BRITISH STANDARD

BS EN 12238:2001

Ventilation for buildings — Air terminal devices — Aerodynamic testing and rating for mixed flow application

The European Standard EN 12238:2001 has the status of a British Standard

ICS 91.140.30

National foreword

This British Standard is the official English language version of EN 12238:2001.

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.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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English version

Ventilation for buildings — Air terminal devices — Aerodynamic testing and rating for mixed flow application

Ventilation des bâtiments — Bouches d'air — Essais aérodynamiques et caractérisation pour applications en diffusion à mélange

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

This European Standard was approved by CEN on 29 June 2001.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

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of an identical text or by endorsement, at the latest by February 2002, and conflicting national standards shall be withdrawn at the latest by February 2002.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 air terminal devices for mixed 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 isothermal conditions.

The testing of low velocity air terminal devices is specified in EN 12239.

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).

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

EN 12239, *Ventilation for buildings — Air terminal devices — Aerodynamic testing and rating for displacement flow applications.*

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

ISO 3966, *Measurement of fluid flow in closed conduits — Velocity area method using Pitot static tubes.*

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).*

3 Terms, definitions and symbols

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

3.1 Functional characteristics of air terminal devices

NOTE The acroynym ATD is used to signify an air terminal device.

3.1.1
nominal size of an air terminal device
nominal value of dimensions of the duct into which the air terminal device is to be fitted

NOTE For an air diffuser, the nominal size is generally known as neck size.

3.1.2 core and specific areas

3.1.2.1
core of an air terminal device
that part of an air terminal device located within a convex closed surface of minimum area, inside which are all the openings of the air terminal device through which the air can pass

3.1.2.2
free area (of an air terminal device)
sum of the smallest areas of the cross-section of all openings of the air terminal device

3.1.2.3
core of a grille
that part of a grille located inside a convex closed plane curve of minimum length of contour, inside which are all the openings of the grille

3.1.2.4
core area (of a grille)
area limited by the plane curve defined in 3.1.2.3

3.1.2.5
free area (of a grille)
sum of the minimum measured areas of each opening through which the air can pass

3.1.2.6
free area ratio (of a grille)
ratio of the free area to the core area

3.1.2.7
effective area of an air terminal device A_k
quotient resultant from measured airflow rate and measured air velocity as determined in a specified manner with a specified instrument

3.1.3 aspect and vane ratios

3.1.3.1
aspect ratio (of a rectangular air terminal device)
ratio of the larger side to the smaller side of the rectangular core

3.1.3.2
vane ratio (of a grille)
ratio of the chord length to the vane pitch

3.1.4 special terms relating to air

3.1.4.1
standard air
atmospheric air having a density of 1,2 kg·m^{-3} at 20 °C, 101 325 Pa (1 013,25 mbar) and 65 % Relative Humidity

3.1.4.2
supply air
air entering a supply air terminal device from an upstream duct

3.1.4.3
induced air
airflow induced by the supply air from a supply air terminal device

3.1.4.4
exhaust air
air leaving an exhaust air terminal device into a downstream duct

3.1.5 specific terms relating to air diffusion rating

3.1.5.1
mean measured air temperature of the occupied zone
arithmetical average of the measured values of air temperature within the occupied zone

3.1.5.2
supply temperature differential
algebraic difference between the supply air temperature and the mean measured air temperature of the occupied zone

3.1.5.3
exhaust temperature differential
algebraic difference of the exhaust air temperature and the mean measured air temperature of the occupied zone

3.1.5.4
temperature differential within the occupied zone
largest value of the difference between measured air temperatures within the occupied zone

3.1.5.5
primary airflow rate
volume of air entering a supply air terminal device in unit time from an upstream duct

3.1.5.6
exhaust airflow rate
volume of air leaving an exhaust air terminal device in unit time

3.1.5.7
local air velocity
magnitude of the time-averaged vector of velocity at a point of an air stream

The velocity vector (and therefore its three mutually perpendicular components u, v, w) in any point of a turbulent stream is submitted to fluctuations with respect to time. The time-averaged vector of velocity is a vector for which each component is averaged with respect to time. The components being:

$$\overline{u} = \frac{1}{T}\int_0^T u dt; \quad \overline{v} = \frac{1}{T}\int_0^T v dt; \quad \overline{w} = \frac{1}{T}\int_0^T w dt;$$

the local air velocity is therefore: $\sqrt{\overline{u}^2 + \overline{v}^2 + \overline{w}^2}$

3.1.5.8
local measured air velocity
measured value of local air velocity

3.1.5.9
treated space
enclosure served by an air distribution system

NOTE In this standard the treated space is the test room described in 6.2.

3.1.5.10
envelope
geometrical surface in a treated space where the local measured air velocity has the same value and is the reference velocity associated with this envelope

3.1.5.11
room air velocity
value of velocity conventionally derived from the various local measured air velocities within the occupied zone

3.1.5.12
free area velocity
primary airflow rate divided by the free area of a supply air terminal device or exhaust airflow divided by the free area of an exhaust air terminal device

3.1.5.13
throw (for a supply air terminal device)
maximum distance between the centre of the core and a plane which is tangent to a specified envelope, such as 0,25 $m \cdot s^{-1}$, 0,5 $m \cdot s^{-1}$, etc., and the centre of the core

3.1.5.14
drop (for a supply air terminal device)
vertical distance between the lowest horizontal plane tangent to a specified envelope, such as 0,25 $m \cdot s^{-1}$, 0,5 $m \cdot s^{-1}$, etc., and the centre of the core

3.1.5.15
rise (for a supply air terminal device)
vertical distance between the highest horizontal plane tangent to a specified envelope, such as 0,25 $m \cdot s^{-1}$, 0,5 $m \cdot s^{-1}$, etc., and the centre of the core

3.1.5.16
spread (for a supply air terminal device)
maximum distance between two vertical planes tangent to a specified envelope, such as 0,25 $m \cdot s^{-1}$, 0,5 $m \cdot s^{-1}$, etc., and perpendicular to a plane through the centre of the core

There can be two different spreads, which are not always equal: one for the left side, the other for the right side (considered when looking at the treated space from the supply air terminal device).

3.1.5.17
occupied zone (for laboratory purposes)
portion of the treated space geometrically limited to be no closer than 0,15 m to all walls and within a height of 1,8 m above the floor

3.1.5.18
slot air terminal device
device with single or multiple components with aspect ratio (the ratio of length to width of the enclosed rectangular opening) of 10:1 or greater for each slot

3.2 Symbols

The symbols used in this standard are given in Table 1.

Table 1 — Symbols

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_f	Free area	m^2
A_k	Effective area (k-factor area) $\left(\frac{q_v}{v_k}\right)$	m^2
b_R	Width of test room or installation	m
D_e	Equivalent diameter $\left(\sqrt{\frac{4 \times A_d}{\pi}}\right)$	m
D_h	Hydraulic diameter $\left(\frac{4 \times A_d}{\text{perimeter}}\right)$	m
d	Diameter	m
h_D	Face height of linear grille of diffuser	m
h_R	Height of test room or installation	m
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
p_t	Total pressure (p_{ta} - p_a)	Pa
$p_{t1,2}$	Total pressure corresponding to a density of 1,2 $kg \cdot m^{-3}$	Pa
p_{tD}	Total pressure requirement of the device	Pa

Table 1 — Symbols (*concluded*)

Symbol	Quantity	SI unit
$p_{s1,2}$	Static gauge pressure corresponding to a density of 1,2 kg·m^{-3}	Pa
p_{sD}	Static pressure requirement of the device	Pa
$p_{d1,2}$	Dynamic pressure (Velocity pressure) $\left(\rho \frac{v^2}{2}\right)$	Pa
Δp	Pressure difference (for a pressure difference device)	Pa
q_v	Volume rate of flow	m^{3}·s^{-1}
v	Velocity	m·s^{-1}
v_k	Velocity referred to the effective area (k-factor velocity) $\left(\frac{q_v}{A_k}\right)$	m·s^{-1}
v_x	Maximum velocity at distance x from centre of supply air terminal device	m·s^{-1}
x	Distance from supply air terminal device along the centreline of the jet	m
X	Throw	m
Y	Spread	m
Z	Drop	m
ζ	Loss coefficient	—
θ	Thermodynamic temperature	K
ρ	Density of air	kg·m^{-3}
R	Area parameter that relates to the effective size of the air terminal device	m^{2}
S	Linear parameter that relates to the effective size of the air terminal device	m
X_C	Coordinate (see annex A)	m
Y_C	Coordinate (see annex A)	m
Z_C	Coordinate (see annex A)	m

4 Instrumentation

4.1 Airflow rate measurement

4.1.1 The airflow rate shall be measured using instruments in accordance with EN ISO 5167-1.

4.1.2 Airflow meters shall have a minimum accuracy according to Table 2 ranges:

Table 2 — Ranges and accuracies of airflow meters

Range $m^3 \cdot s^{-1}$	**Accuracy of measurement** %
> 0,07 ≤ 7	± 2,5
> 0,007 ≤ 0,07	± 5,0

NOTE Flow meters can be calibrated in situ by means of the Pitot static tube traverse techniques described in ISO 3966.

4.1.3 Flow meters shall be checked at intervals as appropriate but not exceeding 12 months. This check may take the form of one of the following:

a) a dimensional check for all flow meters not requiring calibration;

b) a check calibration over their full range using the original method employed for the initial calibration of meters calibrated in situ;

c) a check against a flow meter which meets EN ISO 5167-1.

4.2 Pressure measurement

4.2.1 Pressure in the duct shall be measured with a calibrated manometer.

4.2.2 The maximum scale interval shall not be greater than the characteristics listed for the accompanying range of manometer, shown in Table 3.

Table 3 — Maximum scale intervals for the ranges of manometers

Range Pa	**Maximum scale interval** Pa
≤ 25	1,0
> 25 ≤ 250	2,5
> 250 ≤ 500	5,0
> 500	25

4.2.3 For airflow rate measurements, the minimum pressure differential shall be:

a) 25 Pa with an inclined tube manometer or micromanometer;

b) 500 Pa with a vertical tube manometer.

4.2.4 Calibration standards shall be:

a) for instruments with the range up to 25 Pa, a micromanometer accurate to ±0,5 Pa;

b) for instruments with the range up to 100 Pa, a micromanometer accurate to ±1 Pa;

c) for instruments with the range over 100 Pa, a micromanometer accurate to ±1 % of reading.

4.3 Temperature measurements

Measurements of temperature shall be made by means of mercury-in-glass thermometers, resistance thermometers, thermocouples or other suitable instruments. Instruments shall be graduated or give readings in intervals not greater than 0,5 K and calibrated to an accuracy of ±0,25 K.

4.4 Velocity measurements

4.4.1 The measurements of low velocities within treated spaces, to determine air terminal device performance characteristics, shall be made with a measuring device in accordance with prEN 13182:1998

4.4.2 The measurements of air terminal device velocities to determine air terminal device v_k velocity characteristics shall be made with a measuring device in accordance with prEN 13182:1998

5 Testing of pressure and air velocity v_k (first test installation)

5.1 Measurement of pressure requirement for a supply air terminal device

5.1.1 General

5.1.1.1 The-pressure requirement of an air terminal device is, for a given value of flow rate, dependent on the type and size of the device and on the velocity profile upstream of the device. A standard test duct immediately upstream of the air terminal device shall be employed. If an inlet duct arrangement, or flow equalizing and/or damping device, is an integral part of an air terminal device, then the standard test duct shall be employed immediately upstream of the integral inlet duct or accessory.

5.1.1.2 The test system shall comprise at least a fan, a means for controlling the airflow rate, a flow rate measuring device and a standard test duct for the air terminal device. Tests shall be carried out under isothermal conditions.

5.1.1.3 Pressure tests on the air terminal device alone, or the air terminal device in combination with a flow equalizing and/or damping device, shall be conducted to establish a pressure for a given airflow rate. The air terminal device shall be mounted in one of the two test installations described in 5.1.2 (see Figure 1) or 5.1.4 (see Figure 3). To determine minimum pressure, measurements shall be made with flow equalizing and/or damping devices in the normally open position. Pressure tests on the air terminal device shall be clearly referenced to any position of adjustment.

Two methods can be used for determining pressure requirements on test installation A: one by measuring static pressure (see 5.1.2), the other by directly measuring total pressure (see 5.1.3).

5.1.2 Measurement of static gauge pressure p_s with the first test installation A

5.1.2.1 This test installation shall be used for air terminal devices normally duct mounted.

The air terminal device shall be mounted in a test duct with cross-sectional dimensions equal to the nominal size of the device or to the duct dimensions normally recommended by the manufacturer. This duct shall be straight and at least $20D_e$ long to guarantee a 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. It is recommended that straightener cells have an axial length at least equal to six times the hydraulic diameter of their cross-section.

5.1.2.2 The test installation shall be generally constructed as shown in Figure 1. The plane of 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 pressure at the selected point of test in the plane of measurement shall not differ by more than 10 % from both the maximum and the minimum value within the pressure measurement plane. As an alternative method a piezometer ring can be used.

5.1.2.3 Record the results for a minimum of four airflow rates regularly distributed over the working range for each air terminal device tested.

5.1.2.4 The total pressure p_t in the plane of measurement is equal to the sum of the measured static gauge pressure p_s and the dynamic pressure p_d according to the following formula.

$$p_t = p_s + \frac{\rho}{2}\left(\frac{q_v}{A_d}\right)^2$$

5.1.3 Direct measurement of total pressure p_t with the first test installation A

5.1.3.1 This installation shall be used for air terminal devices normally installed duct mounted.

The test installation and the plane of measurement shall be the same as described in 5.1.2. A pitot tube shall be used for successively measuring the total pressure at five points in this plane. These five points shall be distributed as shown in Figure 2. One point is on the duct axis, the other four points are located on two orthogonal diameters at a distance from the duct axis equal to 0,4 times the diameter of the cross-section. The total pressure is the mean arithmetic value of the five total pressure recorded measurements.

For rectangular cross-section, measurements shall be made on diagonals with their length used as the referenced dimensions to locate the four supplementary points as shown on Figure 2.

5.1.3.2 Record the results for a minimum of four airflow rates regularly distributed over the working range for each air terminal device tested.

5.1.4 Measurement of static pressure p_s with the first test installation B

5.1.4.1 This test installation shall be used for air terminal devices normally installed in a plenum. The test installation shall be constructed as shown in Figure 3 such that the following formula is satisfied:

$$\frac{q_v}{A} < \sqrt{\frac{p_s}{5\rho}}$$

where

q_v is the volume flow rate;

A is the area of the internal cross-section of the chamber; ($A = W \cdot H$)

p_s is the required pressure;

ρ is the density of the air.

The air terminal device to be tested shall be mounted in a short test duct equal to the nominal size of the air terminal device and having a length equal to D or 0,15 m, whichever is greater. The test duct shall have a conical entrance.

The required pressure shall be measured with at least a single wall static tapping located within 0,05 m of the inside surface of the air terminal device mounting plate.

Equalizing sections shall be provided within the chamber to ensure that a relatively uniform flow, free from swirl, exists in the test chamber with the air terminal device mounting plate removed.

5.1.4.2 Record the results for a minimum of four airflow rates regularly distributed over the working range for each air terminal device tested.

5.1.4.3 The measured pressure p_s is equal to the total pressure p_t.

5.1.5 Presentation of total pressure p_t

5.1.5.1 Correct the data to standard air conditions according to the following formula:

$$p_{t1,2} = p_t \frac{1,2}{\rho}$$

Present the data in a graph showing the total pressure versus the airflow rate.

5.1.5.2 Alternative method: Presentation of static pressure p_s. Correct the data to standard air conditions according to the following formula:

$$p_{s1,2} = p_s \frac{1,2}{\rho}$$

Present the data in a graph showing the static pressure versus the airflow rate.

5.1.5.3 Alternative method: Presentation of the loss coefficient ζ. The loss coefficient ζ may by calculated from the following appropriate relationships, based upon the pressures measured under 5.1.2, 5.1.3 and 5.1.4.

$$\zeta = \frac{p_t}{p_d} \quad \text{(see 5.1.3 and 5.1.4)}$$

$$\zeta = \frac{p_s}{p_d} + 1 \quad \text{(see 5.1.2)}$$

Where p_t and p_s are the measured quantities and p_d is calculated as follows:

$$p_d = \frac{\rho}{2}\left(\frac{q_v}{A_d}\right)$$

and where both ρ and q_v are at the same test conditions.

5.2 Measurement of pressure requirement for an exhaust air terminal device

5.2.1 Procedure

5.2.1.1 The pressure requirement of an exhaust air terminal device is for a given value of flow rate dependent on the type and size of the device and on the velocity profile upstream and downstream of the device. A standard test duct immediately downstream of the air terminal device shall be employed. If a connecting duct arrangement, flow equalizing and/or damping device is an integral part of an air terminal device, then the standard test duct shall be employed immediately downstream of the integral connecting duct or accessory.

5.2.1.2 The test system shall comprise at least a fan, a means for controlling the airflow rate, a flow rate measuring device and a standard test duct for the air terminal device. Tests shall be carried out under isothermal conditions.

5.2.1.3 The device under test shall be mounted in a simulated wall or ceiling surface using the method of fixing recommended by the manufacturer. For circular and rectangular air terminal devices this surface shall extend on all sides of the air terminal device to at least $2D_e$ from the boundaries of the air terminal device.

For slots or similar air terminal devices, the surface shall extend by at least twice the width of the slot on each side of the device.

For special exhaust air terminal devices (for example, heat removal luminaries), where the velocity does not exceed 1 $m{\cdot}s^{-1}$ in the plane of the ceiling surface, no extended surface is necessary.

5.2.1.4 Pressure tests on the exhaust air terminal device alone or in combination with connecting ducts, flow equalizing and/or damping devices shall be conducted to establish a pressure for a given airflow rate. The air terminal device shall be mounted in one of the test installations described in 5.2.2 (see Figure 4) or 5.2.4 (see Figure 5).

To determine the minimum pressure, measurements shall be made with the damping device in the normally open position. Pressure tests on the exhaust air terminal device shall be clearly referenced to any position of adjustment.

Two methods may be used for determining pressure requirements on test installation C: one by measuring static pressure (see 5.2.2), the other by directly measuring total pressure (see 5.2.3).

5.2.2 Measurement of static pressure with the first test installation C for exhaust air terminal device (excluding air transfer devices)

5.2.2.1 The air terminal device shall be mounted in a test duct with a cross-sectional dimension equal to the nominal size of the device or to the duct dimensions normally recommended by the manufacturer. The duct shall be straight for at least 7,5D_e from any part of the exhaust air terminal device.

5.2.2.2 The test installation shall be generally constructed as shown in Figure 4. To establish the plane of measurement in the straight, constant area duct section, static pressure measurements shall be made at increments of not less than 1D_e down-stream of the device until the rate of change between the measurements is substantially zero. A pressure traverse shall be taken on two orthogonal diameters in order to obtain the maximum and minimum values. The measured pressure at the selected point of test in the plane of measurement shall not differ more than 10 % from both the maximum and the minimum value within the pressure measurement plane.

5.2.2.3 Record the results for a minimum of four airflow rates regularly distributed over the working range for each air terminal device tested.

5.2.2.4 Obtain the static pressure requirement of the device p_{sD} by correcting for the static pressure change along the duct length from the equation:

$$p_{sD} = |p_s| - (0{,}02\, L/D_h)\, p_d$$

where

$|p_s|$ is the absolute value of the static gauge pressure measured on the axis of the duct in the section where it begins not to vary noticeably;

L is the distance between the air terminal device to the measuring section;

D_h is the hydraulic diameter of the duct;

p_d is the dynamic pressure corresponding to the mean velocity in the test duct.

5.2.2.5 The total pressure p_t in the plane of measurement is equal to the sum of the measured static gauge pressure p_s and the dynamic pressure p_d according to the following formula:

$$p_t = p_s + \frac{\zeta}{2}\left(\frac{q_v}{A_D}\right)^2$$

NOTE p_s has a negative value.

5.2.3 Direct measurement of total pressure with the first test installation C, for exhaust air terminal device.

5.2.3.1 The test installation shall be the same as described in Figure 4 and in 5.2.2.

The plane of measurement through which a pitot static tube shall be used shall be the same as described in 5.2.2.2. Measurements of total and static pressure shall be made at the same five points in the plane as defined in 5.1.3 and for successive planes as defined in 5.2.2.2. If the maximum discrepancy in the static pressure value for these five measured points does not exceed two tenths of the mean static pressure measured in the duct, the value of the mean total pressure p_{tm} used to calculate the total pressure loss is the mean arithmetical value of the total pressure data obtained for each of the five points.

5.2.3.2 Record the results for a minimum of four airflow rates regularly distributed over the working range for each air terminal device tested.

5.2.3.3 Obtain the total pressure requirement of the device (p_{tD}) by correcting for the total pressure change along the duct length from the equation:

$$p_{tD} = |p_t| - (0,02\,L/D_h)p_d$$

5.2.4 Measurement of static pressure with the first test installation D for exhaust air terminal device

5.2.4.1 The test installation shall be constructed as shown in Figure 5 such that the following formula is satisfied:

$$\frac{q_v}{A} < \frac{\sqrt{|p_s|}}{5\rho}$$

where

q_v is the volume flow rate;

A is the area of the internal cross-section of the chamber ($A = W \cdot H$) (see Figure 5);

$|p_s|$ is the absolute value of the required pressure;

ρ is the density of the air.

The air terminal device to be tested shall be mounted in a short test duct equal to the nominal size of the air terminal device and having a length equal to D_e or 0,15 m, whichever is greater.

The required pressure shall be measured with at least a single wall static tapping located within 0,05 m of the inside surface of the air terminal device mounting plate.

Equalizing sections shall be provided within the chamber to guarantee that a relatively uniform flow, free from swirl, exists in the test chamber with the air terminal device mounting plate removed.

5.2.4.2 Record the results for a minimum of four airflow rates regularly distributed over the working range for each air terminal device tested.

5.2.4.3 The measured pressure, p_s, is considered to be the total pressure, p_t.

5.2.5 Presentation of total pressure p_t

5.2.5.1 Correct the data to standard air conditions according to the following formula:

$$p_{t1,2} = p_t \frac{1,2}{\rho}$$

Present the data in a graph showing the total pressure versus the airflow rate.

5.2.5.2 Alternative method: Presentation of static pressure p_s. Correct data to standard air conditions according to the following formula:

$$p_{s1,2} = p_s \frac{1,2}{\rho}$$

Present the data in a graph showing the static pressure versus the airflow rate.

5.2.5.3 Alternative method: Presentation of the loss coefficient ζ. The loss coefficient ζ may be calculated from the following appropriate relationships, based upon the pressures measured under 5.2.2, 5.2.3 and 5.2.4.

$$\zeta = \frac{|p_s|}{p_d} - (1 + 0,002 \frac{L}{D_h}) \quad \text{(see 5.2.2)}$$

$$\zeta = \frac{|p_t|}{p_d} - 0,02 \frac{L}{D_h} \quad \text{(see 5.2.3)}$$

$$\zeta = \frac{|p_t|}{p_d} \quad \text{(see 5.2.4)}$$

where p_s and p_t are the measured quantities, and p_d is calculated as:

$$p_d = \frac{\rho}{2}\left(\frac{q_v}{A_d}\right)^2$$

where both ρ and q_v are at the same test conditions.

5.3 Determination of air velocity v_k and the corresponding area A_k for the air terminal device (not mandatory)

5.3.1 Principle

This test is to measure the air velocity v_k and from it to determine the corresponding area A_k for the air terminal device under test.

5.3.2 Test installation

The test installation and air terminal device mounting shall be the same as that used to measure the pressure/flow rate characteristics (see Figure 1 or 3 for supply air terminal device and Figures 4 and 5 for exhaust air terminal devices).

The air velocity, v_k, shall be measured with an air velocity meter selected in accordance with specifications in prEN 13182:1998

5.3.3 Test procedure

Start the fan and set any flow equalizing and/or damping devices integral with the air terminal device in the normally open position.

Measure and record the following parameters at a minimum of four airflow rates, evenly distributed over the working range of the device under test:

— air volume flow rate;

— air temperature at the flow meter;

— air temperature at the test duct;

— barometric pressure;

— air velocity v_k at the number and position of points on the air terminal device as specified by the manufacturer.

With the v_k values, record the positions on the air terminal device at which the velocity measurements are made.

5.3.4 Correction of flow rates to standard air conditions

For each test, correct the measured volume airflow rate as follows:

$$q_{v1,2} = q_v \frac{\rho}{1,2}$$

5.3.5 Calculation of A_k

For each of the flow rates, calculate the arithmetic mean of the air velocity v_k measurements. Calculate the A_k value for each flow rate by dividing the corrected flow rate by the mean v_k, at that flow rate.

Reporting of test results. Calculate the arithmetic mean of the A_k values for all the test airflow rates.

If the mean A_k value differs more than 5 % from any of the individual values, then report the A_k values as a function of airflow rate.

6 Test to measure the isothermal air discharge characteristics of a supply air terminal device (second test installation)

6.1 Test measurements

The characteristics of the isothermal air discharge from an air terminal device can be determined from measurements of the throw X, spread Y and drop Z under isothermal conditions within a specified test environment.

6.2 Test room

6.2.1 Tests shall be conducted in an enclosed test room having typically the following dimensions, length: 7,5 m, width: 5,6 m, height: 2,8 m.

6.2.2 Larger or smaller test rooms shall have a width-to-height ratio between 1,5 and 2,2.

6.2.3 All surfaces of the test room shall be normal at the corners and any surface over which the jet flows shall be smooth and flat. Any light fittings and windows shall be flush with the surface in which they are mounted.

6.2.4 For isothermal testing, the test room shall be sufficiently well insulated to ensure that the temperatures of the inner surfaces of the test room do not differ by more than 2 K from the air temperature of the adjacent room.

6.2.5 The exhaust grille shall be located so that it is not the direct path of the jet from the device under test. The area of the exhaust grille shall be such that under any test condition the air velocity through the grille shall be not greater than 1 $m \cdot s^{-1}$.

6.3 Test room equipment and instrumentation

The system supplying the test room shall comprise a fan, a means of controlling the airflow rate, a flow rate measuring device and a standard test duct (first test installation).

6.4 Installation of the air terminal device

6.4.1 Classification of air terminal devices

Air terminal devices can be divided into four broad classes:

— Class I	Devices from which the jet is essentially three dimensional: A) nozzles; B) grilles and registers.
— Class II	Devices from which the jet flows radially along a surface or as a free jet, ceiling diffusers.
— Class III	Devices from which the jet is essentially two dimensional: linear grilles, slots and linear diffusers.
— Class IV	Low velocity air terminal devices. Not included in this standard (see EN 12239).

6.4.2 Mounting of air terminal devices

6.4.2.1 The air terminal devices shall be installed (using the method recommended by the manufacturer) in the following positions within the second test installation. (See Figure 6.)

6.4.2.2 Class IA devices (nozzles) shall be mounted in such a position as to provide the maximum throw with a minimum effect from adjacent boundaries, for example at the centre of one of the smaller test room walls.

6.4.2.3 Class IB devices (grilles and registers) shall be positioned on the centre line of one of the smaller walls of the test room, with the inner upper surface of the air terminal device 0,2 m from the ceiling.

6.4.2.4 Class II devices (diffusers) shall be mounted flush with the mounting surface and in a position defined by:

a) diffusers of radial pattern such that the centre of the test duct is no closer to any one wall than approximately half the width of the test room;

b) diffusers of directional pattern shall be as typically applied and installed in accordance with the manufacturer's recommendation.

6.4.2.5 Class III devices (linears) when tested as side-wall air terminal devices shall be mounted as in 6.4.2.3. Slot air terminal devices shall be mounted as Class I or II, whichever is applicable. Artificial side-walls shall be employed with air terminal devices that would normally span the distance between two walls. The minimum length of the air terminal device tested shall be equal to or greater than 1,2 m when artificial side-walls are employed.

6.4.3 Test duct and flow rate

6.4.3.1 The test duct shall be normal to the surface in which the air terminal devices are mounted unless otherwise recommended by the manufacturer.

6.4.3.2 The highest flow rate for an air terminal device, that may be utilized in a given room size, shall be limited to the rate for which the maximum air jet velocity does not exceed 0,5 $m \cdot s^{-1}$, at a distance of 1,0 m from the boundary wall, in the direction under investigation.

Diffusers producing other flow patterns shall be positioned as typically applied in accordance with the recommendations of the manufacturer.

6.5 Test procedure

6.5.1 Testing shall commence after steady state isothermal conditions have been achieved. Such conditions shall be considered to exist when temperature-measuring probes placed in the following positions indicate temperatures that do not differ from each other by more than 2 K for a period of 5 min prior to, and during, the test:

a) in the supply duct, upstream of the air terminal device;

b) at the centre of the exhaust terminal device.

6.5.2 The flow rate shall not vary by more than ±2 % before and during the test.

6.5.3 Any velocity measurements made within the following distances from a wall towards which the air is flowing shall not be used for rating purposes.

— Class I	1 m
— Class II	0,5 m
— Class III	1 m (without side-walls); 0,5 m (with side-walls)

6.5.4 Throw, spread, and drop shall be established at four substantially different flow rates for each size of air terminal device tested.

6.6 Determination of isothermal performance

6.6.1 Test measurements

This test is to determine under isothermal conditions the throw X, spread Y and drop Z by measuring velocities within the air stream at various distances away from the supply air terminal device. The air velocities shall be measured with an instrument as specified in prEN 13182:1998 and an exploratory technique shall be used to determine the location of the air stream envelope(s).

6.6.2 Determination of the main air stream direction

The air velocity measurements shall be carried out in the main air stream direction. This main air stream direction can be visually identified by use of smoke (see example in Figure 7A).

If the main air stream direction can not be identified using smoke, air velocity measurements shall be carried out in a horizontal line (or in a circle around radial discharge diffusers) perpendicular to the preliminary identified main air stream direction, and at a distance from the air terminal device where the air velocity is within the range of 1,0 $m \cdot s^{-1}$ to 1,5 $m \cdot s^{-1}$ (see Figure 7B). These measurements shall be carried out in approximately 10 points located at 50 mm from the ceiling for air terminal device with wall effect, or at the same level as the centreline of the air terminal device without wall effect, on both sides of the assumed main air stream direction, with a maximum spacing of 50 mm.

The line from the middle of the air terminal device to the point where the measured velocity is a maximum is the main air stream direction.

6.6.3 Measurement of air stream velocities

The throw, drop and spread shall be measured in the main air stream direction. First of all, a quick air velocity measurement shall be carried out to determine the distance from the air terminal device where the air velocity is about 0,5 m·s^{-1}. This point shall be at least 0,5 m or 1,0 m (depending on the class of air terminal device, see 6.5.3) from the opposite wall.

Air velocity measurements shall be carried out in at least 8 points equally spaced one to another. The first measuring point shall be located 0,3 m from the air terminal device, and the last measuring point shall be the position where the air velocity is in the range of 0,4 m·s^{-1} to 0,5 m·s^{-1} (see Figure 7C).

At each point measurements shall be carried out for at least six different levels in a vertical plane for an air terminal device with wall effect; e.g. 25 mm, 75 mm, 150 mm, 225 mm, 300 mm and 600 mm from the ceiling, or 13 different levels in a vertical plane, for an air terminal device without wall effect; e.g. 0 mm, 25 mm, 75 mm, 150 mm, 225 mm, 300 mm and 600 mm above and below the centreline of the air terminal device.

At each distance measurements shall be made at a horizontal line through the point of maximum air velocity and perpendicular to the main air stream direction. A survey shall be made at a number of points at each side of the main air stream direction so as to be able to determine the points were the air velocity equals 0,5 m·s^{-1}. From these points an envelope (isovel) can be determined.

6.6.4 Determination of throw

6.6.4.1 Draw a graph of the results of the maximum air velocity measurements at various distances from the air terminal device, for each test conducted in accordance with 6.6.3, on logarithmic graph paper in the form:

$$\frac{R}{q_v} \cdot v_x \quad \text{against} \quad \frac{x}{S}$$

where

R is an area parameter that relates to the effective size of the device under test;

S is a corresponding linear parameter.

NOTE The most appropriate value of R is likely to be the minimum area through which the air passes within the air terminal device, but as this is rarely a measurable parameter the following values are commonly used:

— Class I $R = A_f$ (free area) $S = \sqrt{A_f}$

— Class II $R = A_d$ (neck area) $S = \sqrt{A_d}$

— Class III $R = A_f$ (free area) $S = A_f / n$

(where n is the length of the air terminal device)

Use values of R and S appropriate to the air terminal device under consideration (see example shown in Figure 8). The plot can, as an alternative presentation, be drawn with absolute values (see example in Figure A.2). For details on the classes see 6.4.1.

6.6.4.2 If tests have been conducted on a series of modularly similar air terminal devices, superimpose the results for each device on the same graph.

6.6.4.3 Draw a single curve to the average values of the points plotted in accordance with 6.6.4.1 and 6.6.4.2. If the plotted points all fall within a band $\pm 0{,}2 \frac{X}{S}$ about this curve, then it can be used as the basis for presenting throw performance data for the range of sizes tested.

In order to perform the throw, a tangent to the average curve shall be drawn with a slope of:

— 1 for Class I and II devices;

— 0,5 for Class III devices.

NOTE 1 For specific devices values of the slope can be used which slightly will differ from the above mentioned. The manufacturer should explain the use of this special slope.

NOTE 2 This curve may also be used for the determination of the flow rate/throw relationship of other modularly similar devices within the size range tested.

NOTE 3 If the plotted points do not fall within the tolerance band stated in 6.6.4.3, attempts may be made to improve the correlation between device sizes by using alternative area parameters in the derivation of R and S.

6.6.4.4 If the plotted points do not fall within the tolerance band stated in 6.6.4.3, derive separately, for each size of device tested, the performance data for presentation from the average curve through the individual set of plotted points for that size. Under these circumstances, no interpolation or extrapolation to other device sizes shall be made.

6.6.4.5 The throw X for a given airflow rate can be based on any appropriate velocity v_x. The v_x selected shall be referenced in the recorded data.

6.6.5 Determination of spread

From the measurements made in the horizontal plane, the maximum distance between the tangents to the 0,5 $m \cdot s^{-1}$ envelope at each side of the main air stream direction can be determined. This distance is the spread. The ratio between the throw at 0,5 $m \cdot s^{-1}$ and this spread shall be used to determine the spread for extrapolation to other geometrically similar devices or other airflow rates.

6.6.6 Determination of rise and drop

In a similar way as described in 6.6.5 the rise and drop can be found.

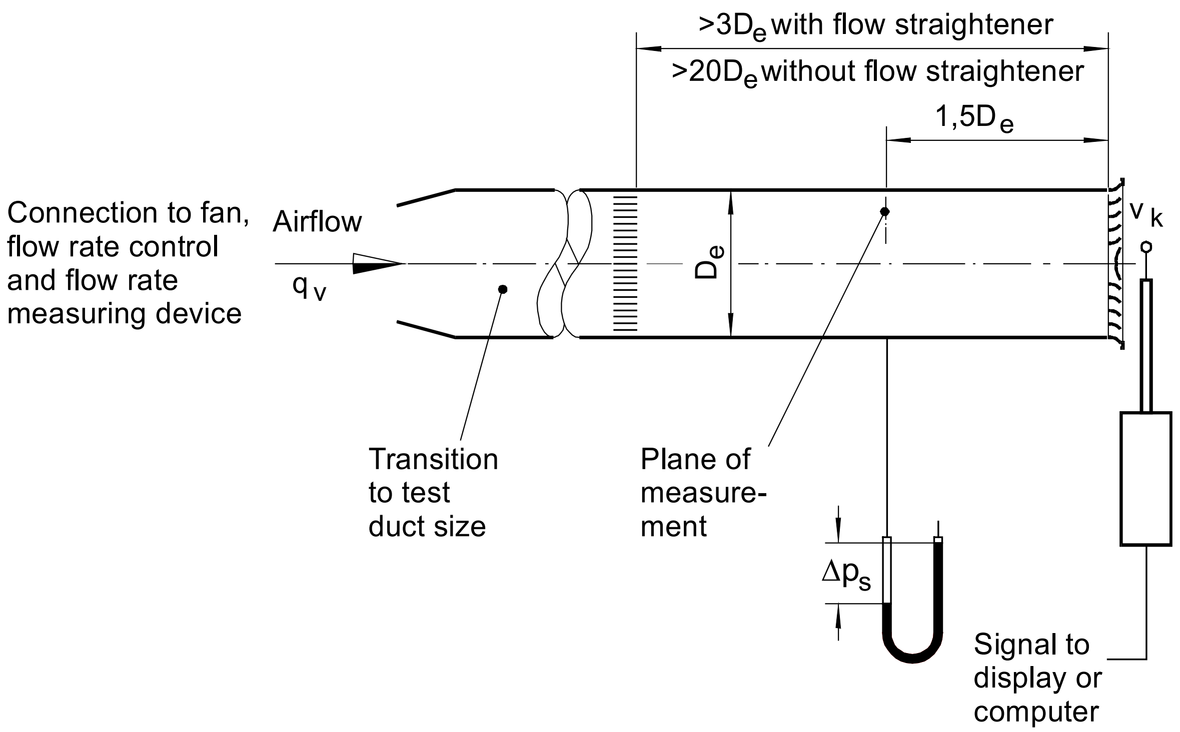


Figure 1 — First test installation "A" for supply air terminal device

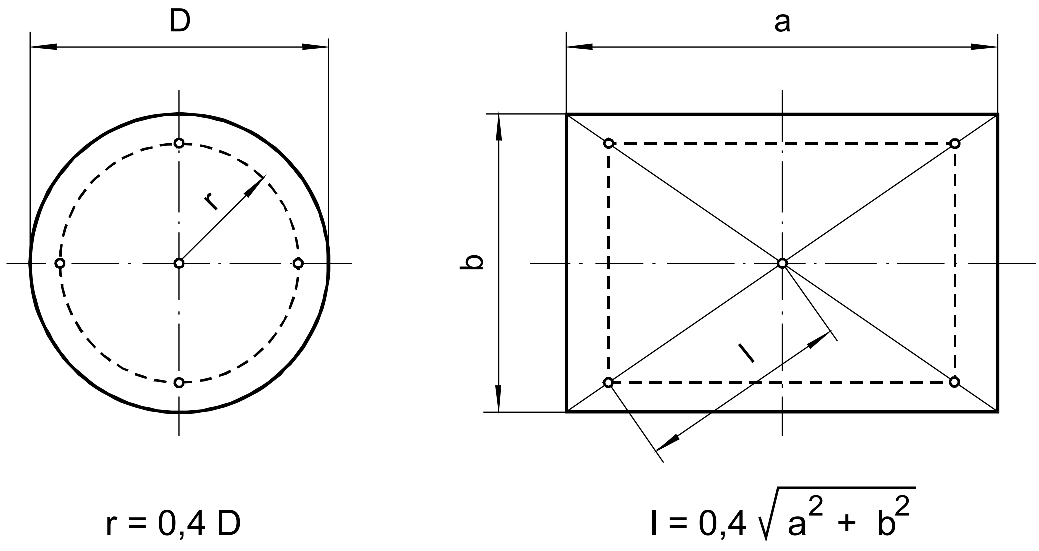
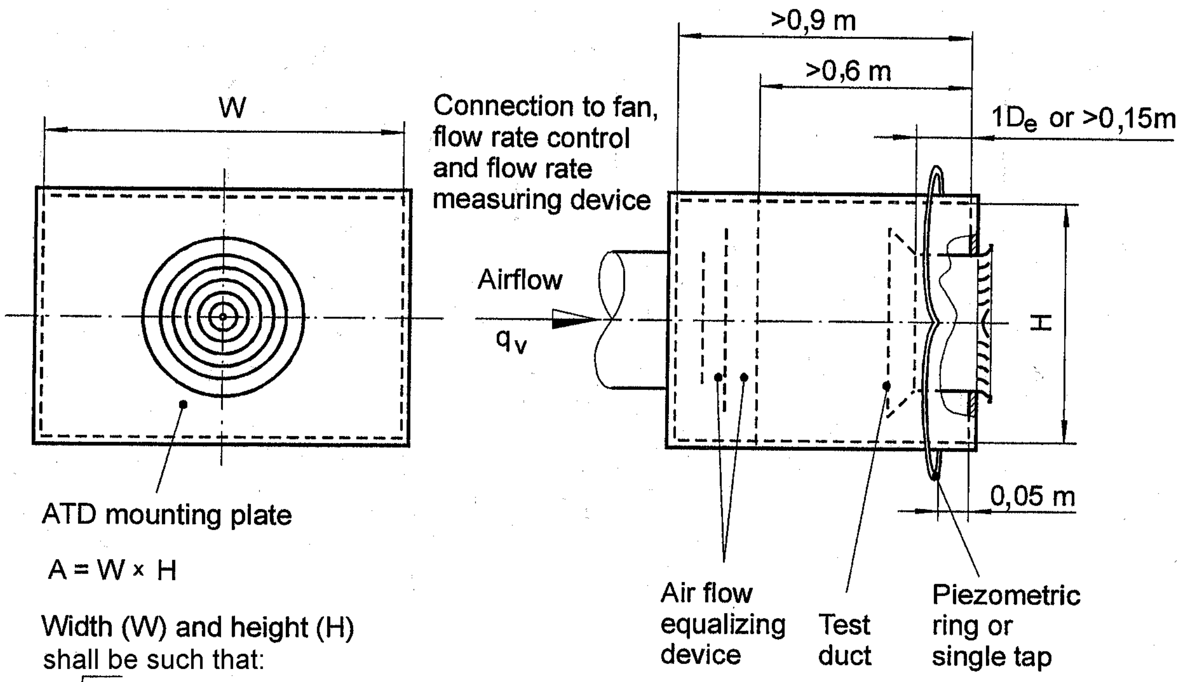


Figure 2 — Pitot tube location for direct measurement of total pressure in first test installation "A" for supply, or "C" for exhaust air terminal device



$$\frac{q_v}{A} = \sqrt{\frac{p_s}{5\rho}}$$

Figure 3 — First test installation "B" for supply air terminal device

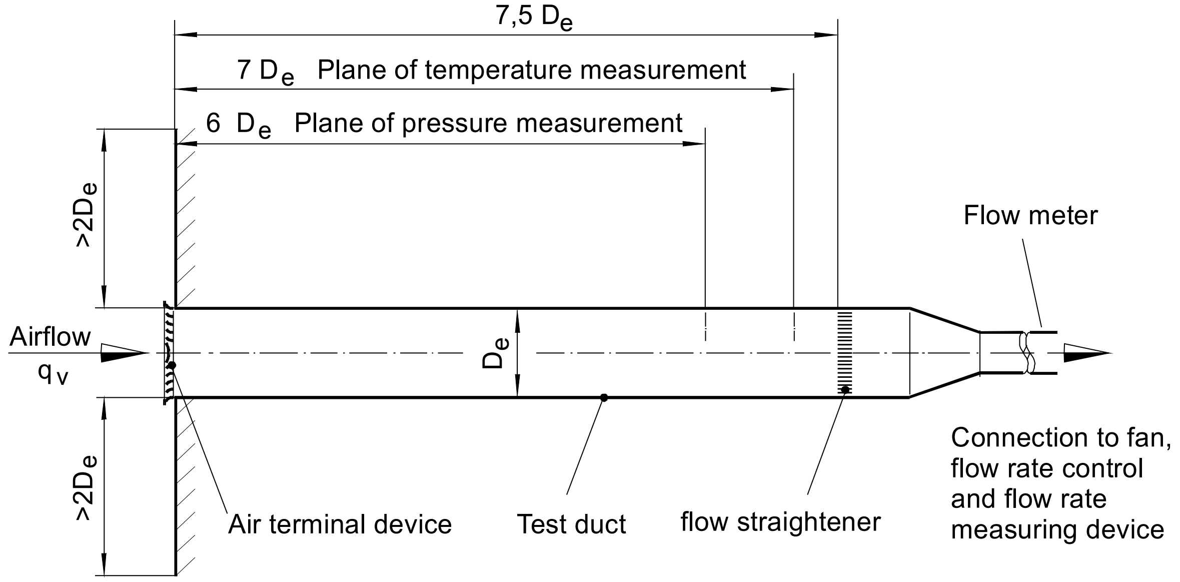
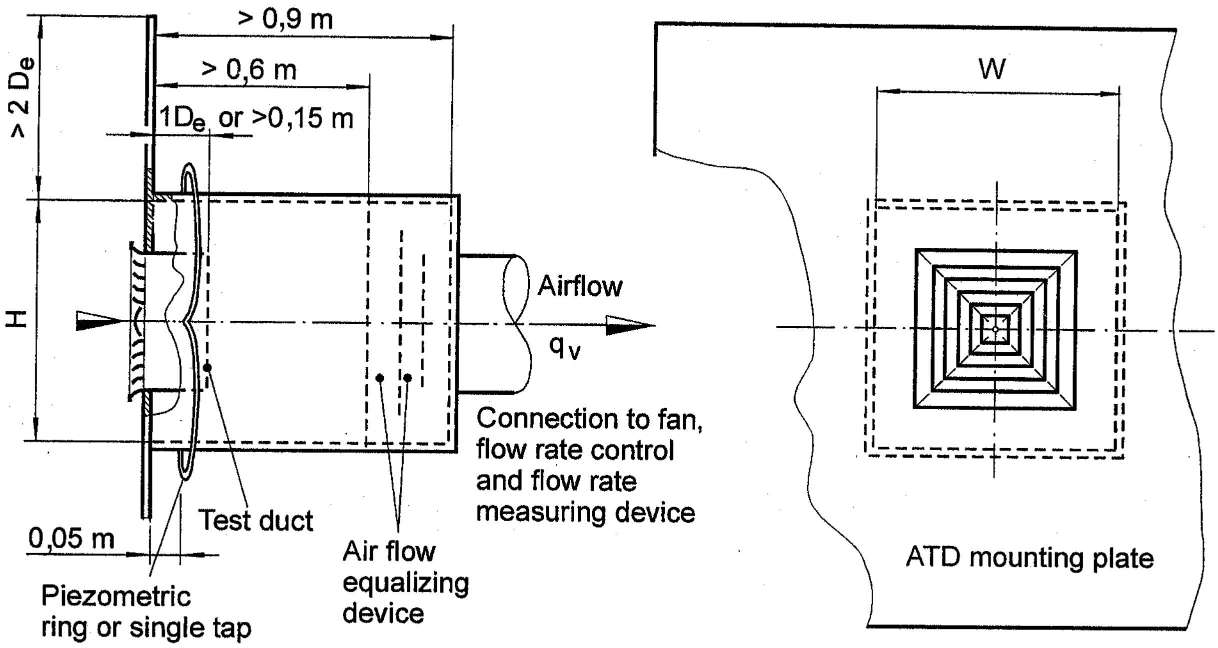


Figure 4 — First test installation "C" for exhaust air terminal device



A = W × H Width (W) and height (H) shall be such that:

$$\frac{q_v}{A} = \sqrt{\frac{p_s}{5\rho}}$$

Figure 5 — First test installation "D" for exhaust air terminal device

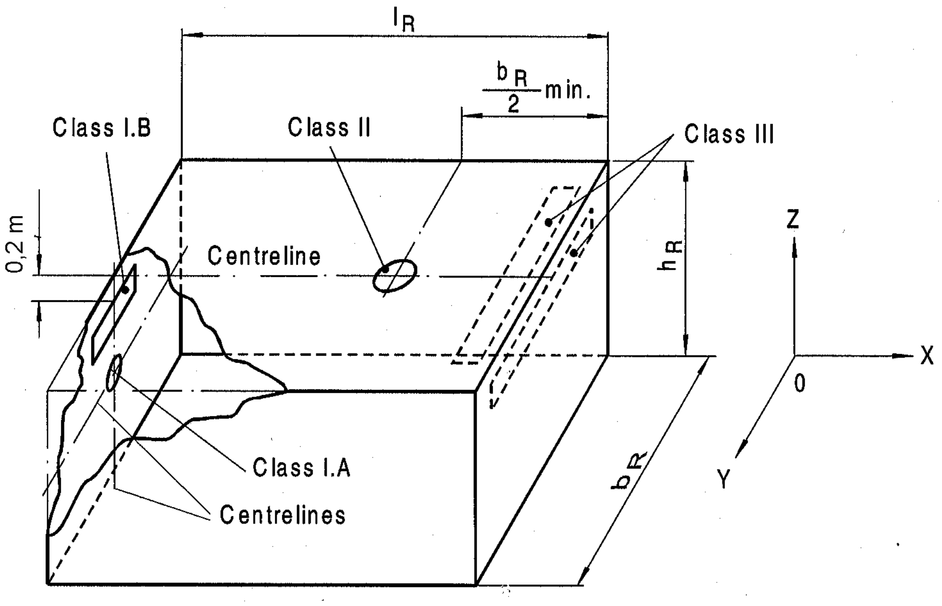


Figure 6 — Air terminal device position for second test installation

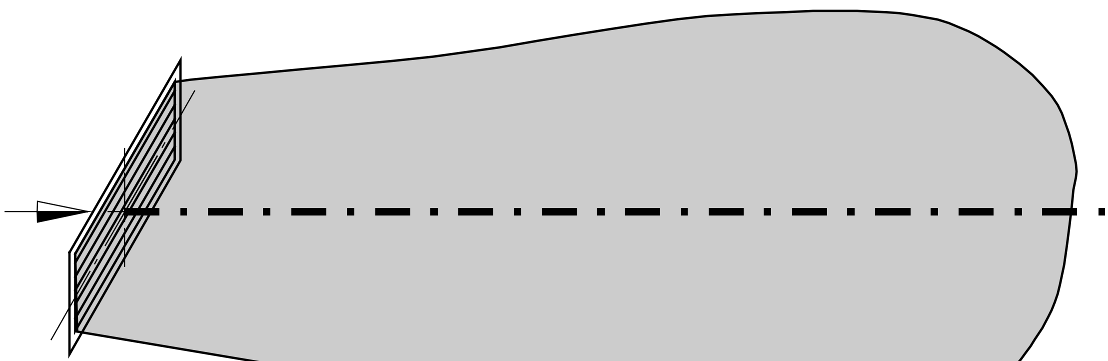


Figure 7A — Use of smoke to identify the main air stream direction

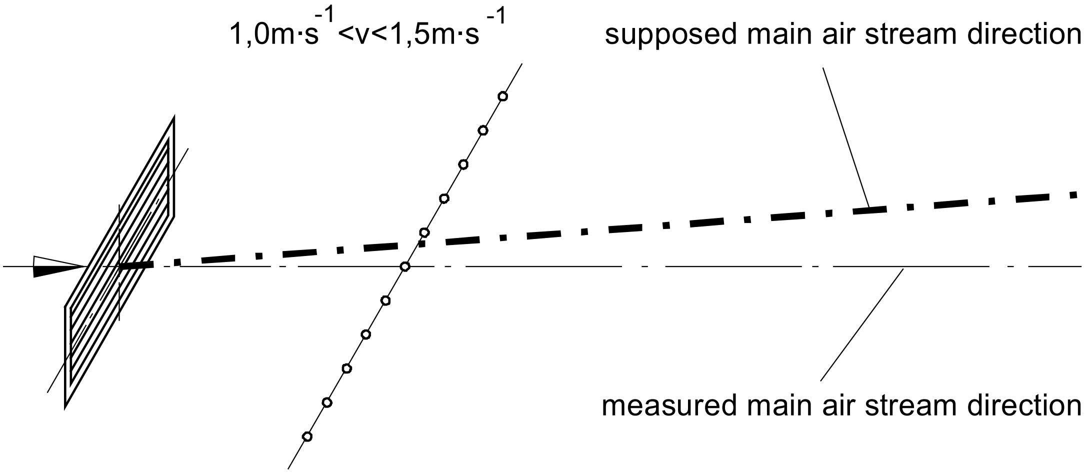


Figure 7B — Use of velocity measurements to identify the main air stream direction

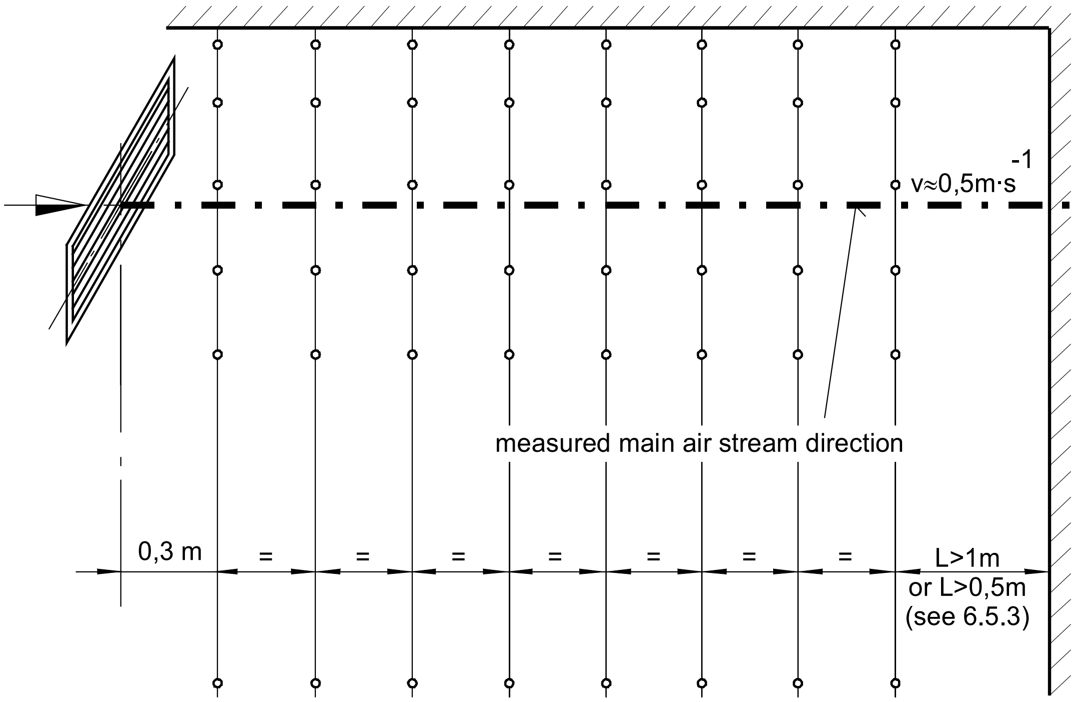


Figure 7C — Measurement of air stream velocities to determine throw, drop and spread

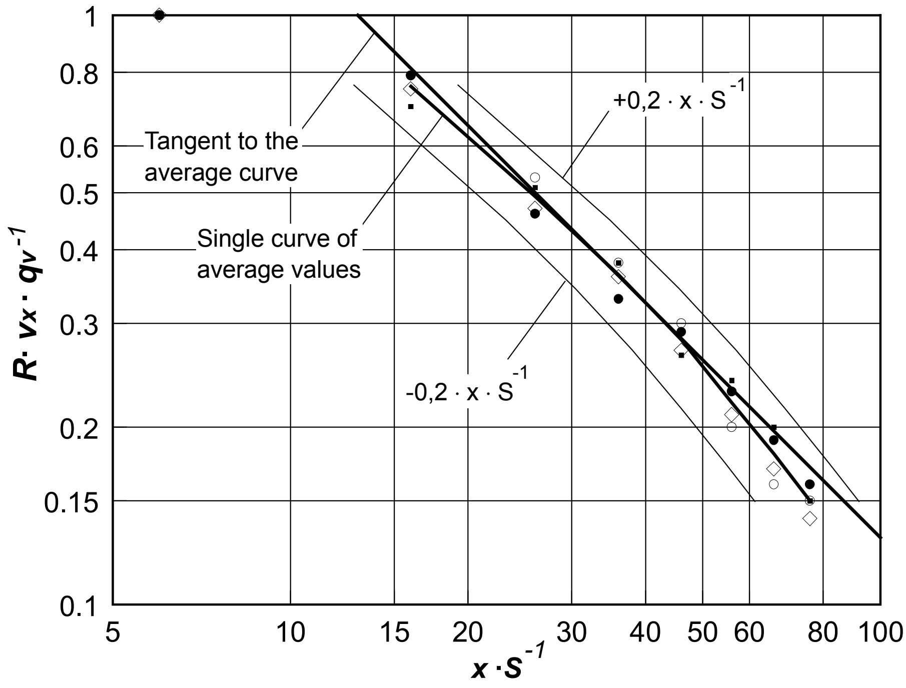


Figure 8 — Typical plot for determination of throw

Annex A
(normative)

Alternative exploratory technique for determination of throw, spread and drop

A.1 Scope

This annex specifies a traversing procedure for the determination of the path(s) of maximum velocity in the air stream from a supply air terminal device, and the air stream envelope in vertical and horizontal planes through the path(s) of maximum velocity.

The procedure relates to a side-wall mounted air terminal device discharging air in a substantially horizontal direction. The techniques may be adapted for other classes of device. For instance, in the case of Class II and III devices, an initial traverse in the vertical direction may be more appropriate than a traverse in the horizontal direction.

A.2 Determination of the point of maximum velocity

A.2.1 Position the velocity measuring probe 300 mm from the centre of the face of the device in the direction of airflow [see Figure A.1a)].

A.2.2 Make a horizontal traverse parallel to the face of the air terminal device at intervals of not more than 50 mm, to determine the point of maximum velocity. The vertical axis through this point shall be denoted Z_c [see Figure A.1b)].

A.2.3 Make a vertical traverse, at intervals in accordance with Table A.1 along axis Z_c and establish the point of maximum velocity, v_x. The horizontal axis through this point shall be denoted Y_c [see Figure A.1c)].

A.2.4 Then position the probe at co-ordinates Y_c and Z_c as determined in A.2.2 and A.2.3 and move it horizontally (parallel to X_c) in the direction of airflow away from the device by an increment no greater than 1 m [see Figure A.1d)].

A.2.5 Repeat the procedure described in A.2.2 and A.2.4 until the maximum measured velocity, v_x is less than 0,5 m·s^{-1} [see Figure A.1e)]. Establish a minimum of five (Y_c, Z_c) coordinates, intermediate locations being introduced when necessary.

A.2.6 Draw a logarithmic plot of the values of v_x versus horizontal distance from the face of the air terminal device, and from this plot determine the distance that corresponds to a velocity at 0,5 m·s^{-1} (see Figure A.2). In order to obtain the throw corresponding to other terminal velocity under consideration it is necessary to extrapolate the curve. Extrapolation shall be in accordance with 6.6.4.3.

A.2.7 If a maximum velocity in A.2.2 or A.2.3 is found to occur at more than one distinct location (as is likely with a grille with diverging vanes, for example), then repeat the complete traversing procedure A.2.2 to A.2.5 for each path of maximum velocity.

A.3 Determination of points at envelope velocity

A.3.1 Establish the points at which the air stream velocities are at the envelope velocity (about 0,5 m·s^{-1}) on each of the Y_c, Z_c axes as follows, either during or following the traverse described above.

A.3.2 Move the probe vertically downwards along one of the Z_c axis until the measured velocity falls to about 0,45 m·s^{-1}. Make a note of the probe position and the measured velocity, [see Figure A.3a)].

A.3.3 Traverse the probe at intervals no greater than 100 mm back along the Z_c axis towards the (Y_c, Z_c) co-ordinate. At each position, record the velocity and continue the traverse until at least four measurements have been made and the measured velocity has risen to more than 0,55 m·s^{-1} [see Figure A.3b)].

A.3.4 Repeat the traversing procedure with the probe initially moved vertically upwards along the same Z_c axis and then in the two horizontal directions along the corresponding Y_c axis [see Figure A.3c)].

A.3.5 Repeat the procedure described in A.3.2, A.3.3 and A.3.4 at each of the Y_c and Z_c axis.

A.3.6 For each of the traverses, make a plot of measured velocity versus position. From this, determine the point that corresponds to a velocity of 0,5 m·s^{-1} (see Figure A.4).

A.4 Determination of spread

Draw a plot in the plane of the Y_c axis of the relevant points determined in A.3.5 and the throw, and draw the best curve joining the points. Note, as the spread, the maximum width of the area bounded by the envelope curve in the direction parallel to face of the air terminal device (see Figure A.5).

A.5 Determination of the rise and drop

Draw a plot, similar to that specified in A.4, in the plane of the Z_c axis, of the relevant points determined in A.3.5 and draw the best curve joining the points. Note, as the rise and drop respectively, the maximum positive and negative distance from a line through the centre, and perpendicular to the face of the air terminal device, to the envelope (see Figure A.6).

A.6 Number of determinations

A.6.1 Repeat the procedure as described in clauses A.2 to A.5 for each test flow rate.

A.6.2 In cases of non-symmetrical jets, make additional measurements in varying planes to determine the envelope velocities.

NOTE The procedure covered in this annex is directly related to isothermal testing. It may equally well be used as a procedure for non-isothermal testing when the conditions appropriate to non-isothermal testing are included.

Table A.1 — Vertical traverse interval

Distance of probe sensing head below ceiling surface[1)] mm	Maximum traverse interval mm
> 200	50
≤ 200 > 120	40
≤ 120 > 60	20
≤ 60	10
[1)] Similar criteria should be used for air streams discharged close to and along other room surfaces.	

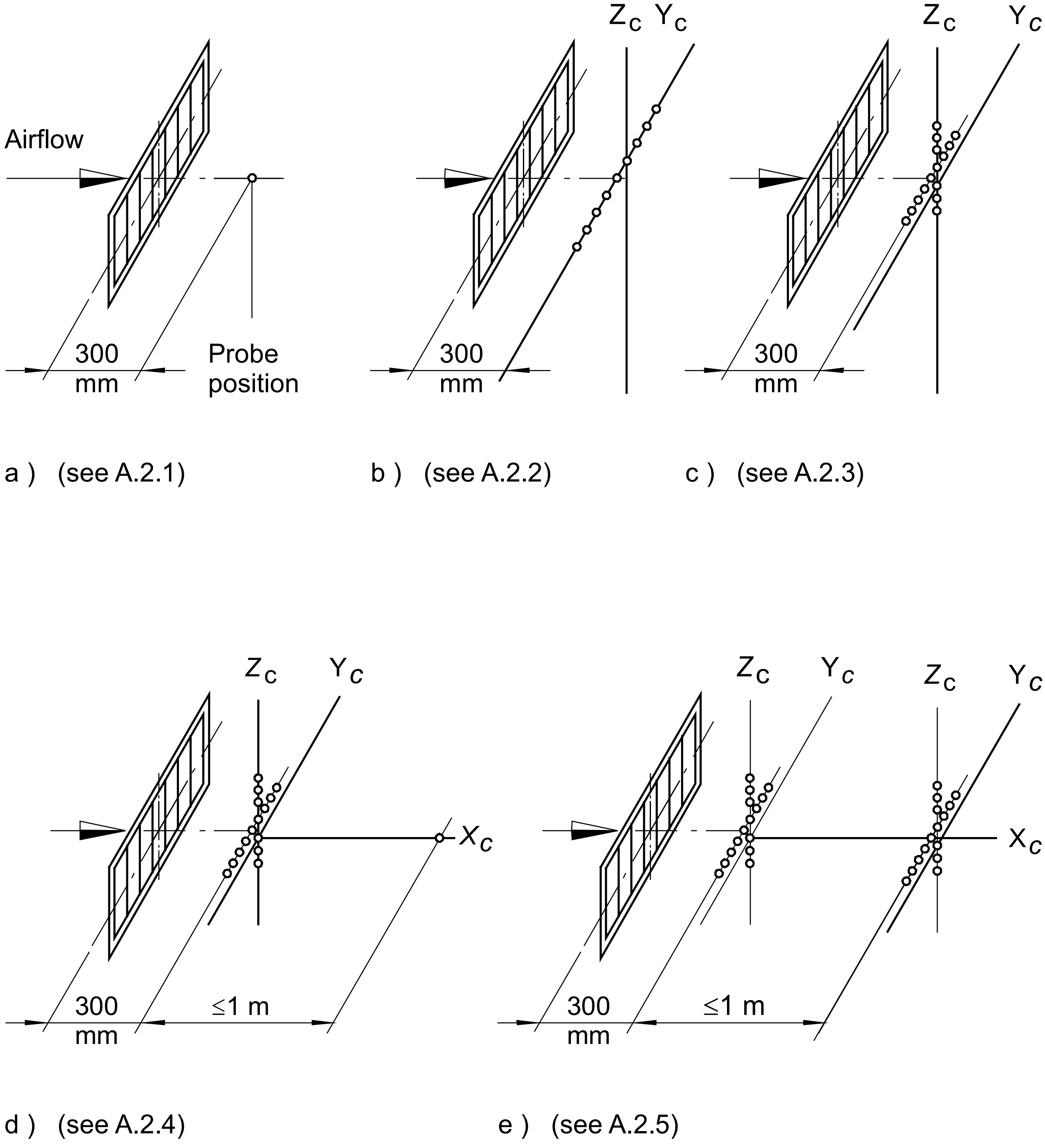


Figure A.1 — Determination of path of maximum velocity

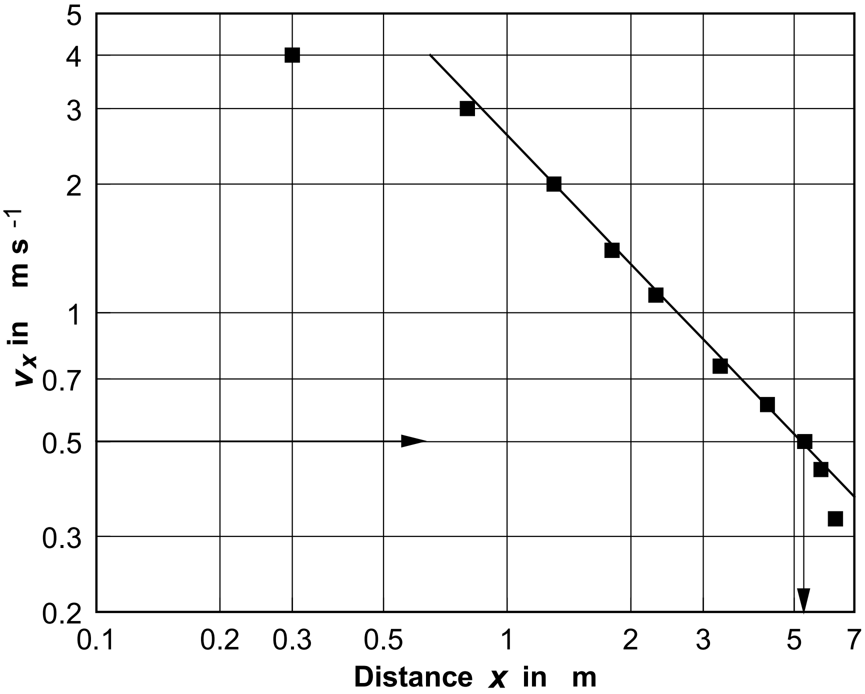


Figure A.2 — Typical plot used in the determination of throw (see A.2.6)

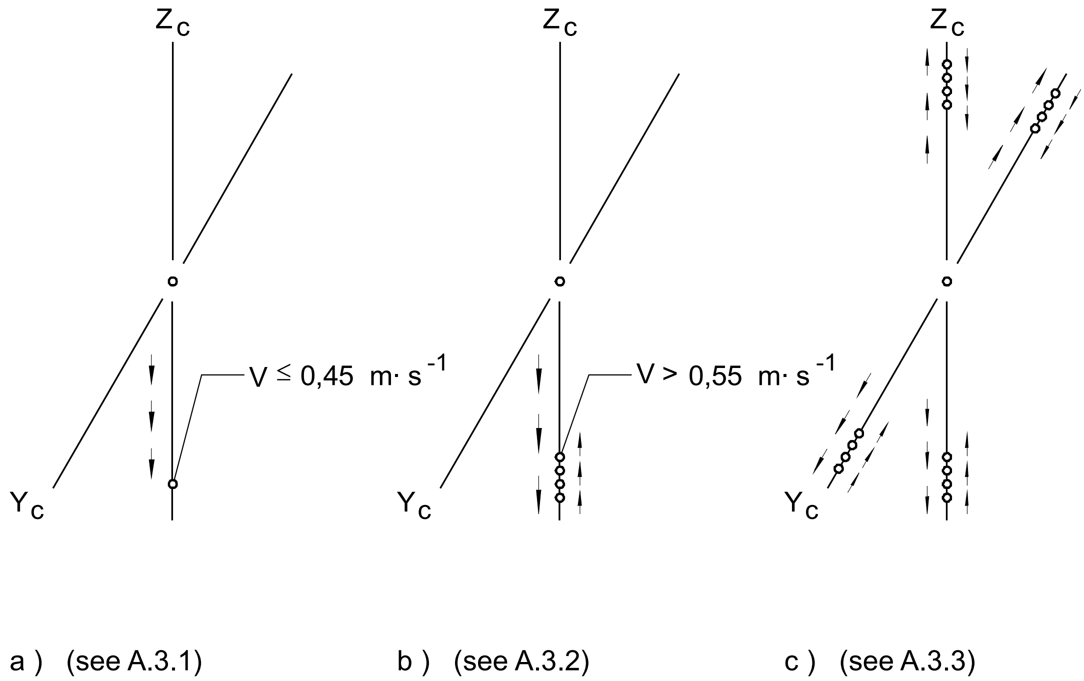


Figure A.3 —Determination of envelope

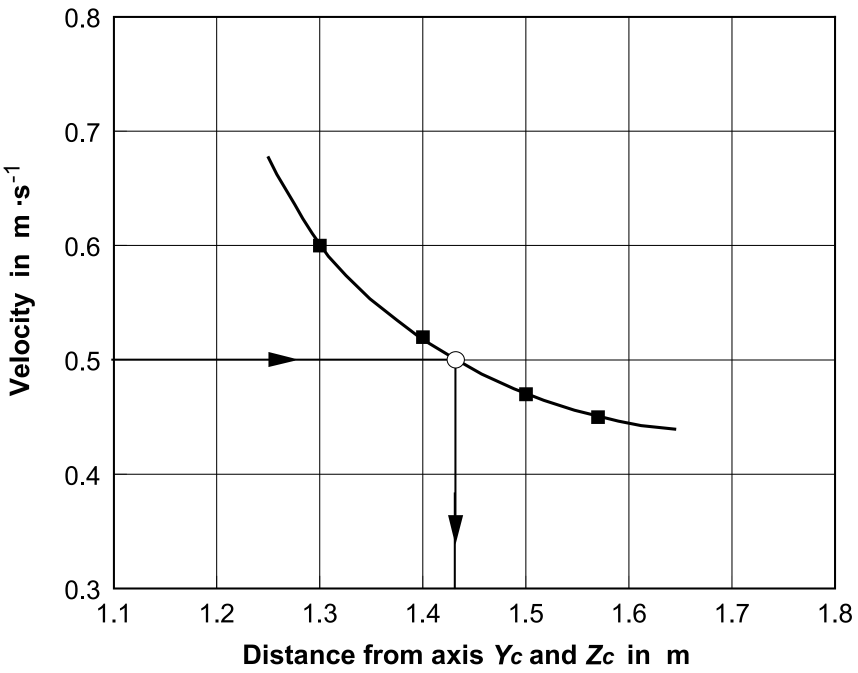


Figure A.4 — Typical plot for determination of envelope location (see A.3.5)

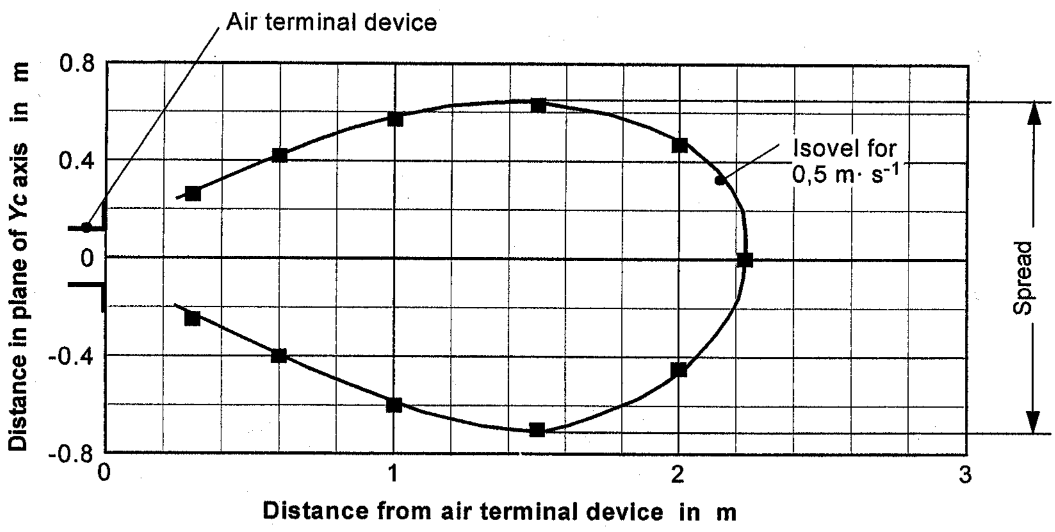


Figure A.5 — Typical plot for determination of spread (see A.4)

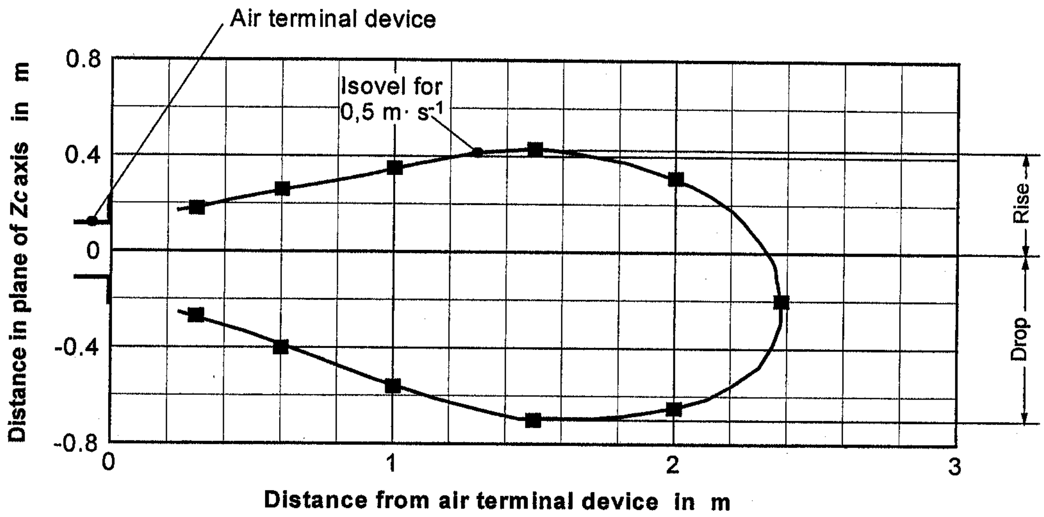


Figure A.6 — Typical plot for determination of rise and drop (see A.5)

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