# INTERNATIONAL STANDARD

# ISO 9053

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# Acoustics — Materials for acoustical applications — Determination of airflow resistance

*Acoustique — Matériaux pour applications acoustiques — Détermination de la résistance à l'écoulement de l'air*



Reference number
ISO 9053:1991(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 9053 was prepared by Technical Committee ISO/TC 43, *Acoustics*.

Annex A of this International Standard is for information only.





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## Introduction

The airflow resistance of porous materials indicates, in an indirect manner, some of their structural properties. It may be used to establish correlations between the structure of these materials and some of their acoustical properties (for example, absorption, attenuation, etc.).

This International Standard is, therefore, useful for two purposes:

a) in relating some of the acoustical properties of porous materials to their structure and their method of manufacture;

b) in ensuring product quality (quality control).

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# Acoustics — Materials for acoustical applications — Determination of airflow resistance



## 1 Scope

This International Standard specifies two methods for the determination of the airflow resistance of porous materials for acoustical applications.

It is applicable to test specimens cut from products of porous materials.

NOTE 1 Details of publications relating to flow behaviour under both laminar and turbulent conditions are given in annex A.

## 2 Definitions

For the purposes of this International Standard, the following definitions apply.

**2.1 airflow resistance,** $R$: A quantity defined by

$$R = \frac{\Delta p}{q_V}$$

where

$\Delta p$ is the air pressure difference, in pascals, across the test specimen with respect to the atmosphere;

$q_V$ is the volumetric airflow rate, in cubic metres per second, passing through the test specimen.

It is expressed in pascal seconds per cubic metre.

**2.2 specific airflow resistance,** $R_s$: A quantity defined by

$$R_s = RA$$

where

$R$ is the airflow resistance, in pascal seconds per cubic metre, of the test specimen;

$A$ is the cross-sectional area, in square metres, of the test specimen perpendicular to the direction of flow.

It is expressed in pascal seconds per metre.

**2.3 airflow resistivity,** $r$: If the material is considered as being homogeneous, that quantity defined by

$$r = \frac{R_s}{d}$$

where

$R_s$ is the specific airflow resistance, in pascal seconds per metre, of the test specimen;

$d$ is the thickness, in metres, of the test specimen in the direction of flow.

It is expressed in pascal seconds per square metre.

**2.4 linear airflow velocity,** $u$: A quantity defined by

$$u = \frac{q_V}{A}$$

where

$q_V$ is the volumetric airflow rate, in cubic metres per second, passing through the test specimen;

$A$ is the cross-sectional area, in square metres, of the test specimen.

It is expressed in metres per second.

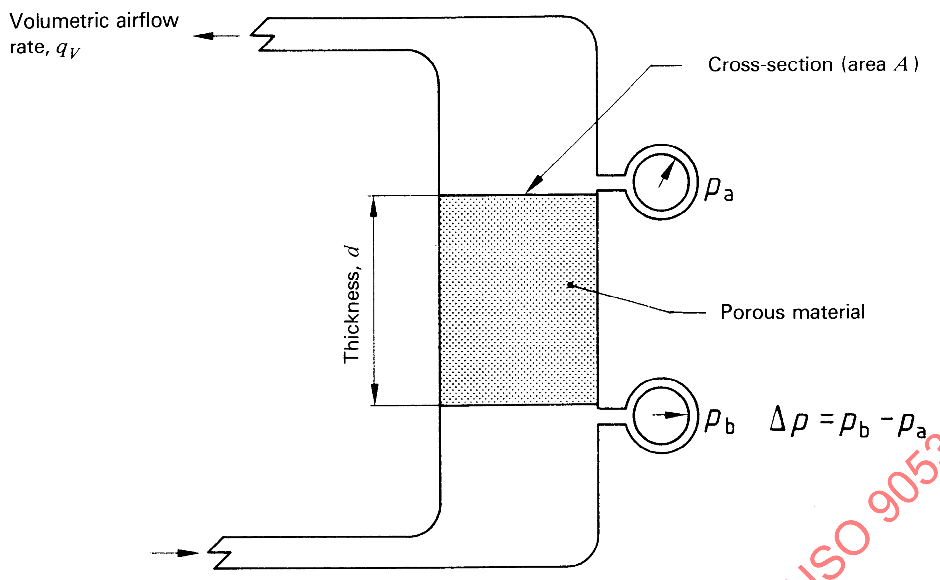


**Figure 1 — Direct airflow method (method A) — Basic principle**

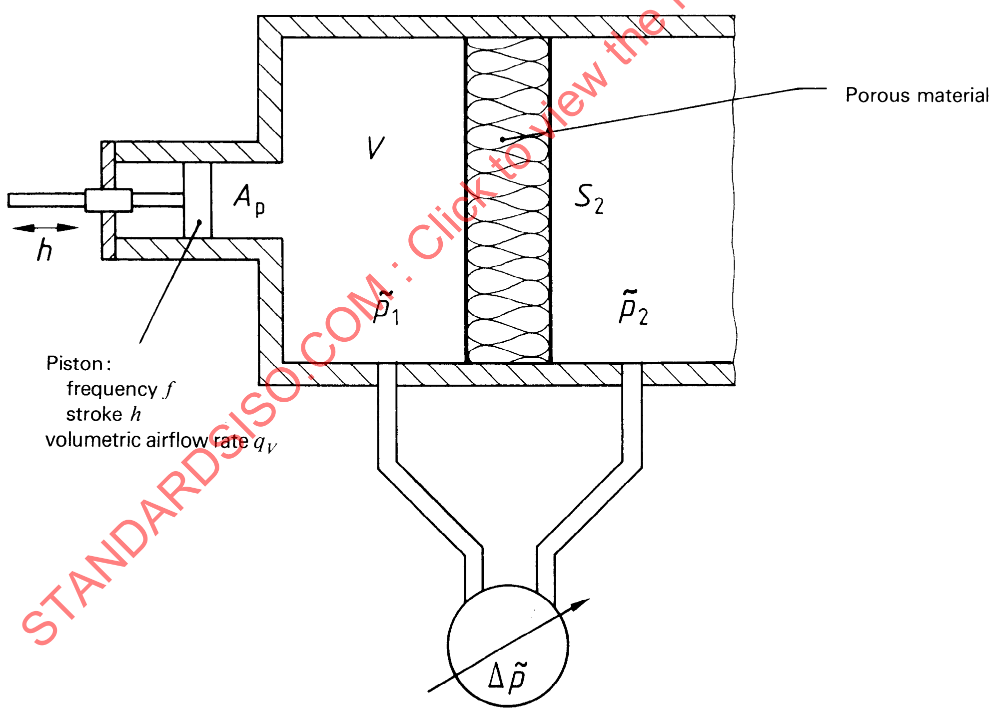


**Figure 2 — Alternating airflow method (method B) — Basic principle**

## 3 Principle

### 3.1 Direct airflow method (method A)

Passing of a controlled unidirectional airflow through a test specimen in the form of a circular cylinder or a rectangular parallelepiped, and measurement of the resulting pressure drop between the two free faces of the test specimen (see figure 1).

### 3.2 Alternating airflow method (method B)

Passing of a slowly alternating airflow through a test specimen in the form of a circular cylinder or a rectangular parallelepiped, and measurement of the alternating component of the pressure in a test volume enclosed by the specimen (see figure 2).

## 4 Equipment

### 4.1 Equipment for method A

The equipment shall consist of

a) a measurement cell into which the test specimen is placed;

b) a device for producing a steady airflow;

c) a device for measuring the volumetric airflow rate;

d) a device for measuring the pressure difference across the test specimen;

e) a device for measuring the thickness of the test specimen when it is in position for the test.

An example of suitable equipment is shown in figure 3.



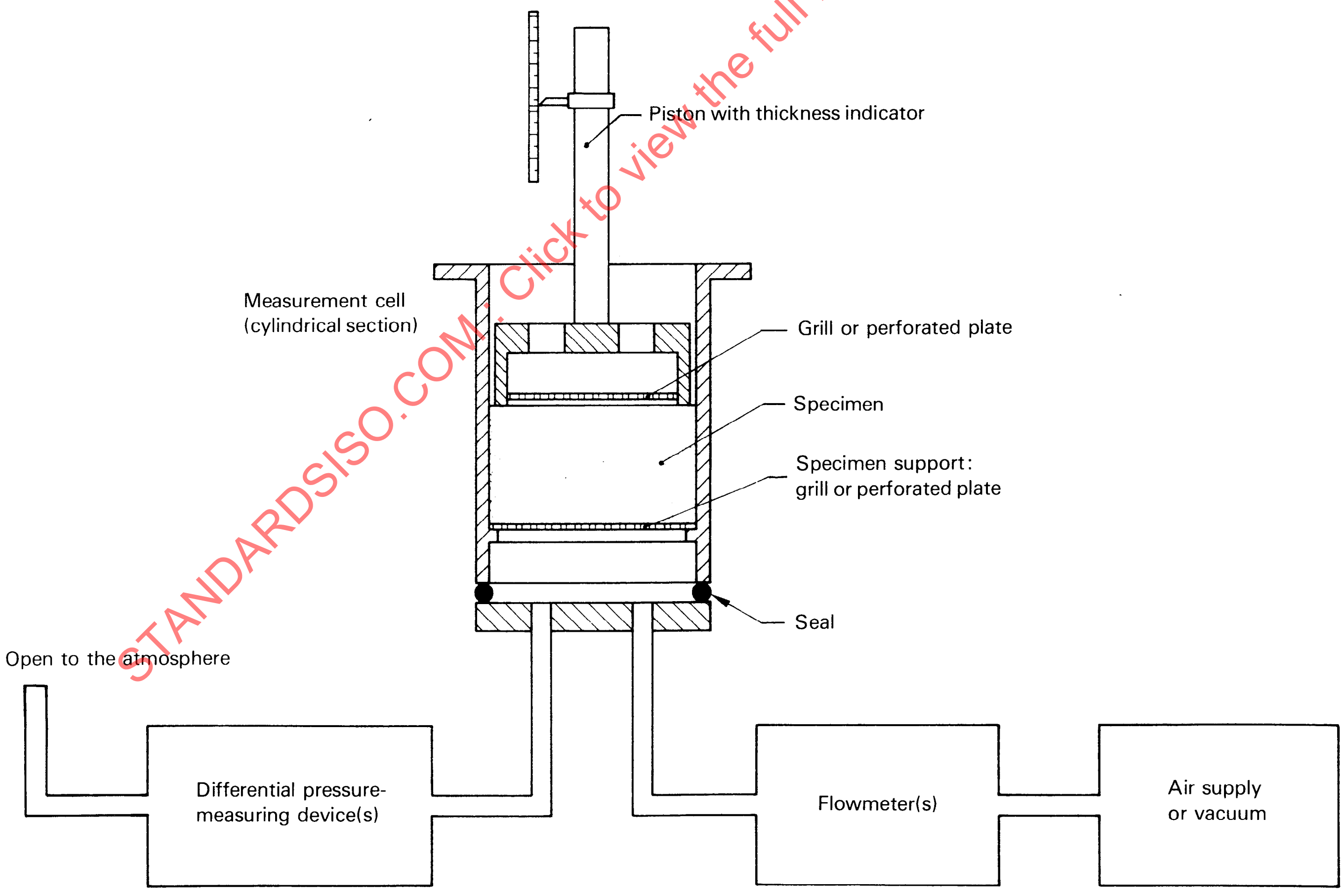


**Figure 3 — Measurement equipment, with cylindrical section, for direct airflow method (method A)**

#### 4.1.1 Measurement cell

The measurement cell shall be in the shape of a circular cylinder or a rectangular parallelepiped. An example of a cylindrical measurement cell is shown in figure 3.

If it is circular in cross-section, the internal diameter shall be greater than 95 mm.

For the rectangular parallelepiped shape, the preferred cross-section is a square. In any case, all sides shall measure at least 90 mm.

The total height of the cell should be such that there is essentially laminar undirectional airflow entering and leaving the test specimen. The height should be at least 100 mm greater than the thickness of the test specimen.

The test specimen shall rest inside the measurement cell (on a perforated support if necessary), positioned far enough above the base of the cell to meet the above requirement. This support shall have a minimum open area of 50 %, evenly distributed. The holes in the support shall have a diameter not less than 3 mm.

NOTE 2 In some cases it may be necessary to increase the percentage of the open area in order not to restrict the airflow through the test specimen.

The tapping points for the measurement of pressure and airflow shall be leak-free and arranged below the level of the perforated support.

#### 4.1.2 Device for producing airflow

It is recommended that pressure depression systems of the water reservoir or vacuum pump type be used. Alternatively, pressurization systems (air compressor, etc.) may be used if they do not contaminate the air.

Whatever airflow source is used, the installation shall permit fine control of the flow and shall ensure the stability of the flow in the lower part of the test cell.

The airflow source should provide airflow rates such that the resulting velocities will be low enough to ensure that the measured airflow resistances are independent of velocity.

It is recommended that the source be such as to permit airflow velocities down to $0,5 \times 10^{-3}$ m/s to be obtained.

#### 4.1.3 Device for measuring volumetric airflow rate

The pressure tap of the instrument for measuring the volumetric airflow rate shall be placed between the source and the test specimen, inside the test cell as close as possible to the test specimen.

The arrangement used shall permit measurement of the airflow to an accuracy of $\pm 5$ % of the indicated value.

#### 4.1.4 Device for measuring differential pressure

The equipment used for measuring differential pressures shall permit measurements of pressures as low as 0,1 Pa.

The arrangement used shall permit measurement of the differential pressure to an accuracy of $\pm 5$ % of the indicated value.



### 4.2 Equipment for method B

The equipment shall consist of

a) a measurement cell into which the test specimen is placed;

b) a device for producing an alternating airflow;

c) a device for measuring the alternating component of the pressure in the test volume enclosed by the test specimen;

d) a device for measuring the thickness of the test specimen when it is in position for the test.

Two examples of suitable equipment with different specimen holders are shown in figure 4 and figure 5.

#### 4.2.1 Measurement cell

The measurement cell is composed of two parts:

a) the specimen holder;

b) the test volume (see figure 4 and figure 5).

Both parts shall be in the shape of a circular cylinder, as shown in figure 4 and figure 5, or a rectangular parallelepiped.

If the shape of the specimen holder is circular in cross-section, the internal diameter shall be greater than 95 mm.

For rectangular specimen holders, the preferred cross-section is a square. In any case, all sides shall measure at least 90 mm.

In all cases, the test volume shall have a cross-section equal to at least that of the specimen holder.

The test specimen shall rest inside the specimen holder (on a perforated support if necessary). The lower face of the test specimen delineates the test volume.

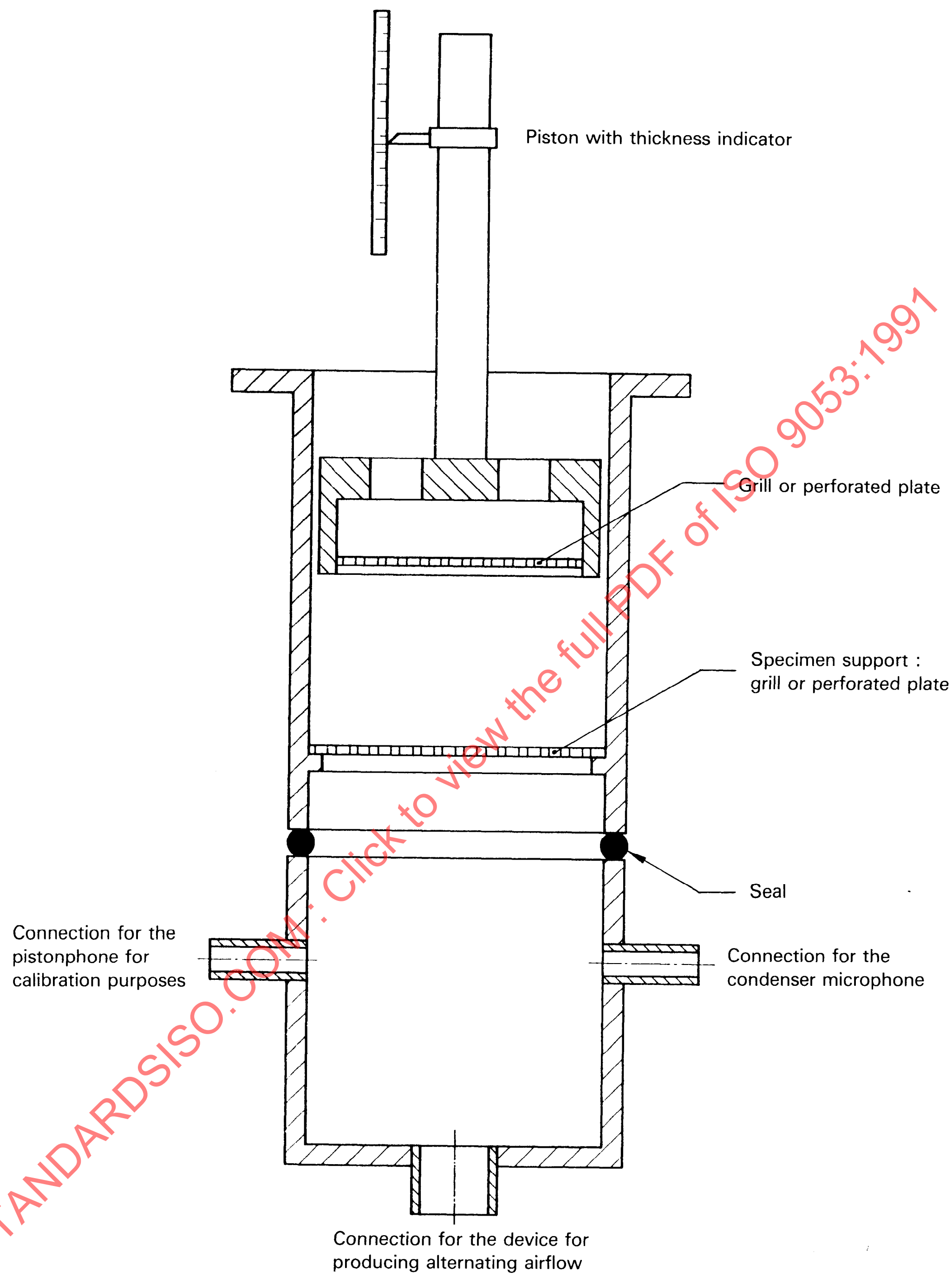




**Figure 4 — Measurement cell with specimen holder for measuring fibre materials of loose and wadding structure (method B)**

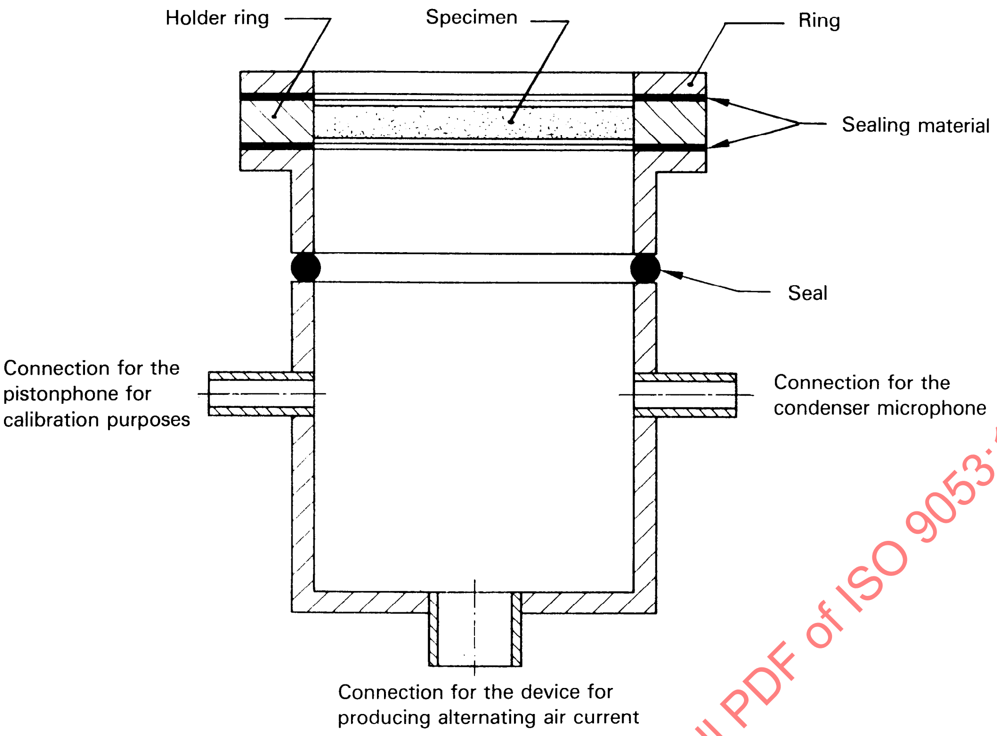


**Figure 5 — Measurement cell with holder for cylindrical specimen (method B)**



The support, if used, shall have a minimum open area of 50 % evenly distributed. The holes in the support shall have a diameter not less than 3 mm.

NOTE 3 In some cases it may be necessary to increase the percentage of the open area in order not to restrict the airflow through the test specimen. The flow resistance of such elements (measured with an airflow rate greater than the maximum airflow rate to be used during the specimen test) should be less than 1 % of the flow resistance measured when testing the specimen.

### 4.2.2 Device for producing alternating airflow

The alternating volumetric airflow rate is produced by a piston moving sinusoidally at a frequency of about 2 Hz. Its r.m.s. value, $q_{V,\,\mathrm{r.m.s.}}$, in cubic metres per second, is given by

$$q_{V,\,\mathrm{r.m.s.}} = \frac{\pi}{\sqrt{2}} f h A_{\mathrm{p}}$$

where

- $f$ is the frequency, in hertz, of the piston;
- $h$ is the stroke (peak to peak displacement), in metres, of the piston;
- $A_{\mathrm{p}}$ is the cross-sectional area, in square metres, of the piston cylinder.

The resulting r.m.s. value of the linear airflow velocity, $u_{\mathrm{r.m.s.}}$, in metres per second, is given by

$$u_{\mathrm{r.m.s.}} = \frac{q_{V,\,\mathrm{r.m.s.}}}{A}$$

where

- $q_{V,\,\mathrm{r.m.s.}}$ is the r.m.s. value of the alternating volumetric airflow rate, in cubic metres per second;
- $A$ is the area, in square metres, of the test specimen.

It is recommended that the range of $u_{\mathrm{r.m.s.}}$ values be between 0,5 mm/s and 4 mm/s.

The alternating pressure in the specimen holder shall be measured by a laterally mounted condenser microphone connected to an amplifier and meter. The pressure measurement device shall be calibrated using a pistonphone connected to the specimen holder. The specimen holder vessel is closed airtight for the calibration; the specimen holder is also closed airtight for the measurement. The alternating pressure with the pistonphone, $p_{\mathrm{eff}}$, in pascals, is given by

$$p_{\mathrm{eff}} = 1{,}4 \frac{p_0}{\sqrt{2}} \cdot \frac{V_{\mathrm{pk}}}{V}$$

where

- $p_0$ is the atmospheric pressure, in pascals;

$V_{pk}$ is the product of the amplitude and piston cross-sectional area of the calibration pistonphone, in cubic metres;

$V$ is the volume of the test vessel, in cubic metres.

The measuring device can thus be calibrated absolutely in pressure units. With unchanged amplitude of the measuring piston, the scale is able to indicate the specific flow resistance directly.

The piston of the calibrating pistonphone shall have a diameter of approximately 10 mm and a stroke of approximately 5 mm.

NOTE 4 Intercomparison measurements of a specimen with known specific flow resistance have shown that the pressure in the test vessel varies nearly adiabatically with the piston operating at 2 Hz.

### 4.3 Device for measuring specimen thickness

The specimen holder shall be equipped with a micrometer or other indicator allowing the measurement of specimen thickness to an accuracy of $\pm 2,5$ % of the indicated value.

## 5 Test specimens

### 5.1 Shape

The test specimen may be circular or rectangular, depending on the type of measurement cell available.

### 5.2 Dimensions

#### 5.2.1 Lateral dimensions

When testing soft, compressible materials, such as fibrous insulations or flexible foams, care shall be taken in the preparation of the specimens to reduce the possibility of leaks along the edges. In these cases, test specimens shall be prepared with lateral dimensions slightly larger than those of the measurement cell.

Specimens of rigid materials shall have the same dimensions as the measurement cell.

NOTE 5 Care should be taken to avoid distortion of the test specimen.

#### 5.2.2 Thickness

The thickness of the test specimen shall be chosen to obtain pressure drops measurable under optimum conditions and to suit the usable depth of the measurement cell.

If the test specimens available are not sufficiently thick to produce a suitable pressure drop, test specimens — but not more than five — chosen in the same way, may be superimposed.

### 5.3 Number of test specimens

At least three samples shall be taken, from each of which three test specimens shall be cut.

## 6 Test procedure

**6.1** Place the test specimen, prepared as described in clause 5, in the measurement cell.

**6.2** Ensure that the edges are properly sealed. Petroleum jelly may be used to seal the edges of rigid specimens.

**6.3** Bring the device for measuring the thickness of the test specimens into contact with the upper surface of the test specimens, compressing it lightly if necessary.

**6.4** Note the thickness and use this measurement to determine the free or the compressed volume and from this derive the free or the compressed density of the test specimen when in position.

**6.5** Since the specific airflow resistance of many sound-absorbing materials has been found to increase with the linear airflow velocity in a certain range, it should be measured at the smallest possible linear airflow velocity. A linear airflow velocity, $u$, of $0,5 \times 10^{-3}$ m/s is recommended as the lower limit. This value of particle velocity would correspond to a sound pressure of 0,2 Pa (80 dB reference 20 µPa).

In the case of the procedure using direct airflow (method A), the pressure drop $\Delta p$ shall be measured either directly at $u = 0,5 \times 10^{-3}$ m/s or stepwise down to the lower limit of linear airflow velocity. The specific airflow resistance shall be calculated in accordance with 2.2.

In the case of incremental reduction of airflow, plot for each specimen a graph of specific airflow resistance versus linear airflow velocity. From this, the specific airflow resistance for $u = 0,5 \times 10^{-3}$ m/s shall be determined by graphical averaging or, if necessary, by extrapolation to this value.

In the case of a procedure using alternating airflow (method B), the specific airflow resistance can usually be determined at a r.m.s. velocity, $u$, of $0,5 \times 10^{-3}$ m/s. Otherwise, the step-by-step procedure as described in the case of method A shall be used.

## 7 Precision

Interlaboratory precision experiments are planned.

## 8 Test report

The test report shall include the following information in addition to the results calculated for the test specimens as described in 6.5 and their mean and other statistical parameters (standard deviation, etc.), if they are demanded by the product specification:

a) a reference to this International Standard;

b) the material of the product, and its apparent density, including the appropriate test standard used;

c) the method used and its lower limit for determining the airflow resistance;

d) the test conditions used, particularly the shape and dimensions of the measurement cell;

e) the method of preparation of the test specimen;

f) the number of test specimens and their lateral dimensions;

g) if necessary, the orientation of the axis of the test specimens with respect to the principal axes of symmetry;

h) the presence and nature of any skin;

i) the thickness and density of the material as tested;

j) any deviation from the procedures specified in this International Standard which may have influenced the results.