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Polymeric materials, cellular, flexible — Determination of air flow value at constant pressure-drop

Matériaux polymères alvéolaires souples — Détermination de l'indice d'écoulement d'air à chute de pression constante

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Foreword

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This document was prepared by Technical Committee ISO/TC45, *Rubber and rubber products*, Subcommittee SC 4, *Products (other than hoses),* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 249, *Plastics,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 7231:2010), which has been technically revised.

The main changes are as follows:

— the previous Annex A has been moved to Clause 6 as method B2;

— the previous 6.5 (the precision of method B1) has been moved to a new Annex A.

— the previous precision of method B2 has been added to a new Annex A.

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Polymeric materials, cellular, flexible — Determination of air flow value at constant pressure-drop

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1 Scope

This document specifies two methods for determining the air flow value of flexible cellular polymeric materials:

— method A, for conventional types of flexible cellular polymeric material;

— method B, for all types of flexible cellular polymeric material, but especially for materials with a low permeability to air.

For method B, two methods are specified in this document:

— method B1: with manual measurement;

— method B2: with automatic measurement.

NOTE 1 Air flow values can be used to give an indication of the effects of formulation and production variables on the cellular structure.

NOTE 2 In this document, the expression "conventional type of flexible cellular polymeric material" means types which are unsuitable for sealing purposes.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
air flow value
volume flow rate required to maintain a constant pressure differential across a flexible foam test piece

4 Principle

A specified constant air pressure differential is created across a standard flexible foam specimen. The rate of flow of air required to maintain this pressure differential is measured as the air flow value.

5 Method A

5.1 Apparatus

The usual laboratory apparatus and, in particular, the following shall be used. Diagrams of suitable apparatus are shown in Figure 1 (using an air pressure below atmospheric) and Figure 2 (using an air pressure above atmospheric). The essential parts are described in 5.1.1 to 5.1.4.

5.1.1 Flow meters, low-pressure-drop, with an accuracy of up to ±2 %. These are required for air flow measurements. The actual air flow shall be adjusted by a combination of valve restriction, as shown in Figures 1 and 2, and blower or vacuum pump speed, so that the required pressure difference across the specimen [see 5.4 c)] is maintained constant.

Air flow meters with at least 250 mm scales are recommended. Flow-meters measuring in the range 0 dm^3/s to 10 dm^3/s cover a wide variety of cellular polymeric materials.

5.1.2 Manometer, graduated in the 0 Pa to 250 Pa range and with an accuracy of ±2 %. Traps to prevent manometer fluid being drawn into the test chamber by accidental pressure changes shall be provided. A plunger in the fluid reservoir is used to set the zero point after levelling the manometer.

The use of an inclined manometer with 2 Pa graduations is recommended. A level mounted on the manometer should be used to ensure that the proper degree of inclination from the horizontal is maintained.

5.1.3 Air supply or suction equipment, where the air supply or suction may be such that positive or negative pressure differences from atmospheric pressure are obtained across the test piece, using compressed air, an exhaust blower or a vacuum pump, etc.

NOTE A particular apparatus can be constructed to use only positive or negative pressure.

5.1.4 Test piece mounting, with a chamber of nominal dimensions 140 mm diameter × 150 mm depth (see Figure 1) or 75 mm diameter × 1 000 mm length (see Figure 2), incorporating a test piece mounting and fittings for the manometer and exhaust. The test piece cavity shall be (50 ± 0,05) mm × (50 ± 0,05) mm × (25 ± 0,05) mm.

The test piece shall be supported by suitable means, e.g. by the use of vanes, wires or a perforated support. The support shall provide a minimum open proportion of 70 % of the overall area, evenly distributed over its area (see Figures 1 and 2 for the positioning of the supports). Manometer and exhaust fittings shall be as shown in Figures 1 and 2.

5.1.5 Vacuum chamber operated at below atmosphere pressure.

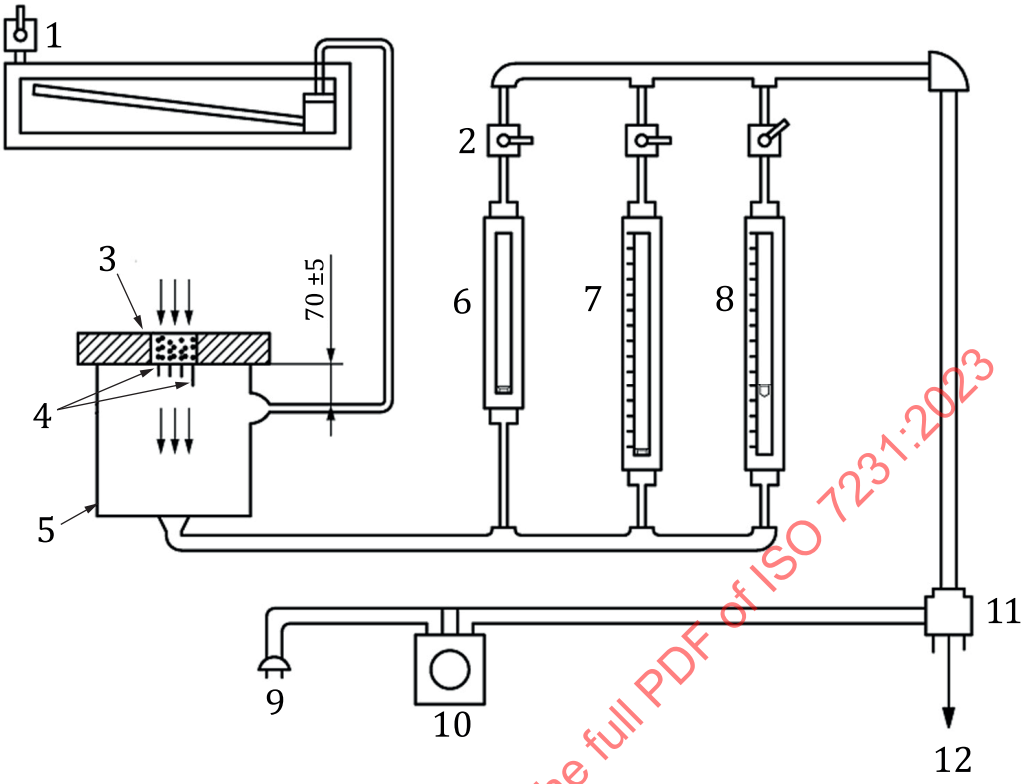
The apparatus, shown in Figure 1, shall be checked for leaks in the following manner.

a) Seal the test piece mounting cavity with masking tape.

b) With all the flow-meter valves closed, turn the air supply to approximately one-third of the maximum setting and observe any movement of the manometer. The manometer reading shall not exceed 1 Pa after 30 s.

c) Open the valve on the lowest-range flow-meter very slightly. The flow shall be essentially zero, as shown by a movement of less than 3 mm of the flow-meter float from its static position.

Dimensions in millimetres

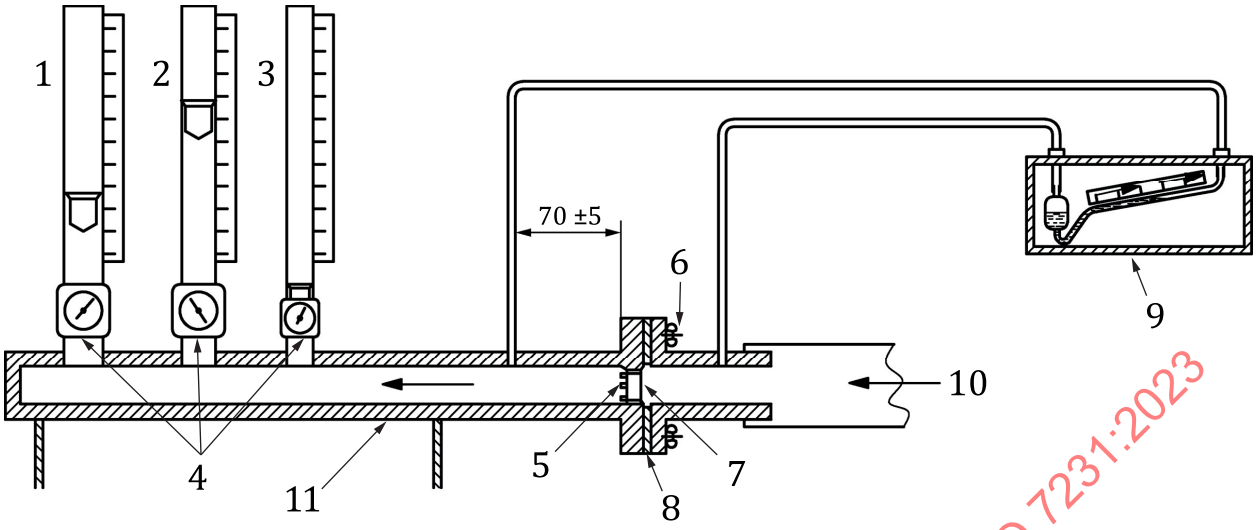


Key

1 inclined oil manometer
2 two-way ball valve
3 test piece
4 test piece support vanes
5 vacuum chamber
6 low-range air flow-meter
7 medium-range air flow-meter
8 high-range air flow-meter
9 power supply
10 voltage control
11 vacuum pump
12 exhaust

Figure 1 — Method A: Air flow apparatus (using air pressure below atmospheric)

Dimensions in millimetres



Key

1 high-range air flow-meter
2 medium-range air flow-meter
3 low-range air flow-meter
4 valves
5 horizontal steel rods to retain test piece in position
6 wing nut
7 test piece
8 gasket
9 inclined manometer
10 air supply
11 test chamber

Figure 2 — Method A: Air flow apparatus (using air pressure above atmospheric)

5.2 Test pieces

The test pieces shall normally be in the form of a right parallelepiped of dimensions (51,0 ± 0,3) mm × (51,0 ± 0,3) mm × (25,0 ± 0,3) mm. If test pieces of a different thickness are used, the thickness shall be stated in the test report. Any test pieces with length or breadth dimensions outside the required tolerance shall be discarded as they will lead to inaccurate air flow values. The test pieces shall be cut out without deformation of the original cell structure. Three test pieces shall be tested.

NOTE Test pieces both with and without surface skin can be tested by this method, but the results will not be comparable.

5.3 Test conditions

Testing shall be carried out under the standard conditions of either (23 ± 2) °C and (50 ± 5) % relative humidity or (27 ± 2) °C and (65 ± 5) % relative humidity, unless otherwise specified.

NOTE Since the flow-meter calibration is sensitive to temperature, the results obtained with these two sets of conditions will not necessarily be comparable.

5.4 Procedure

The method of measurement shall be as follows:

a) Place the test piece in the test cavity with any skin on the side exposed to the lower pressure. Make sure that the test piece is free from undue strain and that a good air seal is obtained between the edges of the test piece and the apparatus.

b) Close the flow-meter valves and switch on the blower or vacuum pump.

c) Open the high-range flow-meter slowly and adjust the air flow to obtain a pressure differential of (125 ± 1) Pa on the manometer.

d) If this reading is less than 10 % of full scale, close the valve of this flow-meter and open the medium-range flow-meter valve. Repeat this procedure until the correct flow-meter has been selected and the reading obtained.

   For greater accuracy, it is preferable to use two adjacent flow-meters, holding the higher-range one steady on an appropriate graduation mark and making the adjustment on the lower-range one. In this case, the air flow value is obtained from the sum of the two flow-meter readings after maintaining the pressure differential for 10 s.

e) Record the reading obtained as described in step d), in cubic decimetres per second, as the air flow value for the specimen.

NOTE Calibration of the apparatus can be carried out using a plate of known flow-rate value which is usually supplied by the manufacturer.

5.5 Test report

The test report shall include the following information:

a) a reference to this document including its year of publication, i.e. ISO 7231:2023;

b) the method used, i.e. method A;

c) all details necessary to identify the material tested;

d) the individual test results and the mean air flow value (in dm^3/s);

e) if test pieces of thickness different from that specified in 5.2 were used, the thickness of the test pieces;

f) the orientation of the test pieces with respect to the direction of any anisotropy and the presence or absence of any skins;

g) the test conditions used, i.e. temperature, relative humidity, apparatus type and pressure direction;

h) any deviations from the procedure;

i) any unusual features observed;

j) the date of the test.

6 Method B

6.1 Method B1 with manual measurement

6.1.1 Apparatus

The usual laboratory apparatus and, in particular, the following shall be used. An example of the manual test apparatus is shown in Figure 3. The essential parts of the apparatus are as described in 6.1.1.1 to 6.1.1.4.

6.1.1.1 Air orifice.

A metal plate with an orifice of a suitable size shall be mounted in the partition in the cylindrical test chamber. Generally, 10 such plates with different sizes of orifice are available, and one of them is chosen according to the air flow value of the test piece.

6.1.1.2 Clamping ring.

A metal ring shall be used to hold the test piece on top of the cylinder as shown in Figure 3. It shall have a hole in the centre to allow air to pass through the central uncovered area of the test piece. The diameter of the hole is normally 70 mm, although holes of other diameters may be used, depending on the particular test apparatus.

6.1.1.3 Manometers, both inclined and vertical, graduated to an accuracy of ±2 %.

The inclined-manometer range shall be 0 Pa to 250 Pa (25 mm H_2O), and 2,0 Pa (0,2 mm H_2O) graduations are recommended.

The vertical manometer should be capable of measuring from 0 Pa to 3 000 Pa (300 mm H_2O). Graduations of 25 Pa (2,5 mm H_2O) are recommended.

With both manometers, traps shall be provided as shown in Figure 3 to prevent manometer fluid being drawn into the chamber by accidental pressure changes. A plunger in the trap is used to set the zero point after the manometer has been setup in the correct position. A level mounted on the manometer shall be used to ensure that this correct position is maintained during the test.

6.1.1.4 Air supply or suction equipment, designed to operate under negative applied pressure and, typically, containing an integral extractor fan. Alternatively, the test equipment can be connected to a vacuum pump.

6.1.1.5 Vacuum chamber operated at below atmosphere pressure.

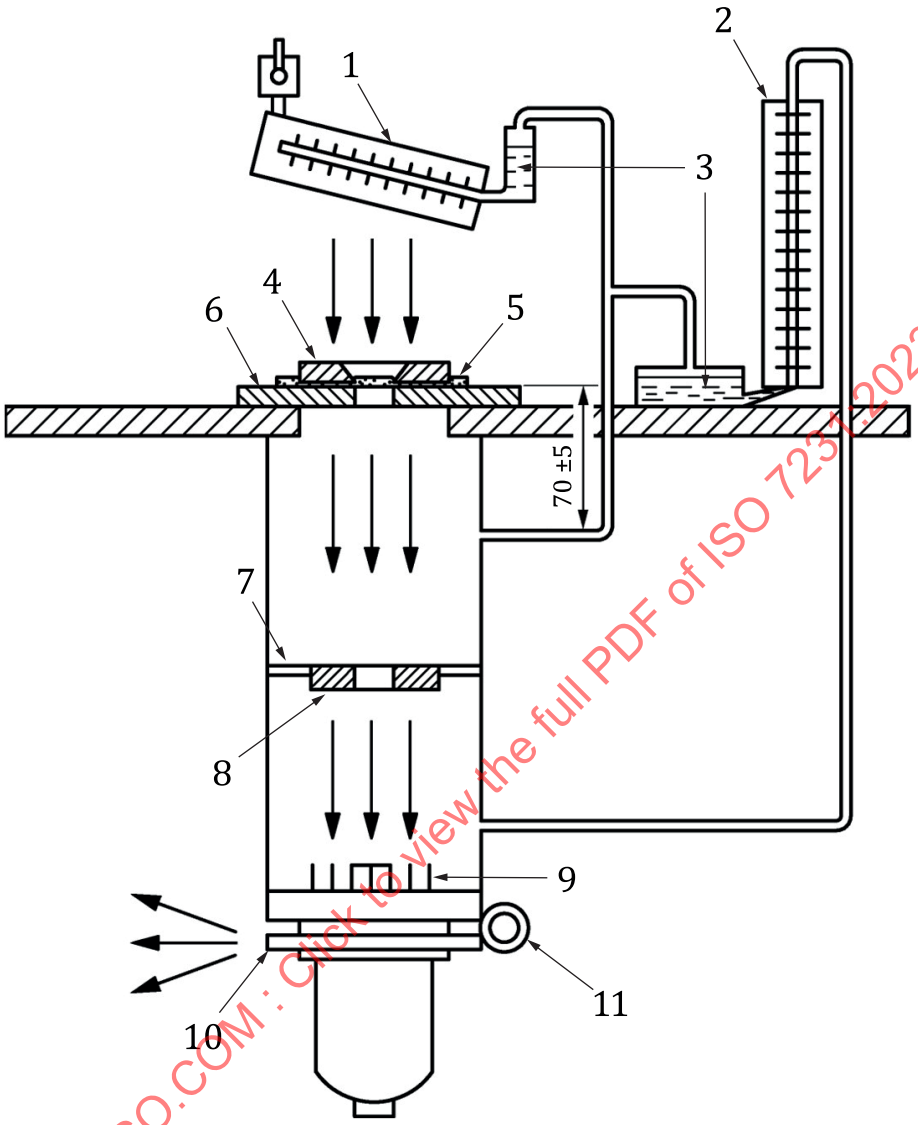
The apparatus, shown in Figure 3, shall be checked for leaks in the following manner:

a) Place an impermeable film (such as thin rubber or plastic sheet) on the test piece mounting plate and lock it in place with the clamping ring.

b) Set the pressure differential to (125 ± 1) Pa.

c) Start the measurement and confirm that the air flow value has no change.

Dimensions in millimetres



Key

1 inclined manometer
2 vertical manometer
3 traps for manometer fluid
4 clamping ring
5 test piece
6 test piece mounting plate
7 partition
8 air orifice
9 air baffles
10 extractor fan
11 air outlet

Figure 3 — Method B1: Example of a manual test apparatus

6.1.2 Test pieces

Take three test pieces, each 10 mm thick, 220 mm wide and 220 mm long, from the product under test. Place the first test piece under the clamping ring, which ensures a tight seal. If the measurement on a particular test piece has to be repeated, the test piece can be moved and re-clamped in place to expose a different area.

6.1.3 Test conditions

Testing shall be carried out under the standard conditions of either (23 ± 2) °C and (50 ± 5) % relative humidity or (27 ± 2) °C and (65 ± 5) % relative humidity, unless otherwise specified.

NOTE Since the flow-meter calibration is sensitive to temperature, the results obtained with these two sets of conditions will not necessarily be comparable.

6.1.4 Procedure

The method of measurement shall be as follows:

a) Mount the chosen air orifice (6.1.1.1) in the partition wall.

b) Mount the test piece under the clamping ring.

c) Start up the apparatus and adjust the fan/pump speed to give a scale reading on the inclined-manometer scale corresponding to a pressure differential of (125 ± 1) Pa.

d) Record the pressure indicated on the vertical manometer and the size of air orifice used. The resultant air flow value, in millilitres per square centimetre per second (ml/cm^2/s), is obtained from the conversion chart specific to the test apparatus.

e) Express the air flow value as the average of those obtained for the three test pieces, rounded to one decimal place.

NOTE Calibration of the apparatus can be carried out using a plate of known flow-rate value which is usually supplied by the manufacturer.

6.1.5 Precision

The precision of the method is given in Annex A.

6.1.6 Test report

The test report shall include the following information:

a) a reference to this document including its year of publication, i.e. ISO 7231:2023;

b) the method used, i.e. method B1;

c) all details necessary to identify the material tested;

d) the individual test results and the mean air flow value (in ml/cm^2/s);

e) the orientation of the test pieces with respect to the direction of any anisotropy and the presence or absence of any skins;

f) the test conditions used, i.e. temperature, relative humidity and apparatus type;

g) any deviations from the procedure;

h) any unusual features observed;

i) the date of the test.

6.2 Method B2 with automatic measurement

6.2.1 Apparatus

The usual laboratory apparatus and, in particular, the following shall be used. An example of the automatic test apparatus is shown in schematic form in Figure 4. The apparatus is connected to a computer which controls the extractor fan, maintains the pressure at the value set and displays the measured value of the air flow through the test piece on a screen. The essential parts of the apparatus are as described in 6.2.1.1 to 6.2.1.5.

6.2.1.1 Test piece mounting plate and clamping ring.

These are the main parts of the test piece holder and both have a circular hole of specified area at the centre. The cross-sectional area of the hole is normally 38 cm^2 (corresponding to a diameter of 70 mm), although holes of other diameters can be used, depending on the particular test requirements. The clamping ring has an outer diameter of 110 mm and inner diameter of 70 mm. A locking system holds the test piece on the mounting plate firmly enough to ensure an airtight seal around the hole, but not so firmly that it damages the test piece. The outer diameter of the mounting plate should be larger than that of the clamping ring. Both of the plates should be thick enough to avoid deformation caused by the locking system.

6.2.1.2 Air orifice.

In the computer-controlled apparatus, the air orifice plate mounted in the partition in the test chamber is designed with eight orifices of different sizes. Computer control of the plate enables it to be rotated to select a single orifice of the diameter desired for the test.

6.2.1.3 Pressure gauge, connected to the test head to indicate a pressure with an accuracy of 2 % at least between 100 Pa and 200 Pa.

NOTE When using the device shown in the Figure 4, the pressure gauge inlet is located (70 ± 5) mm below the upper surface of the test piece mounting plate.

6.2.1.4 Flow meter.

The air flow rate measured by the flow-meter is displayed on the computer screen.

6.2.1.5 Extraction fan, controlled by computer to maintain the under pressure in the test chamber at the required value.

6.2.1.6 Vacuum chamber operated at below atmosphere pressure.

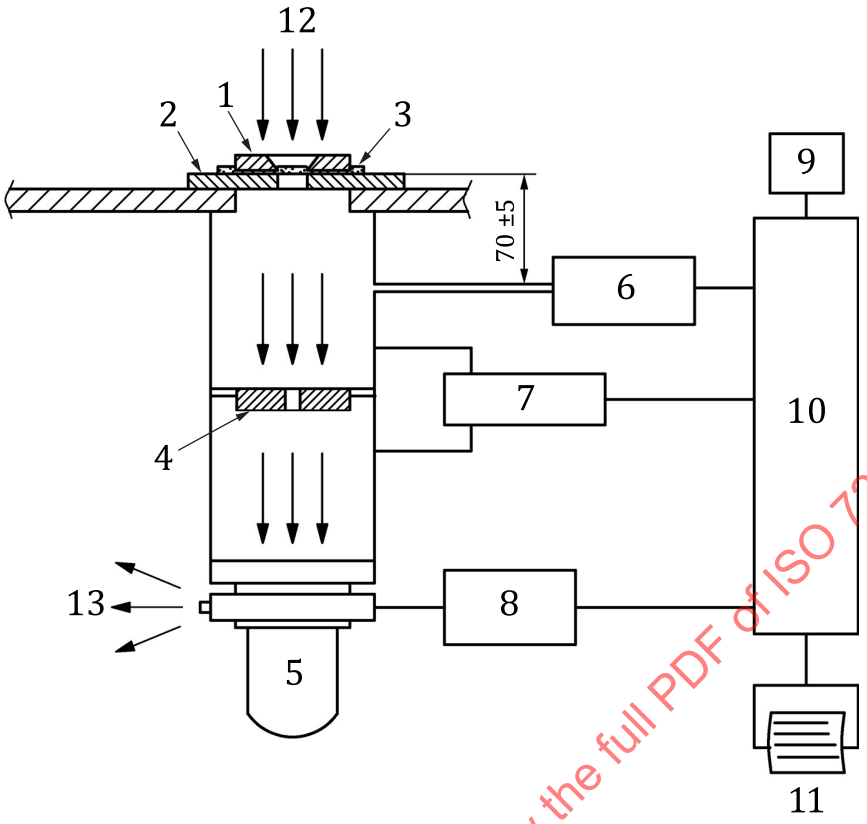
The apparatus, shown in Figure 4, shall be checked for leaks in the following manner:

a) Place an impermeable film (such as thin rubber or plastic sheet) on the test piece mounting plate and lock it in place with the clamping ring.

b) Set the pressure differential to (125 ± 1) Pa.

c) Start the measurement and confirm that the air flow value has no change.

Dimensions in millimetres



Key

1 clamping ring
2 test piece mounting plate
3 test piece
4 air orifice plate
5 extractor-fan motor
6 pressure gauge
7 flow-meter
8 controller for extractor-fan motor
9 start/stop switch
10 computer
11 printer
12 air inlet
13 air outlet

Figure 4 — Method B2: Example of an automatic test equipment

6.2.2 Test pieces

See 6.1.2

6.2.3 Test conditions

See 6.1.3

6.2.4 Procedure

The method of measurement is typically as follows, although the procedure can be modified in accordance with the operating instructions given by the manufacturer of a particular apparatus:

a) Press the start switch to start the apparatus and then switch on the extractor fan.

b) Set the pressure differential to (125 ± 1) Pa.

c) Place an impermeable film (such as a thin rubber or plastic sheet) on the test piece mounting plate and lock it in place with the clamping ring.

d) Start the extractor fan and confirm that there are no leaks, i.e. that there is zero air flow with the selected orifice size.

e) Switch off the extractor fan, remove the film and then re-start the fan.

f) Set the pressure differential to (125 ± 1) Pa.

g) Mount the test piece on the mounting plate and lock it in place with the clamping ring, taking care to avoid wrinkling or folding of the test piece.

h) Select the desired orifice size by adjusting the switch on the computer.

i) Read the result displayed on the computer screen after a few seconds when a steady flow rate has been obtained (stable to better than ±3 %) and record this result as the air flow value, rounding up to the second decimal place.

j) Switch the fan off and remove the test piece.

k) Repeat the procedure with a further two test pieces and compute the average of the three values, rounding the average to one decimal place.

l) Check for side leakage between the test piece mounting plate and the clamping ring by inserting a test piece, covering its upper surface with an impermeable film and repeating steps g) to j). If a positive air flow value is obtained, subtract this from the average value computed in step k) to give a corrected average.

NOTE Calibration of the apparatus can be carried out using a plate of known flow-rate value which is usually supplied by the manufacturer.

6.2.5 Test report

The test report shall include the following information:

a) a reference to this document including its year of publication, i.e. ISO 7231:2023;

b) the method used, i.e. method B2;

c) all details necessary to identify the material tested;

d) the individual test results and the mean air flow value (in ml/cm^2/s);

e) the orientation of the test pieces with respect to the direction of any anisotropy and the presence or absence of any skins;

f) the test conditions used, i.e. temperature, relative humidity and apparatus type;

g) any deviations from the procedure;

h) any unusual features observed;

i) the date of the test.

Annex A
(informative)

Precision of methods B1 and B2

A.1 General

A.1.1 The interlaboratory test programme of method B1was conducted in 2005 and its precision was determined in accordance with ISO/TR 9272[1)]. Six laboratories participated, using two different types of flexible polyurethane foam, namely No. 1 (conventional ether foam) and No. 2 (conventional ester foam), and testing three test pieces of each type.

A.1.2 The interlaboratory test programme of method B2 was conducted in 2022 and its precision was determined in accordance with ISO 19983, method A. Five laboratories participated, using three different types of flexible polyurethane foam, namely No. 1 (conventional ester foam), No. 2 (conventional ether foam) and No.3 (conventional ether foam), and testing three test pieces of each type.

A.1.3 The precision results as determined by the interlaboratory test programme should not be used for acceptance or rejection of any group of materials without documentation that the results of this precision evaluation are actually applicable to the particular group of materials tested.

A.2 Results

A.2.1 General

The precision results of each method are given in Table A.1 and A.2.

Table A.1 — Precision results of Method B1

Sample foam	Mean value	Within-laboratory			Between laboratories		
	ml/cm²/s	s_r	r	(r)	s_R	R	(R)
No. 1	99,5	9,9	28,0	28,2	13,6	38,6	38,7
No. 2	108,8	9,7	27,4	25,2	15,1	42,8	39,3

Key

s_r is the repeatability standard deviation;

r is the repeatability, in measurement units;

(r) is the relative repeatability, in percent of the mean level;

s_R is the reproducibility standard deviation;

R is the reproducibility, in measurement units;

(R) is the relative reproducibility, in percent of the mean level.

1) Withdrawn and replaced by ISO 19983.