex C is for information only.

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

Part 3:
Sheffield method

1 Scope

This part of ISO 8791 specifies a method for the determination of the roughness of paper and board using the Sheffield apparatus. It should be read in conjunction with ISO 8791-1.

The method is applicable to papers and boards which have Sheffield roughness values between zero and about 3 000 ml/min. It is not suitable for soft papers which allow the lands to indent the surface or for high air permeance paper which allow a significant flow of air to pass through the sheet, or for papers which will not lie flat during the test.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 8791. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 8791 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 186:1985, *Paper and board — Sampling to determine average quality*.

ISO 187:1977, *Paper and board — Conditioning of samples*.

ISO 8791-1:1986, *Paper and board — Determination of roughness/smoothness (air leak methods) — Part 1: General method*.

3 Definition

For the purposes of this part of ISO 8791, the following definition applies.

Sheffield roughness: A measure of the rate at which air will pass between flat circular lands (a flat surface) and a sheet of paper or board when tested under specified conditions and at operating pressure.

It is expressed in millilitres per minute.

NOTE 1 It has been found that the scale units (Sheffield units) on different instruments and particularly on instruments of different ages, can correspond to different air flows. To overcome any such differences between instruments, it is necessary to calibrate the scale in millilitres per minute and to convert the scale reading to millilitres per minute.

4 Principle

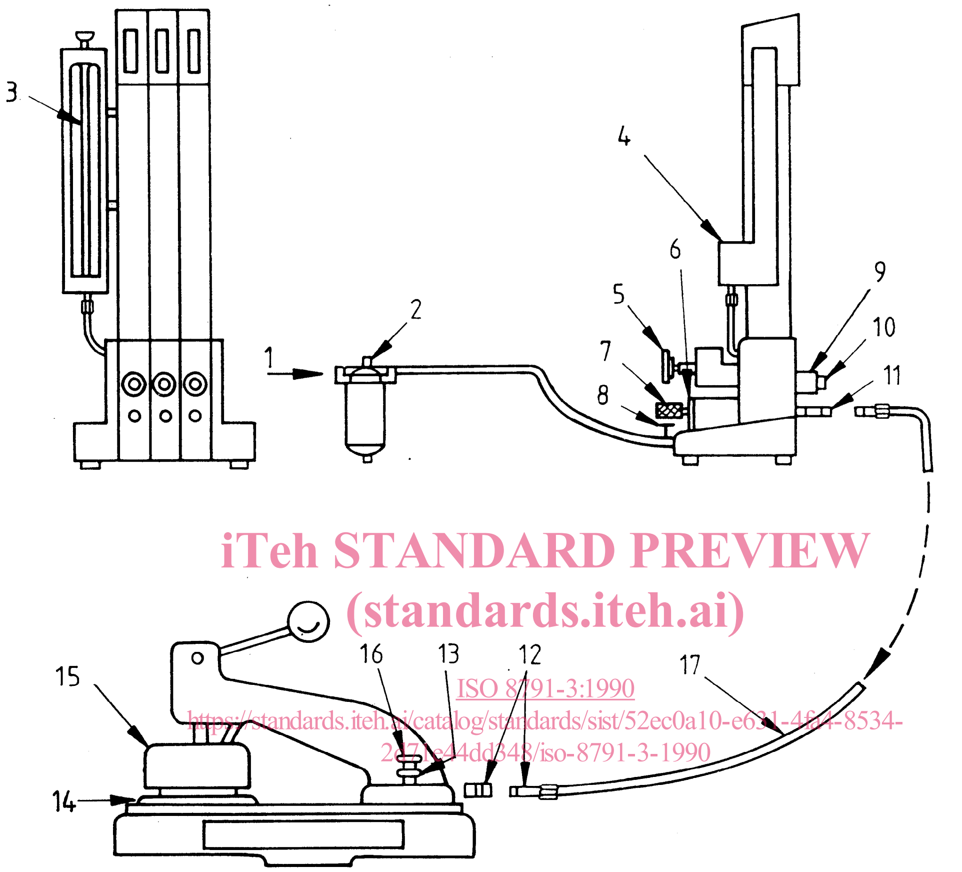
Clamping a test piece between a flat plate and two flat concentric circular lands. Supplying air at a nominal pressure of 10,3 kPa to the space enclosed between the two lands and measuring the rate of air flow between the lands and the test piece.

5 Apparatus

The apparatus consists of an air supply, a pressure controlling and flow measuring device, and a test assembly which houses a flat plate, the test lands and a mechanical device for lowering the lands on to the flat plate (see figure 1).

5.1 Air supply, free of water, oil and other contaminants, at 420 kPa to 950 kPa pressure. A small compressor using laboratory air is preferred to external compressed air.

5.2 Pressure regulating and flow measuring device. The pressure regulator consists of a primary regulator to reduce the pressure to between 205 kPa and 210 kPa and a further regulator and manometer to adjust to 10,3 kPa.



1 Air supply
2 Air filter
3 Manometer 10,3 kPa
4 Manometer mercury reservoir
5 Regulator 10,3 kPa, with knob
6 Pressure indicator
7 Primary regulator
8 Shut-off valve
9 Calibrating knob
10 Float position knob
11 Quick-disconnect coupling (female with shut-off)
12 Quick-disconnect coupling (female without shut-off)
13 Calibrating orifice
14 Glass plate
15 Test head
16 Plug assembly master block
17 Hose assembly, 1,5 m

Figure 1 — Sheffield roughness tester

The flow measuring device comprises three variable-area flowmeters each consisting of a tapered glass column containing a metering float which is suspended by the air flow in the column. The three columns represent one continuous scale of flow rate with some overlap of scales between tubes. Each is provided with adjustment for flow rate (float position knob) and span calibration (calibrating knob) (see items 9 and 10 on figure 1). On some instruments the float position knob is located above the relevant flowmeter. The flowmeter shall be calibrated periodically against an external flow measurement device such as that described in annex B, clause B.2.

5.3 Test assembly, containing a detachable gauging element which is mounted so that it can be lowered on to a test piece lying on an optically flat plate. The gauging element together with a dead weight which it carries has a mass of 1 640 g ± 2 g. The gauging element has two concentric annular lands which contact the test piece. The total area of the contacting surface is 97 mm^2 ± 3 mm^2 and each land is 0,380 mm ± 0,010 mm wide. The gauging element is made of, or coated with, a corrosion-resistant material.

The flat plate is usually glass and shall be free from surface flaws. The test assembly has four couplings to which a hose may be connected. One of these is unnumbered and is connected via an orifice to the space between the lands of the gauging element. The other three are numbered and connected to corresponding orifices which are used for internal calibration of the flowmeters.

5.4 Plastics or rubber hose 1,50 m ± 0,15 m long and 6,25 mm ± 0,25 mm internal diameter, to convey air from the flowmeter to the test assembly.

5.5 Sheffield reference surface masters are available to check orifices for contamination and gauging elements for wear or damage. A spare orifice manifold shall be kept for checking the flow rates of the working orifices.

6 Sampling

Sampling shall be carried out in accordance with ISO 186.

7 Conditioning

Samples shall be conditioned in accordance with ISO 187.

8 Preparation of test pieces

Cut at least 10 test pieces, each at least 100 mm × 100 mm for each surface to be tested, and identify the two sides (e.g. side one and side two). The test pieces shall be free from creases, wrinkles, rubber marks, watermarks and other manufacturing defects. Do not handle that part of the test piece which will become part of the test area.

9 Internal adjustment of flowmeters

Flowmeters shall be adjusted frequently if the instrument is used continuously, and at least twice in an 8 h day by the procedure prescribed in annex B, clause B.1.

10 Procedure

10.1 Test atmosphere

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

10.2 Determination

10.2.1 Ensure that the instrument is on a surface free from vibration, and level the instrument.

10.2.2 Raise the gauging element by operating the lever on top of the assembly. Place a test piece, with the side to be tested uppermost, on the flat plate and gently lower the gauging element. A careful action is necessary at this stage to ensure that the lands do not indent the paper surface. Any test piece showing indentation from the lands shall be discarded.

10.2.3 Connect the air hose between the unnumbered coupling of the assembly and whichever of the three flowmeters will give a reading closest to mid-scale.

10.2.4 When the metering float in the appropriate air flowmeter first reaches a point of relative stability, record the reading corresponding to the top of the float.

The point of stability in No. 3 column can be difficult to judge because of the low air flow and hence the longer time the float takes to settle.[1] Some degree of care is required to obtain reliable readings.

All papers are hygrosensitive to some degree, and readings have to be taken at the initial stabilization point to avoid any possible effect of the incoming air adding moisture to, or extracting moisture from, the test piece.

10.2.5 Test the remaining test pieces by the same method.

11 Expression of results

11.1 Convert each scale reading to flow rate, in millilitres per minute, using the calibration chart prepared as described in annex B.

11.2 Calculate the mean flow rate to three significant figures for each side to be tested.

11.3 Calculate the standard deviation or coefficient of variation of a single flow rate determination to two significant figures for each side to be tested.

12 Test report

The test report shall include the following particulars:

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 temperature and relative humidity used for the test;

f) the number of test pieces tested;

g) the flowmeter range used;

h) the arithmetic mean result (as calculated in 11.2);

i) the standard deviation or coefficient of variation (as calculated in 11.3);

j) any deviations from the procedure specified.

Annex A
(normative)

Care and maintenance of test instrument

A.1 Weekly, or more often if required, check the cleanliness of the working orifices by testing against the spare calibration orifice manifold. If necessary, clean with a suitable solvent, e.g. petroleum ether, boiling point 60 °C to 100 °C.

A.2 If the floats tend to stick in the air flowmeter columns, this may be due to dirt or static charges and cleaning should be carried out as outlined in the instrument manual.

A.3 Rubber gaskets in the hose quick-disconnect couplings shall be renewed at least once a year.

A.4 Clean the inside of the glass column in the mercury manometer as required.

Annex B
(normative)

Calibration of flowmeters

B.1 Internal adjustment

B.1.1 General

Flowmeters shall be adjusted frequently if the instrument is being used continuously. Should the air supply to the instrument be interrupted for any reason, the flowmeters shall be adjusted before testing is resumed. For daily use it is preferable to leave the air supply on in order to minimize drifts in the regulator.

During the initial adjustment (steps B.1.2.4 to B.1.2.8) the top of the float shall be positioned precisely on the appropriate red lines. In the cross-calibration (steps B.1.2.9 to B.1.2.13) the top of the float shall be within plus or minus one scale division at each of the check points.

B.1.2 Procedure

B.1.2.1 Check zero on the mercury manometer.

B.1.2.2 Set the primary air regulator so that the air pressure to the instrument is between 205 kPa and 210 kPa.

NOTE 2 Although SI units are used throughout this part of ISO 8791, the pressure scales of some instruments are graduated in pounds-force per square inch (1 lbf/in^2 = 6,89 kPa).

B.1.2.3 Adjust the mercury manometer *upward* to a pressure of 10,3 kPa by turning the pressure regulator (5 on figure 1) located at the back of the tester, making sure that the top of the meniscus is within an estimated 0,1 scale division (± 0,07 kPa) of the line.

B.1.2.4 Connect the air hose between the coupling on No. 3 column and the coupling on No. 3 orifice on the orifice manifold.

B.1.2.5 Close the air valve on the orifice and adjust the float position knob (10 on figure 1) until the top of the float is opposite the lower red line on the scale. Open the air valve on the orifice and observe the position of the float relative to the upper red line on the scale. If the top of the float is *above* the red line, adjust its position by turning the calibrating knob (9 on figure 1) counterclockwise until the float falls an equal distance *below* the red line on the scale. If the top of the float is *below* the red line, adjust its position by turning the calibrating knob clockwise until the float is positioned an equal distance *above* the red line on the scale. Then adjust the float position knob until the top of the float is opposite the upper red line on the scale.

B.1.2.6 Close the air valve and check the float position relative to the lower red line on the scale. The top of the float should be opposite the lower red line when the valve is closed and opposite the upper red line when the valve is open. If not, repeat step B.1.2.5 until the desired calibration is obtained.

B.1.2.7 Connect the air hose between No. 2 column and No. 2 orifice. Repeat steps B.1.2.5 and B.1.2.6.

B.1.2.8 Connect the air hose between No. 1 column and No. 1 orifice and repeat steps B.1.2.5 and B.1.2.6.

B.1.2.9 Connect the air hose between No. 3 column and the unnumbered coupling. Lower the gauging element on to the flat plate by operating the lever on top of the assembly. This operation should result in a zero (lower red line) reading in No. 3 column.

B.1.2.10 Connect the air hose between No. 3 column and No. 2 orifice and close the air valve on No. 2 orifice. The top of the float should be opposite the upper red line in No. 3 column.

B.1.2.11 Connect the air hose between No. 2 column and No. 3 orifice and open the air valve on No. 3 orifice. The top of the float should be opposite the lower red line in No. 2 column.

B.1.2.12 Connect the air hose between No. 2 column and No. 1 orifice and close the air valve on No. 1 orifice. The top of the float should be opposite the upper red line in No. 2 column.

B.1.2.13 Connect the air hose between No. 1 column and No. 2 orifice and open the air valve on No. 2 orifice. The top of the float should be opposite the lower red line in No. 1 column.

B.1.2.14 Connect the air hose between the clamping gauge and the appropriate column and check zero as in B.1.2.9.

B.2 Calibration of variable-area flowmeters

B.2.1 General

Variable-area flowmeters may be calibrated by a soap-bubble meter of which there are several designs.[2] Figure B.1 is a diagrammatic representation of a suitable meter.

B.2.2 Apparatus and product

B.2.2.1 Soap-bubble meter, consisting of:

— glass flask or bottle, capacity 1 litre;

— volumeter, with graduation marks indicating 50 ml, 1 000 ml and 2 000 ml; the different ranges may be achieved with replaceable volumeters (suitable designs are in a paper by Gooderham [2]);

— needle valve;

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

B.2.2.2 Stop-watch.

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

B.2.3 Procedure

Conduct the internal adjustment of the flowmeter as described in clause B.1. To calibrate the flowmeter tubes, disconnect the test assembly from the downstream end of the rubber or plastic tubing and connect in its place the soap-bubble meter at (A). Set the valves to deliver through the 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 time measurements are in excess of 30 s. Repeat the procedure at about six air flows distributed over the upper 80 % of the flowmeter range. Note the atmospheric pressure.

NOTE 3 At air flows above 1 200 ml/min the pressure drop in the Sheffield system is substantial and to ensure reproducibility of results it is necessary that the tubing used to connect the flowmeter to the measuring head be carefully controlled at 1,50 m ± 0,01 m in length and 6,25 mm ± 0,25 mm in internal diameter. For the same reason, openings in valves and other fittings on the instrument must not be changed from those provided by the instrument manufacturer.

B.2.4 Calculation

If the actual atmospheric pressure differs by more than 5 % from 101,3 kPa, correct the flow rates for pressure as follows:

$$q_0 = \frac{p \times V \times 60}{111{,}6 \times t}$$

$$= \frac{0{,}538 pV}{t}$$

where

q_0 is the flow rate, in millilitres per minute, corrected to 111,6 kPa [normal atmospheric pressure (101,3 kPa) plus nominal operating pressure (10,3 kPa) at 23 °C];

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 (10,3 kPa).

B.2.5 Accuracy

This method of calibration gives satisfactory accuracy for test atmospheric conditions which do not deviate appreciably from 101,3 kPa and 23 °C.

B.3 Construction of calibration graph

Construct a graph of scale reading against true air flow for each flowmeter. The graph should be a straight line and the results from the three flowmeters should all lie on the same line. If not, there is a defect in either the flowmeter tubes or the standard orifice manifold.