Ventilation for buildings — Air terminal devices — Aerodynamic testing and rating for displacement flow applications

The European Standard EN 12239:2001 has the status of a British Standard

ICS 91.140.30

National foreword

This British Standard is the official English language version of EN 12239:2001.

The UK participation in its preparation was entrusted to Technical Committee RHE/2, Air distribution and air diffusion, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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This British Standard, having been prepared under the direction of the Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 16 October 2001

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Ventilation for buildings — Air terminal devices — Aerodynamic testing and rating for displacement flow applications

Ventilation des bâtiments — Bouches d'air — Essais aérodynamiques et caractérisation pour applications déplacement d'air

Lüftung von Gebäuden — Luftdurchlässe — Aerodynamische Prüfung und Bewertung für Anwendung bei Verdrängungsströmung

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 156, Ventilation for buildings, the Secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2002, and conflicting national standards shall be withdrawn at the latest by February 2002.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies methods for the laboratory aerodynamic testing and rating of low velocity air terminal devices for displacement flow applications, including the specification of suitable test facilities and measurement techniques.

The standard gives only tests for the assessment of characteristics of the air terminal devices under non-isothermal conditions.

This standard applies to Class IV air terminal devices as defined in EN 12238.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references the subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 12238, *Ventilation for buildings — Air terminal devices — Aerodynamic testing and rating for mixed flow applications.*

prEN 13182:1998, *Ventilation for buildings — Instrumentation requirements for air velocity measurements in ventilated spaces.*

EN ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full (ISO 5167-1:1991).*

CR 12792, *Ventilation for buildings — Symbols and terminology.*

ISO 5221, *Air distribution and air diffusion — Rules to methods of measuring airflow rate in an air handling duct.*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in CR 12792, together with the following, apply.

3.1.1
low velocity air terminal device
air terminal device which is designed for thermally controlled ventilation e.g. displacement flow applications

3.1.2
primary airflow rate q_p
volume of air entering the air terminal device in unit time from an upstream duct

3.1.3
internally induced airflow rate q_i
volume of air in unit time induced into the primary airflow inside the air terminal device

3.1.4
total airflow rate q_t
volume of air in unit time, discharged into the room from the air terminal device

3.1.5
primary air temperature θ_p
air temperature of the primary airflow

3.1.6
induced air temperature θ_i
air temperature of the internally induced airflow

3.1.7
total air temperature θ_t
air temperature of the total airflow from the air terminal device

3.1.8
reference air temperature of the room θ_r
average of at least five measurements of the air temperature at a height of 1,1 m from the floor and outside the area directly influenced from the device

3.1.9
primary air temperature difference $\Delta\theta_p$
algebraic difference of the primary air temperature and the reference air temperature of the occupied zone

3.1.10
isovel
loci of points of equal mean velocity

3.1.11
length of the specified isovel a_v
maximum horizontal distance from the air terminal device (or wall) to the rectangle circumscribing the specified isovel, independent of the distance from the floor as shown in Figure 4

3.1.12
width of the specified isovel b_v
maximum width of the rectangle circumscribing the specified isovel perpendicular to a_v, independent of the distance from the floor as shown in Figure 4

3.1.13
height of the specified isovel h_v
maximum height above floor of the specified isovel as shown in Figure 5

3.1.14
induction rate i
the ratio of the internally induced airflow rate and primary airflow rate $i = q_i / q_p$

3.1.15
static pressure p_s
static pressure relative to the atmosphere

3.1.16
dynamic pressure p_d
dynamic pressure corresponding to the mean velocity in the connecting duct. For plenum connection without duct, the dynamic pressure is equal to zero

3.1.17
total pressure p_t
sum of the static and dynamic pressures

3.1.18
equivalent diameter D_e
equivalent diameter of the nominal size of the duct

3.2 Symbols

The nomenclature shown in Table 1 is used throughout this European Standard.

Table 1 — Symbols used in the testing of air terminal devices

Symbol	Quantity	SI unit
A	Area	m^2
A_d	Area corresponding to the cross section of the nominal size of the duct to which the device is fitted (neck area)	m^2
a_v	Length of isovel	m
b_R	Width of test room or installation	m
b_v	Width of isovel	m
C_i	Concentration measured in the internally induced airflow	—
C_p	Concentration measured in the primary airflow	—
C_t	Concentration measured in the total airflow of the air terminal device	—
D_e	Equivalent diameter $\left(2\sqrt{\frac{A_d}{\pi}}\right)$	m
D_h	Hydraulic diameter $\left(\frac{4\,A_d}{\text{perimeter}}\right)$	m
d	Diameter	m
h_v	Height of isovel	m
h_R	Height of test room or installation	m
i	Induction rate	—
l_R	Length of test room or installation	m
p_{sa}	Absolute static pressure	Pa
p_a	Atmospheric pressure	Pa
p_s	Static pressure or static gauge pressure (p_{sa} - p_a)	Pa
p_{ta}	Stagnation (or absolute total) pressure	Pa

Table 1 — Symbols used in the testing of air terminal devices *(concluded)*

Symbol	Quantity	SI unit
p_t	Total pressure (p_{ta} - p_a)	Pa
$p_{t1,2}$	Total pressure corresponding to a density of 1,2 kg·m^{-3}	Pa
p_{tD}	Total pressure requirement of the device	Pa
$p_{s1,2}$	Static gauge pressure corresponding to an air density of 1,2 kg·m^{-3}	Pa
p_d	Dynamic pressure (Velocity pressure) $\left(\rho \frac{v^2}{2}\right)$	Pa
Δp	Pressure difference (for a pressure difference device)	Pa
q_i	Internally induced airflow rate	m^3·s^{-1}
q_p	Primary airflow rate	m^3·s^{-1}
q_t	Total airflow rate	m^3·s^{-1}
v	Velocity	m·s^{-1}
v_m	Mean air velocity	m·s^{-1}
v_x	Maximum velocity at distance x from centre of supply air terminal device	m·s^{-1}
θ_p	Primary air temperature	K
θ_i	Induced air temperature	K
θ_t	Total air temperature	K
θ_r	Reference air temperature of the room	K
$\Delta\theta_p$	Primary air temperature difference	K
ρ	Density of air	kg·m^{-3}

4 Types of air terminal devices

The air terminal devices can be divided into the following types:

— Type 1 (categories α and β): devices for horizontal discharge of air;

— Type 2 (categories α and β): floor mounted devices with vertical discharge of air;

— Type 3 (categories α and β): ceiling mounted devices.

NOTE Category α is applicable to devices without internal induction.
Category β is applicable to devices with internal induction.

Two different test installations can be identified:

— test installation D: the air terminal device is connected to a duct;

— test installation P: the air terminal device is connected to the plenum without duct.

5 Method of test

5.1 Principle

The test consists of the determination of the pressure loss, isovel and, for category β devices, the induction rate of the air terminal device.

The air velocity shall be measured at different distances and heights from the air terminal device under non-isothermal conditions.

The air velocity shall be measured at sufficient points and locations to determine the specified isovel, according to the uncertainty given in clause 6.

For air terminal devices mainly designed for comfort ventilation, the isovel for v = 0,20 $m \cdot s^{-1}$ shall be determined.

For air terminal devices mainly designed for industrial purposes, the isovel for v = 0,30 $m \cdot s^{-1}$ shall be determined.

5.2 Test set-up

The test set-up is shown in Figures 1 and 2.

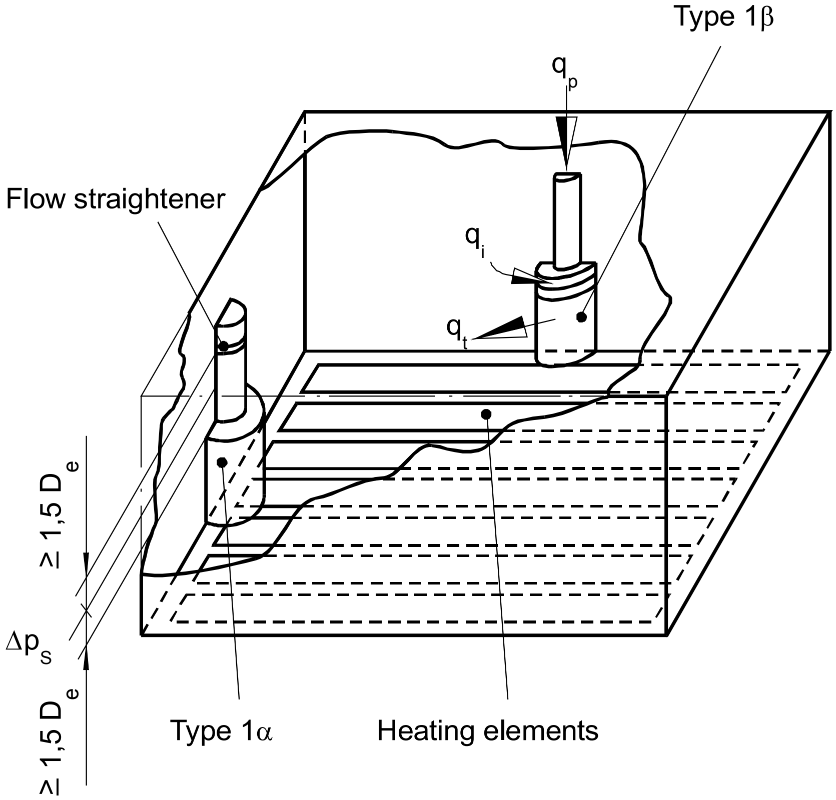

Figure 1 — Test set-up for Type 1 devices

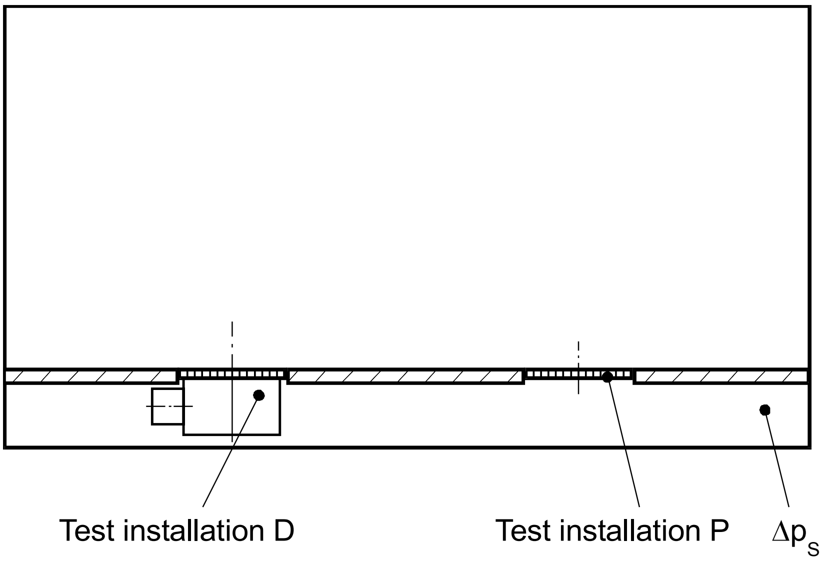

Figure 2 — Test set-up for Type 2 devices

5.3 Installation

5.3.1 General

The air terminal device shall be installed in accordance with the manufacturer's recommendation.

The primary air temperature shall be measured at a position $3D_e$ upstream of the air terminal device.

The temperature shall not vary by more than ±0,5 K, and the airflow rate shall not vary by more than ±2 % during the test.

5.3.2 Test installation D

The connection between the duct and the air terminal device shall be equal to the nominal size of the device.

The connecting duct shall be straight and at least $20D_e$ long to ensure uniform velocity profile or shall include an efficient flow straightener located at a position at least $3D_e$ from any part of the air terminal device. The straightener cells should have an axial length at least equal to six times the hydraulic diameter of their cross-section.

The plane of static pressure measurement shall be at $1{,}5D_e$ upstream of the air terminal device. A static pressure traverse shall be taken on two orthogonal diameters in order to obtain the maximum and minimum values. The measured pressures shall not differ by more than ±10 % from the pressure at the selected point of test in the plane of measurement. As an alternative method, a piezometer ring may be used.

5.3.3 Test installation P

The air velocity in the plenum shall not exceed 1 $m \cdot s^{-1}$ at a distance of $2D_e$ from the centre of the air terminal device inlet.

The static pressure shall be measured in the plenum where the air velocity is less than 1 $m \cdot s^{-1}$.

The primary air temperature shall be measured in the plenum at a maximum distance of $2D_e$ from the centre of the air terminal device inlet.

5.4 Velocity instruments

The measurement of low velocities shall be made with instruments in accordance to prEN 13182:1998.

5.5 Test room

The test shall be conducted in an enclosed room having all surfaces orthogonal at the corners and any surfaces over which the supply airflows shall be smooth and flat. Typical dimensions of the test room are 7,5 m in length, 5,6 m in width and 2,8 m in height. Larger or smaller test rooms shall have a width to height ratio between 1,5 and 2,2.

The minimum dimensions of the test room shall be:

Length	5,0 m
Width	4,2 m
Height	2,8 m

Air shall be exhausted from the test room at a position of at least 2,5 m from the floor.

The reference air temperature of the room is the average of at least five measurements at a height of 1,1 m from the floor and outside the area directly influenced from the device. The air temperature at these measuring points shall not differ by more than ±0,5 K from the mean value at any place.

The primary temperature difference shall be constant within ±0,5 K during the test.

Heating elements shall be distributed uniformly over the floor area and covered by the floor. The surface temperature of the floor shall not exceed the reference air temperature by more than 4 K.

5.6 Procedure

5.6.1 General

Do not commence testing until steady state conditions have been achieved.

Express the performance for category "α" devices for at least a primary air temperature difference $\Delta\theta_p$ of 3 K (cooling).

NOTE Air terminal devices of category "β" may also have their performance presented for a primary air temperature difference $\Delta\theta_p$ of 6 K (cooling).

Conduct the tests for a minimum of four airflow rates, equally distributed over the air terminal device working range.

Measure the mean velocity and the induction rate for a period of at least 3 min.

To determine the specified isovel, measure the low velocities in accordance with prEN 13182:1998.

NOTE It is an advantage if the turbulence intensity can be determined together with the mean velocity.

For Type 1 and 2 devices, take measurements of the mean velocity at a minimum of four distances from the air terminal device and at different heights in order to establish the highest mean value.

The velocity shall not be measured closer than 0,03 m above the floor.

Particular attention shall be taken when taking measurements between the levels 0,03 m to 0,10 m, since the maximum horizontal air velocities normally occur close to the floor.

Do not take any velocity measurements until at least one minute after moving a probe.

For Type 3 devices, two different cases can be separated:

a) free flow pattern down to floor level;

b) flow pattern along walls down to floor level.

In both cases, determine the isovel along the floor as described above.

For the free flow pattern case, carry out an additional test to determine the isovel, or the level of the highest velocity between the air terminal device and the floor.

For calculating the induction rate of category β devices (in accordance with 5.7.3), measure the temperatures θ_t and θ_i according to the following:

— the induced air temperature is the average of at least three measurements in representative positions at a maximum distance of 20 mm from the opening of the induced air;

— the total air temperature is the average of at least six measurements in representative positions distributed over the outlet area and a maximum distance of 100 mm from the air terminal device, ensuring by flow-visualization that measurements are made within the airstream.

The following measuring methods to determine the induction rate can however also be used:

a) measurement with tracer gas (in accordance with 5.6.2);

b) measurement with the zero pressure-difference method (in accordance with 5.6.3).

5.6.2 Measuring with tracer gas

For calculating the induction rate of category β devices (see 5.7.3), measure the concentrations C_t and C_i according to the following:

— the induced air concentration is the average of at least three measurements in representative positions at a maximum distance of 20 mm from the opening of the induced air;

— the total air concentration is the average of at least six measurements in representative positions distributed over the outlet area and a maximum distance of 100 mm from the air terminal device.

Measure the primary air concentration C_p under the same conditions as the primary air temperature given in 5.3.2 and 5.3.3.

For the test installation D, induce the tracer gas into the primary airflow at a position of at least $20D_e$ from any part of the air terminal device, and with constant emission.

For the installation P, induce the tracer gas into the primary airflow outside the plenum, and with constant emission.

5.6.3 Measuring with the zero pressure-difference method

5.6.3.1 Flow rates

Mount the unit under test in a system as typically shown in Figure 3.

When measuring induction rate using the zero pressure-difference method, the following airflow rates shall be measured:

- primary airflow rate;
- induced airflow rate or total airflow rate.

Measure the airflow rates using instruments in accordance with ISO 5221.

5.6.3.2 Test installation

The test installation shall conform to the typical arrangement shown in Figure 3.

To achieve ambient pressure in the connection chamber, a compensation fan shall be used.

The connection chamber shall be connected to the induction air inlet.

5.6.3.3 Test procedure

Measure the airflow rates when zero pressure-difference is achieved in the connection chamber.

Maintain ambient pressure in the connection chamber by adjusting the compensation fan.

Calculate the induction rate as the average of at least four measured airflow rates, equally distributed over the air terminal device working range.

Allow at least 3 min to elapse between measurements.

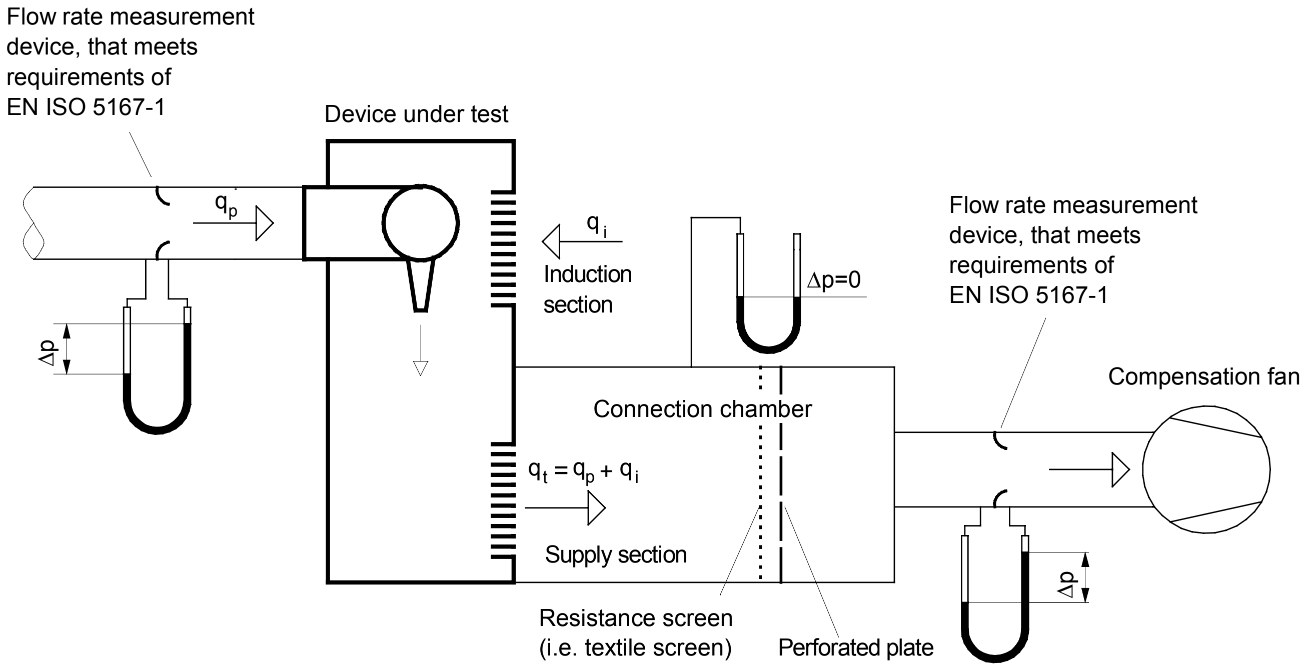

Figure 3 — Principal test installation for measurement of induction rate using the zero pressure-difference method

5.7 Expression of results

5.7.1 Pressure measurement for a given flow rate

Measure the static pressure in accordance with 5.3.2 and 5.3.3 for each airflow rate under consideration.

The dynamic pressure is calculated from $p_d = \frac{\rho \cdot v_m 2}{2}$ in Pa

where v_m is the mean air velocity obtained by dividing the test airflow rate by the duct cross-sectional area.

The total pressure is calculated from $p_t = p_s + p_d$ in Pa.

Correct pressures to a standard air density of 1,2 kg $^{-3}$ using the following:

$$p_{t1,2} = p_t \cdot \frac{1,2}{\rho} \text{ in Pa.}$$

5.7.2 Velocity measurement

Interpolate the isovel from the measured velocities.

Draw an isovel. Specify the maximum length, a_v, and width, b_v, of the specified isovel as shown in Figures 4 and 5. For Type 2 devices, also specify the height h_v.

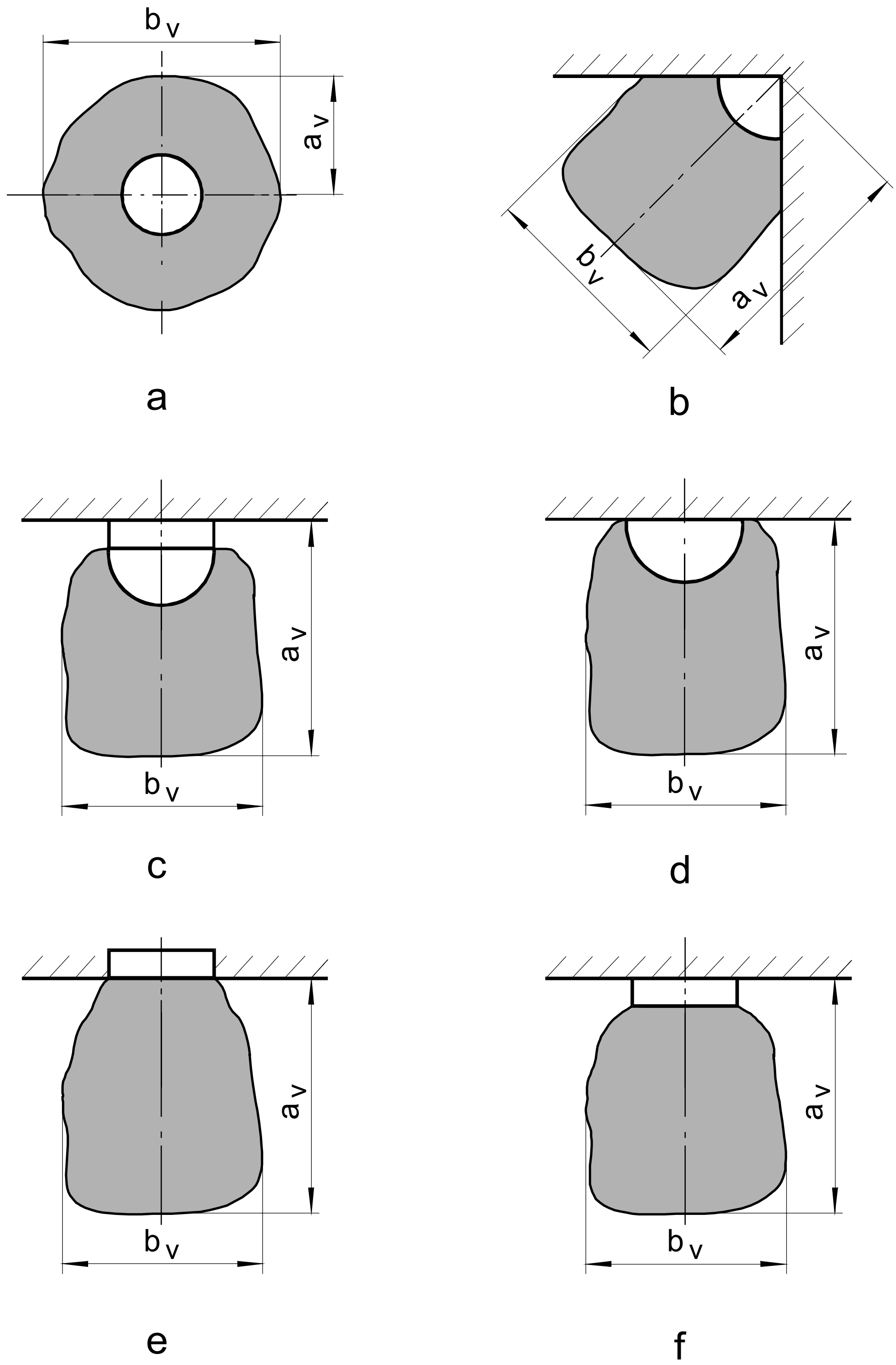

Figure 4 — Examples of typical isovels

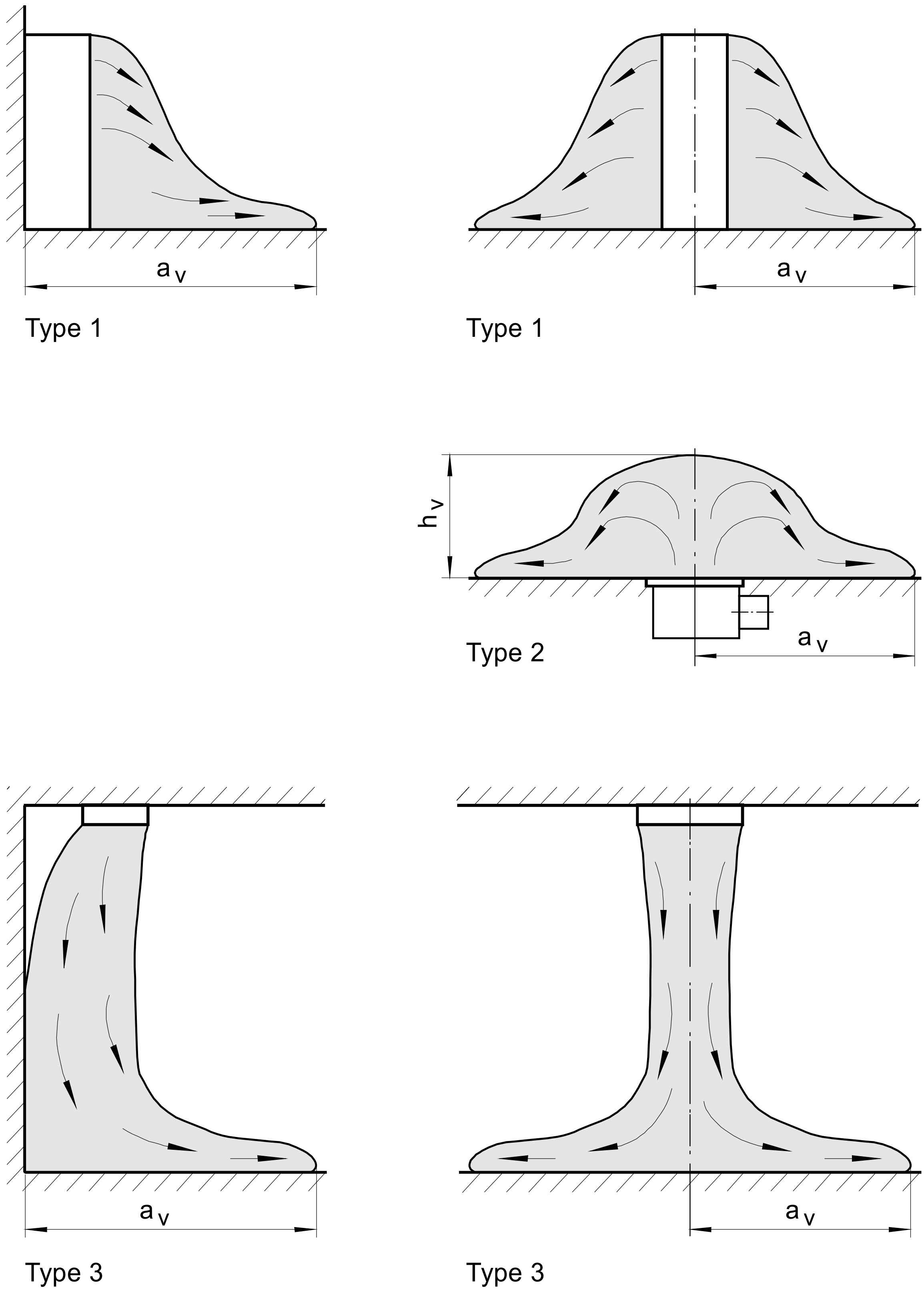

Figure 5 — Examples of typical isovels

5.7.3 Induction rate measurement

Calculate the induction rate for each airflow rate as follows:

$$i = \frac{\theta_t - \theta_p}{\theta_i - \theta_t}$$ when measuring temperatures;

$$i = \frac{C_t - C_p}{C_i - C_t}$$ when measuring concentrations of the tracer gas;

$$i = \frac{q_i}{q_p}$$ when measuring the airflow rate with the zero pressure-difference method.

6 Uncertainty

The measuring equipment chosen should be such as to give a total uncertainty in the determination of:

- airflow of less than ±3 % of the measured flow rate;
- static pressure of less than ±5 % or ±1 Pa;
- air velocity of less than ±0,05 $m \cdot s^{-1}$;
- air temperature of less than ±0,25 K.

The total uncertainty includes for errors in both the instrumentation and the test method.

The determination of a_v, b_v and h_v shall be better than ±0,2 m.

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