
**Acoustics — Determination of airflow
resistance —**

**Part 1:
Static airflow method**

*Acoustique — Détermination de la résistance à l'écoulement de l'air —
Partie 1: Méthode statique*

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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).

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).

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

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*.

This first edition of ISO 9053-1 cancels and replaces ISO 9053:1991, which has been technically revised. The main changes are as follows:

- title changed;
- alternating airflow method deleted.

A list of all parts in the ISO 9053 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.

Acoustics — Determination of airflow resistance —

Part 1: Static airflow method

1 Scope

This document specifies the measurement of the determination of the static airflow resistance^[1,2], in a laminar flow regime, of porous materials for acoustical applications.

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 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 airflow resistance

R

quantity defined by

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

where

Δp is the air pressure difference, in pascal, across the test specimen with respect to the atmosphere;

q_v is the volumetric airflow rate, in cubic metre per second, passing through the test specimen.

Note 1 to entry: It is expressed in pascal second per cubic metre.

3.2 specific airflow resistance

R_s

quantity defined by

$$R_s = R \times A$$

where

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

A is the cross-section area, in square metre, of the test specimen perpendicular to the direction of flow.

Note 1 to entry: It is expressed in pascal second per metre.

3.3 airflow resistivity

σ

quantity defined by the following formula if the material is considered as being homogeneous

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

where

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

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

Note 1 to entry: It is expressed in pascal second per square metre.

3.4 linear airflow velocity

u

quantity defined by

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

where

q_v is the volumetric airflow rate, in cubic metre per second, passing through the test specimen;

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

Note 1 to entry: It is expressed in metre per second.

3.5 permeability

k_0

quantity defined by the following equation if the material is considered as being homogeneous

$$k_0 = \frac{\eta}{\sigma}$$

where

η is the dynamic viscosity of air in newton second per square metre (approximately $1,82 \times 10^{-5}$ for the air at 20 °C and 1 atmosphere of static pressure);

σ is the static airflow resistivity in pascal second per square metre, of the test specimen.

Note 1 to entry: It is expressed in square metres.

4 Principle

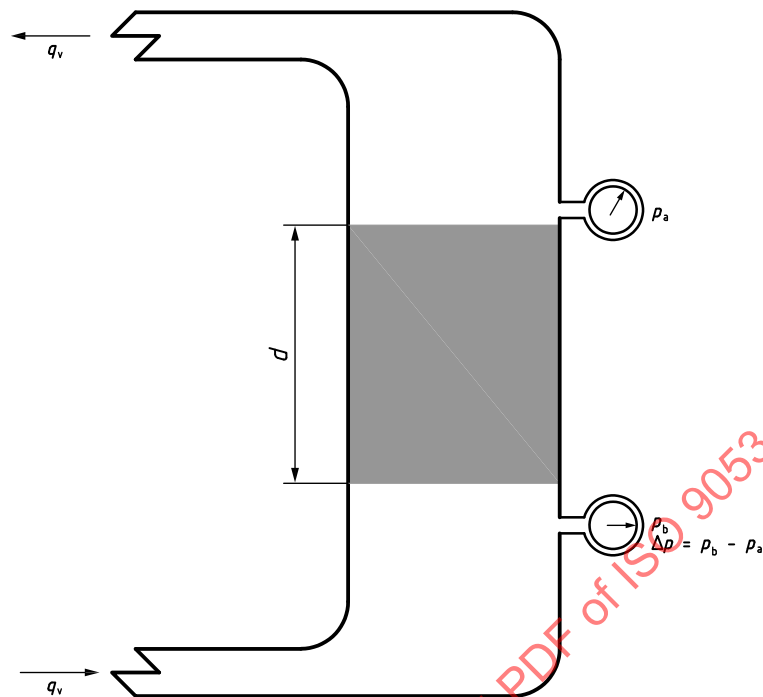


Figure 1 — Basic principle

The principle of the method, as described in [Figure 1](#), is to measure the pressure drop between the two free faces of a test specimen (in the form of a circular cylinder or a rectangular parallelepiped) while it is subjected to a controlled unidirectional airflow.

5 Equipment

5.1 General

The equipment shall consist of:

- a measurement cell into which the test specimen is placed;
- a device for producing a steady airflow;
- a device for measuring the volumetric airflow;
- a device for measuring the pressure difference across the test specimen;
- a device for measuring the thickness of the test specimen when it is in position for the test.

All devices used for measurements [c), d), e)] should be calibrated using their conventional calibration methods at least once every 2 years.

5.2 Measurement cell

The measurement cell shall be in the shape of a circular cylinder or a rectangular parallelepiped (preferably with a square cross-section in this latter case). The diameter or smallest edge of the measurement cell shall be chosen depending on the test specimens (see [6.2.1](#)). In any case, the minimum diameter or smallest edge of the measurement cell shall be 29 mm. Different measurement cells can be used independently as long as they fulfil all the requirements of this document.

The total height of the cell should be such that there is essentially laminar unidirectional airflow entering and leaving the test specimen. Thus, its height should be such that a free space equivalent to, at least, one diameter (or larger transverse dimension) is present in front of the test specimen. A length greater than the diameter (or larger transverse dimension) of the sample holder is recommended behind the test specimen, in particular for thin test specimens with a low porosity (for which the flow distortion has a non-negligible impact on the measurements).

The test specimen shall rest inside the measurement cell (on a perforated support or preferably a grid made of thin wires, 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. The tapping points for the measurement of pressure and airflow shall be leak-free.

In some cases, it can be necessary to increase the percentage of the open area of the perforated support in order not to restrict the airflow through the test specimen. The airflow resistance of the support should be less than 1 % of the flow resistance measured when testing the specimen. The specific airflow resistance of a perforated support with circular perforations can be calculated as:

$$R_s = h8\eta/(\phi r^2)$$

where

h is the thickness of the perforated support in metres;

η is the dynamic viscosity of air (approximately $1,82 \times 10^{-5} \text{ Nsm}^{-2}$ for a room temperature of 20 °C and an atmospheric pressure of 1 atmosphere, i.e. 101 325 Pa);

ϕ is the perforation rate of the perforated support;

r is the perforation radius in metres.

5.3 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 are 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 $0,5 \times 10^{-3} \text{ ms}^{-1}$ to be obtained.

5.4 Device for measuring volumetric airflow

The pressure tap of the instrument for measuring the volumetric airflow shall be placed between the source and the test specimen.

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

5.5 Device for measuring differential pressure

The equipment used for measuring differential pressure 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.

5.6 Use of calibration test specimens

The measurement of at least one calibrated test specimen shall be carried out before a series of measurements to ensure the proper functioning of the hardware and the software.

This measurement shall be carried out at least once a day and after each significant modification of the pressure, temperature and hygrometry conditions (0,5 kPa or more, 5 °C or more, 5 % or more).

This measurement shall also be carried out after each operation or modification concerning the hardware or the software.

The calibration test specimen can be made of straight cylindrical pores for which the measured value can be validated with a theoretical one. The measured value using the calibration test specimen should correspond to the theoretical value within $\pm 10\%$ before measurements with test specimens of unknown static airflow resistivity as described in [Clause 7](#) are performed.

As a reminder, the specific airflow resistance of a perforated support with circular perforations can be calculated as:

$$R_s = h8\eta / (\phi r^2)$$

where

h is the thickness of the perforated support in metres;

η is the dynamic viscosity of air (approximately $1,82 \times 10^{-5}$ Nsm⁻² for a room temperature of 20 °C and an atmospheric pressure of 1 atmosphere, i.e. 101 325 Pa);

ϕ is the perforation rate of the perforated support;

r is the perforation radius in metres.

6 Test specimens

6.1 Shape

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

6.2 Dimensions

6.2.1 Lateral dimensions

The lateral dimensions of a test specimen shall contain a minimum of 10 pores for a foams test specimen, 10 fibres for a fibrous test specimen, 10 grains for a granular test specimen. In case no information about the microstructure of the material (number of pores, fibres or grains per mm) is available, a minimum diameter of 95 mm or a smaller edge of 90 mm minimum is required for the test specimens.

The measurement cell shall have the same lateral dimensions than a test specimen. See [7.2](#) to avoid leaks between the measurement cell and a test specimen.

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

6.2.2 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.

The thickness of the test specimen shall not be modified when it is placed in the measurement cell.

If the test specimens available are not sufficiently thick to produce a suitable pressure drop, test specimens chosen in the same way may be superimposed only if it does not modify the material microscopic structure. In particular, when test specimens of fibrous materials or non-woven textiles are superimposed, the individual superimposed test specimens shall be tested in the same fibre orientation. For perforated plates or woven textiles, holes or patterns should all be superimposed. If superimposition of test specimens is not possible with respect to the conditions above, a method to estimate the static airflow resistivity of thin test specimens using impedance tube measurements is presented in [Annex A](#).

6.3 Number of test specimens

The required number of test specimens depends on the type of the material and is commonly defined in product standards. Usually, three samples are required.

7 Test procedure

7.1 Place the test specimen, prepared as described in [Clause 6](#), in the measurement cell.

7.2 Ensure that the edges are properly sealed. A thin layer of petroleum jelly, thread seal tape or rings may be used to seal the edges of test specimens. When using petroleum jelly, care should be taken to avoid penetration of the petroleum jelly inside the test specimen.

7.3 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.

7.4 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.

7.5 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 corresponds to a sound pressure of 0,2 Pa (80 dB with a decibel reference of 20 μ Pa).

The pressure drop, Δp , shall be measured either directly at $u = 0,5 \times 10^{-3}$ m/s or stepwise up starting from the minimal (and closest to $0,5 \times 10^{-3}$ m/s) value of the flow velocity for which a measurement is possible. The specific airflow resistance shall be calculated in accordance with [3.2](#). If no direct measurement at $u = 0,5 \times 10^{-3}$ m/s is possible and stepwise measurements are required, the highest airflow velocity shall not exceed 15 mm/s (which corresponds to 110 dB). It is possible that the flow already is non-linear for some materials at such a velocity.

In the case of incremental increase of the flow velocity, plot for each test specimen a graph of the pressure drop, Δp , as a function of the flow velocity, u . From these data, a regression, at least of the second order,

shall be used to determine the pressure drop and the specific airflow resistance for $u = 0,5 \times 10^{-3}$ m/s. The regression shall pass through the origin of the graph (which is thus a constrained point).

NOTE The velocities and pressure drops used in this document are not compatible with ISO 9237[3], which requires pressure drops (and thus velocities) much larger than this document. Usually, these quantities are ten to a hundred times higher in ISO 9237 than in this document. Consequently, the resistivities measured with ISO 9237 are higher than those used in acoustics and described in this document (permeabilities are smaller with ISO 9237 than with this document). This document is compatible with ISO 4638[4] when measurements from ISO 4638 are extrapolated to a velocity of $0,5 \text{ mm s}^{-1}$.

8 Precision

From inter-laboratory experiments published in 2003 and 2017[5,6], a reproducibility rate around 15 % has been observed for open-cell foam materials. However, this percentage can strongly increase for granular materials or material with semi-closed pores due to air leakages at the sample perimeter or due to compression of the test specimens.

9 Test report

The test report shall include the following information in addition to the results calculated for the test specimens as described in 7.5 and their mean and other statistical parameters (standard deviation, etc.), if they are required by the product specification:

- a) a reference to this document, i.e. ISO 9053-1:2018;
- b) the material of the product and its volumetric mass density, including the appropriate test standard used;
- c) the flow velocities used to determine the specific airflow resistance and, if applicable, the regression technique;
- 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) if relevant, the presence and nature of any skin;
- i) the thickness and volumetric mass density of the material as tested in the measurement cell;
- j) any deviation from the procedures specified in this document which are likely to have influenced the results.