International Standard 5219

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Air distribution and air diffusion — Laboratory aerodynamic testing and rating of air terminal devices

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

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Air distribution and air diffusion — Laboratory aerodynamic testing and rating of air terminal devices

1 General

1.1 Scope and field of application

This International Standard is intended to standardize laboratory aerodynamic testing and rating of air terminal devices, including the specification of suitable test facilities and measurement techniques.

This International Standard gives only tests for the assessment of characteristics of the air terminal devices under isothermal conditions. Annex D[1] gives specifications for a supplementary but not mandatory test method under non-isothermal conditions.

1.2 Definitions

All definitions are in accordance with ISO 3258 and the following.

1.2.1 Functional characteristics of air terminal devices

1.2.1.1 nominal size of an air terminal device: The nominal value of dimensions of the prepared opening into which the air terminal device is to be fitted.

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

1.2.1.2 Core and specific areas

1.2.1.2.1 core of an air terminal device: That part of an air terminal device located within a convex shut surface of minimum area inside of which are all the openings of the air terminal device through which the air can pass.

1.2.1.2.2 effective area (of an air terminal device): Smallest net area of an air terminal device utilized by the airstream in passing through the air terminal device.

1.2.1.2.3 free area (of air terminal device): Sum of the smallest areas of the cross-section of all openings of the air terminal device.

1.2.1.2.4 core of a grille: That part of a grille located inside a convex shut plane curve of minimum length of contour, inside which are all the openings of the grille.

1.2.1.2.5 core area (of a grille): Area limited by the plane curve defined above.

1.2.1.2.6 free area (of a grille): Sum of the minimum measured areas of each opening through which the air can pass.

1.2.1.2.7 free area ratio (of a grille): The ratio of the free area to the core area.

1.2.1.2.8 A_k **value** (of an air terminal device): The quotient resultant from measured air flow rate and measured air velocity as determined in a specified manner with a specified instrument.

1.2.1.3 Aspect and vane ratios

1.2.1.3.1 aspect ratio (of a rectangular air terminal device): The ratio of the larger side to the smaller side of the rectangular core.

1.2.1.3.2 vane ratio (of a grille): The ratio of the chord length to the vane pitch.

1.2.1.4 Special terms relating to air

1.2.1.4.1 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.

1.2.1.4.2 supply air: Air entering a supply air terminal device from an upstream duct.

1.2.1.4.3 induced air: Air flow from the treated space induced by the supply air from a supply air terminal device.

1.2.1.4.4 exhaust air: Air leaving an exhaust air terminal device into a downstream duct.

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[1] Annexe D is being developed by ISO/TC 144/SC 1 and will be added when approved.

1.2.1.5 Specific terms relating to air diffusion rating

1.2.1.5.1 supply temperature differential: Algebraic difference between the supply air temperature and the mean measured air temperature of the occupied zone.

1.2.1.5.2 exhaust temperature differential: Algebraic difference between the exhaust air temperature and the mean measured air temperature of the occupied zone.

1.2.1.5.3 mean measured air temperature of the occupied zone: Arithmetical average of the measured values of air temperature within the occupied zone.

1.2.1.5.4 temperature differential within the occupied zone: Largest value of the difference between measured air temperature within the occupied zone.

1.2.1.5.5 primary air flow rate: Volume of air entering a supply air terminal device in unit time.

1.2.1.5.6 exhaust air flow rate: Volume of air leaving an exhaust air terminal device in unit time.

1.2.1.5.7 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:

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

$$\overline{w} = \frac{1}{T}\int_0^T w\,dt;$$

the local air velocity is therefore:

$$\sqrt{\overline{u}^2 + \overline{v}^2 + \overline{w}^2}$$

1.2.1.5.8 local measured air velocity: Measured value of local air velocity.

1.2.1.5.9 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.

1.2.1.5.10 room air velocity: Value of velocity conventionally derived from the various local measured air velocities within the occupied zone.

1.2.1.5.11 free area velocity: Primary air flow rate divided by the free area of a supply air terminal device.

Exhaust air flow divided by the free area of an exhaust air terminal device.

1.2.1.5.12 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/s, 0,5 m/s etc., and perpendicular to the intended direction of flow.

1.2.1.5.13 drop (for a supply air terminal device): Vertical distance between the lowest horizontal plane tangent to a specified envelope, such as 0,25 m/s, 0,5 m/s, etc., and the centre of the core.

1.2.1.5.14 rise (for a supply air terminal device): Vertical distance between the highest horizontal plane tangent to a specified envelope, such as 0,25 m/s, 0,5 m/s, etc., and the centre of the core.

1.2.1.5.15 spread (for a supply air terminal device): Maximum distance between two vertical planes tangent to a specified envelope, such as 0,25 m/s, 0,5 m/s, etc., and perpendicular to a plane through the centre of the core.

There may be two different spreads, 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).

1.3 Symbols

The following nomenclature is used throughout this International Standard:

Symbol	Quantity	Corresponding SI unit	Dimensions
A	Area	m^2	L^2
A_d	Area corresponding to the nominal size of the duct to which the device is fitted	m^2	L^2
A_k	k factor area $A_k = \left(\frac{q_V}{v_k}\right)$	m^2	L^2
b_R	Width of test room or installation	m	L
D_e	Equivalent diameter $\left(\sqrt{\frac{4 \times A_d}{\pi}}\right)$	m	L
D_h	Hydraulic diameter $\left(\frac{4 \times A_d}{\text{perimeter}}\right)$	m	L
d	Diameter	m	L
h_D	Face height of linear grille or diffuser	m	L
h_R	Height of test room or installation	m	L
l_R	Length of test room or installation	m	L
p	Absolute static pressure	Pa	$ML^{-1}T^{-2}$
p_a	Atmospheric pressure	Pa	$ML^{-1}T^{-2}$
p_s	Static gauge pressure $(p - p_a)$	Pa	$ML^{-1}T^{-2}$
p_r	Stagnation (or absolute total) pressure	Pa	$ML^{-1}T^{-2}$
p_t	Total pressure $(p_r - p_a)$	Pa	$ML^{-1}T^{-2}$
p_d	Velocity pressure $\left(\varrho \frac{v^2}{2}\right)$	Pa	$ML^{-1}T^{-2}$
Δp	Pressure difference (for a pressure difference device)	Pa	$ML^{-1}T^{-2}$
q_V	Volume rate of flow	m^3/s	L^3T^{-1}
v	Velocity	m/s	LT^{-1}
v_m	Mean flow velocity	m/s	LT^{-1}
v_k	k factor velocity $\left(\frac{q_V}{A_k}\right)$	m/s	LT^{-1}
v_x	Maximum velocity at distance x from centre of supply air terminal device	m/s	LT^{-1}
X	Throw	m	L
Y	Spread	m	L
Z	Drop	m	L
ζ	Loss coefficient	—	Dimensionless number
Θ	Thermodynamic temperature	K	Θ
ϱ	Density	kg/m^3	ML^{-3}

2 Instrumentation

2.1 Air flow rate measurement

2.1.1 Air flow meters shall have the following ranges and accuracies:

Range	Accuracy of measurement
More than 0,07 m^3/s	2,5 %
From 0,007 to 0,07 m^3/s	5 %
Below 0,007 m^3/s	0,0009 m^3/s

All methods meeting the requirements of ISO 5221[1] will meet the accuracies given above and do not require calibration.

Alternatively flow meters may be calibrated *in situ* by means of the pitot static tube traverse techniques described in ISO 3966[2].

2.1.2 Flow meters shall be checked at intervals as appropriate but not exceeding 24 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 ISO flow meter standards.

2.2 Pressure measurement

2.2.1 Pressure in the duct shall be measured with a liquid-filled, calibrated manometer.

2.2.1.1 The maximum scale interval shall not be greater than the characteristics listed for the accompanying range of manometer.

Range Pa	Maximum scale interval Pa
From 1,25 to 25	1,25
From 25 to 250	2,5
From 250 to 500	5,0
Above 500	25

2.2.1.2 For air flow 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.

2.2.1.3 Calibration standards shall be:

a) for instruments with the range 1,25 to 25 Pa, a micromanometer accurate to ± 0,25 Pa;

b) for instruments with the range 25 to 500 Pa, a manometer accurate to ± 2,5 Pa (hook gauge or micromanometer);

c) for instruments with the range 500 Pa and upwards, a manometer accurate to ± 25 Pa (vertical manometer).

2.3 Temperature measurement

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

2.4 Velocity measurement

2.4.1 The measurement of low velocities within treated spaces, to determine air terminal device performance characteristics shall be made with a measuring device in accordance with annex A.

2.4.2 The measurement of air terminal device velocities to determine ATD[3] v_k velocity characteristics shall be made with a measuring device in accordance with annex B.

3 Testing of pressure requirement

3.1 Measurement of pressure requirement for a supply air terminal device

The pressure requirement of an ATD 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 ATD shall be employed. If an inlet duct arrangement or flow equalizing and/or damping device is an integral part of an ATD, then the standard test duct shall be employed immediately upstream of the integral inlet duct or accessory.

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

3.1.2 Pressure tests on the ATD alone or ATD in combination with flow equalizing and/or damping device shall be conducted to establish a pressure for a given air flow rate. The air terminal device shall be mounted in one of the two test installations

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

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

[3] Abbreviation signifying "air terminal device".

described in 3.1.3 (see figure 1) or 3.1.5 (see figure 2). To determine minimum pressure, measurements shall be made with flow equalizing and/or damping devices in the normally open position. Pressure tests on the ATD shall be clearly referenced to any position of adjustment.

Two methods may be used for determining pressure requirements on test installation A: one by measuring static pressure (see 3.1.3), the other by directly measuring total pressure (see 3.1.4).

3.1.3 Measurement of static pressure with the first test installation A

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 shall include an efficient flow straightener located at a position at least three equivalent diameters (D_e) from any part of the ATD. It is recommended that straightener cells have an axial length at least equal to six times the hydraulic diameter of their cross-section.

3.1.3.1 The test installation shall be generally constructed as shown in figure 1. The plane of measurement shall be at 1,5 equivalent diameters upstream of the ATD. 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.

3.1.3.2 Record the results for a minimum of four air flow rates regularly distributed over the upper half of the working range for each ATD tested.

3.1.3.3 The total pressure in the plane of measurement shall be considered to be that equal to the sum of the measured static gauge pressure and the velocity pressure calculated from the velocity obtained by dividing the test air flow rate by the duct cross-sectional area. The pressures so obtained may also be corrected to a standard air density of 1,2 kg/m^3.

3.1.4 Direct measurement of total pressure with the first test installation A

The test installation and the plane of measurement shall be the same as described in figure 1 and in 3.1.3. A pitot tube shall be used for successively measuring the total pressure at five points in this plane. These five points are 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 shall be considered as the mean arithmetic value of the five total pressure recorded measurements. The pressures so obtained may also be corrected to a standard air density of 1,2 kg/m^3. 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 6.

3.1.4.1 Record the results for a minimum of four air flow rates regularly distributed over the upper half of the working range for each ATD tested. The pressure may be corrected to standard density.

3.1.5 Measurement of static pressure with the first test installation B

The test installation shall be constructed as shown in figure 3, such that the following equation is satisfied:

$$\frac{q_V}{A} < \sqrt{\frac{p_s}{5\varrho}}$$

where

q_V is the volume flow rate;

A is the area of the internal cross-section of the chamber;

p_s is the required pressure;

ϱ is the density of the air.

NOTE — As the normal density of the air ϱ = 1,2 kg/m^3, the formula becomes

$$\frac{q_V}{A} < \sqrt{\frac{p_s}{6}}$$

The ATD to be tested shall be mounted in a short test duct equal to the nominal size of the ATD and having a length equal to D_e or 0,15 m, whichever is greater. It is recommended that the test duct should 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 ATD 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 ATD mounting plate removed.

3.1.5.1 Record the results for a minimum of four air flow rates regularly distributed over the upper half of the working range for each ATD tested.

3.1.5.2 The measured pressure, p_s, shall be considered to be the total pressure, p_t, and this pressure may also be corrected to a standard air density of 1,2 kg/m^3.

3.1.6 Presentation of data

3.1.6.1 The data shall be corrected to standard air conditions and the pressure requirements of the ATD determined from a graph of the total pressure versus the air flow rate.

3.1.6.2 The loss coefficient ζ shall be calculated from the following appropriate relationships, based upon the pressures measured under 3.1.3, 3.1.4 and 3.1.5:

$$\zeta = \frac{p_s}{p_d} + 1 \text{ (see 3.1.3)}$$

$$\zeta = \frac{p_t}{p_d} \quad \text{(see 3.1.4 and 3.1.5)}$$

where p_s or p_t is the measured quantity and p_d is calculated as $\frac{\varrho}{2}\left(\frac{q_V}{A_d}\right)^2$

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

The single loss coefficient ζ may be substituted for the graph of total pressure versus air volume flow rate.

3.2 Measurement of pressure requirement for an exhaust air terminal device

The pressure requirement of an exhaust ATD 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 ATD shall be employed. If a connecting duct arrangement, flow equalizing and/or damping device is an integral part of an ATD, then the standard test duct shall be employed immediately downstream of the integral connecting duct or accessory.

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

3.2.1.1 The device under test shall be mounted in a simulated wall or ceiling surface using the method of fixing recommended by the maufacturer. For circular and square ATD's this surface shall extend on all sides of the ATD to at least 2 D_e from the boundaries of the ATD.

For slots or similar ATD's, the surface shall extend by at least twice the width of the slot on each side of the device.

For special exhaust ATD's (for example, heat removal luminaires), where in the plane of the ceiling surface the velocity does not exceed 1 m/s, no extended surface is necessary.

3.2.2 Pressure tests on the exhaust ATD alone or in combination with connecting ducts, flow equalizing and/or damping devices shall be conducted to establish a pressure for a given air flow rate. The air terminal device shall be mounted in one of the test installations described in 3.2.3 (see figure 4) or 3.2.5 (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 ATD 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 3.2.3), the other by directly measuring total pressure (see 3.2.4).

3.2.3 Measurement of static pressure with the first test installation C for exhaust ATD (excluding air transfer devices)

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 manufacturers. This duct shall be straight and shall include an efficient flow straightener located at a position at least 7,5 equivalent diameters from any part of the exhaust ATD. It is recommended that straightener cells have an axial length at least equal to six times the hydraulic diameter of their cross-section.

3.2.3.1 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 1 D_e downstream 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.

3.2.3.2 Record the results for a minimum of four air flow rates regularly distributed over the upper half of the working range for each ATD tested.

3.2.3.3 The static pressure requirement of the device shall be obtained 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 static pressure (negative) measured on the axis of the duct in the section where it begins not to vary noticeably;

L is the distance between the ATD to the measuring section of p_s;

D_h is the hydraulic diameter of the duct;

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

3.2.3.4 The total pressure in the plane of measurement shall be considered equal to the sum of the measured static pressure and the velocity pressure calculated from the velocity obtained by dividing the test air flow rate duct cross-sectional area. The pressures so obtained may also be corrected to a standard density of 1,2 kg/m^3.

3.2.4 Direct measurement of total pressure with the first test installation C, for exhaust ATD

The test installation shall be the same as described in figure 4 and in 3.2.3.

3.2.4.1 The plane of measurement through which a pitot-static tube shall be used shall be the same as described in 3.2.3.1. Measurements of total and static pressure shall be made at the same five points in the plane as defined in 3.1.4 and for successive planes as defined in 3.2.3.1. 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 shall be the mean arithmetical value of the total pressure data obtained for each of the five points.

3.2.4.2 Record the results for a minimum of four air flow rates regularly distributed over the upper half of the working range for each ATD tested.

3.2.4.3 The total pressure requirement of the device shall be obtained by correcting for the total pressure change along the duct length from the equation:

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

The pressure so obtained may also be corrected to a standard density of 1,2 kg/m^3.

3.2.5 Measurement of static pressure with the first installation D for exhaust ATD

The test installation shall be constructed as shown in figure 5 such that the following equation is satisfied:

$$\frac{q_V}{A} < \sqrt{\frac{p_s}{\varrho}}$$

where

q_V is the volume flow rate;

A is the area of the internal cross-section of the chamber;

p_s is the required pressure;

ϱ is the density of the air.

NOTE — As the normal density of the air ϱ = 1,2 kg/m^3, the formula becomes

$$\frac{q_V}{A} < \sqrt{\frac{p_s}{6}}$$

The ATD to be tested shall be mounted in a short test duct equal to the nominal size of the ATD 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 ATD 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 ATD mounting plate removed.

3.2.5.1 Record the results for a minimum of four air flow rates regularly distributed over the upper half of the working range for each ATD tested.

3.2.5.2 The measured pressure, p_s, shall be considered to be the total pressure, p_t, and this pressure may also be corrected to a standard air density of 1,2 kg/m^3.

3.2.6 Presentation of data

3.2.6.1 The data shall be corrected to standard air conditions and the pressure requirements of the ATD determined from a graph of the total pressure versus the air flow rate.

3.2.6.2 The loss coefficient ζ shall be calculated from the following appropriate relationship based upon the pressures measured under 3.2.3, 3.2.4 and 3.2.5:

$$\zeta = \frac{p_s}{p_d} - (1 + 0{,}02\frac{L}{D_h}) \quad \text{(see 3.2.3)}$$

$$\zeta = \frac{p_t}{p_d} - 0{,}02\frac{L}{D_h} \quad \text{(see 3.2.4)}$$

$$\zeta = \frac{p_t}{p_d} \quad \text{(see 3.2.5)}$$

where p_s or p_t is the measured quantity and p_d is calculated as $\frac{\varrho}{2}\left(\frac{q_V}{A_d}\right)^2$

(where both ϱ and q_V are also at the same test conditions).

The single loss coefficient ζ may be substituted for the graph of total pressure versus air volume flow rate.

3.3 Determination of air velocity v_k and the corresponding area value A_k for the air terminal device

3.3.1 The same test installation used to measure pressure shall be used to measure v_k and to calculate A_k, see figures 1, 3, 4 and 5.

3.3.2 The v_k velocity shall be measured with an air velocity meter selected in accordance with specifications in 2.4.2.

3.3.2.1 Specifications for the positions and locations of the air velocity measuring points at the air terminal device shall be stated with the corresponding v_k values.

3.3.2.2 The v_k values shall be referenced to the specific adjustment position of the air terminal device.

3.3.2.3 For each of the test air flow rates, the arithmetic mean of the velocities measured to establish v_k shall be determined from measurements taken at the number and position of points on the ATD as specified by the manufacturer.

3.3.2.4 The A_k values shall be calculated by dividing the measured air flow rate by the mean v_k.

3.3.3 A test shall be carried our for a minimum of four air flow rate values distributed within the range of the air terminal device nominal capacity.

3.3.4 The A_k value may be reported as the arithmetic mean for each of the measured air flow rates tested. A single value shall be reported if the values calculated do not differ by more than 5 % from the mean calculated value. If these values differ by more than 5 % from the mean, the A_k value shall be reported as a function of flow rate.

4 Tests to measure the isothermal air discharge characteristics of a supply ATD (second test installation)

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

4.1 Test room

4.1.1 All measurements shall be made within an enclosed space and this space shall be termed the "test room".

4.1.2 The test room size shall fall within the following dimensional standard:

a) The height (h_R) shall not be less than 2,8 m;

b) The width (b_R) shall be determined from the relationship ($1,5 < \frac{b_R}{h_R} < 2,2$);

c) The minimum length (l_R) shall be 7,5 m;

d) Dimensions in the range of l_R = 7,5 m, b_R = 5,6 m and h_R = 2,8 m, will satisfy a minimum testing requirement. However, a length of 9 m will allow a larger range of unit sizes to be tested. (See figure 6.)

4.1.3 All surfaces shall be normal at corners and any surfaces over which the supply air path flows shall be smooth and flat. All luminaires and windows shall be flush with the surface in which they are mounted.

4.1.4 Air shall be exhausted from the test room at a location away from the supply air path and out of the planes of measurement.

4.2 Test room equipment and instrumentation

The system supplying the test room shall comprise a fan, a means of controlling the air flow rate. A flow rate measuring device, a standard test duct (first test installation) or a test duct which will provide v_k values within 5 % of those obtained in a test conducted in accordance with 3.3.

4.3 Installation of the air terminal device

Terminal devices can be divided into three 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; ceiling diffusers.

Class III Devices from which the jet is essentially two dimensional; linear grilles, slots and linear diffusers.

4.3.1 The air terminal device shall be installed (using the method recommended by the manufacturer) in the following position with the second test installation. (See figure 6.)

4.3.1.1 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.

4.3.1.2 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 ATD 0,2 m from the ceiling.

4.3.1.3 Class II device (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 that as typically applied and installed in accordance with the manufacturer's recommendation.

4.3.1.4 Class III devices (linears) when tested as side wall ATD's shall be mounted as in 4.3.1.2. Slot ATD's shall be mounted as Class I or II whichever is applicable. Artificial sidewalls shall be employed with ATD's that would normally span the distance between two walls. The minimum length of the ATD tested shall be equal to or greater than 1,2 m when artificial sidewalls are employed.

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

4.3.3 The highest flow rate for an ATD that may be utilized in a given room size shall be limited to the one for which the maximum air jet velocity does not exceed 1,0 m/s at a distance of 1,0 m from the boundary wall in the direction under investigation.

4.4 Test procedure

4.4.1 Testing shall commence after steady state isothermal conditions have been achieved. Such conditions shall be said to exist when temperature-measuring probes placed are in the following positions:

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

b) at the centre of the exhaust terminal device;

and indicate temperatures that do not differ from each other by more than 2 K for a period of 5 min prior to and at any time during the test.

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

4.4.3 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)

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

4.5 Determination of isothermal performance

4.5.1 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 ATD. The air velocities shall be measured with an instrument as specified in annex A and an exploratory technique shall be used to determine the location of the air stream envelope(s). The method A (see 4.5.2) or alternatives given in annex C shall be used.

4.5.2 Method A

A vertical plane of maximum velocity should be determined from a plot of the loci of points in the discharge air stream at a uniform velocity within the range of 1,0 to 1,5 m/s (i.e. isovel for ATD discharge stream at uniform velocity in range of 1,0 to 1,5 m/s). Typical orientation of vertical planes of maximum velocity are shown in figures 7A to 7F.

4.5.3 Velocity measurements shall be taken at a minimum of eight distances from the ATD, but not more frequently than at 0,3 m intervals, in the plane of maximum velocity as determined in 4.5.2. These measurements shall begin at a point at which the highest velocity is at least 0,5 m/s greater than the terminal velocity under consideration. Several measuring positions in sequence in the discharge stream at 25, 75, 150, 225, 300, 600, 900 mm, etc., away from the adjacent surface or stream centreline at each distance outlined above shall be required until the highest air stream velocity has been established.

4.5.4 At each distance X from the ATD for which the v_x velocity is measured the non-dimensional relationship of v_x/v_k and the corresponding value of $X\sqrt{A_k}$ shall be calculated with the results plotted as a logarithmic function as shown in figure 8. (For a given ATD the value A_k is substantially constant and v_k typically varies with the airflow rate.)

4.5.4.1 In analyzing the performance of jets, four major zones can be distinguished. They may be defined in terms of the maximum or centreline velocity existing at the cross-section being considered as follows:

Zone 1: A short zone, extending about four diameters or widths from the supply air terminal device face (or *vena contracta* for orifice discharge), in which the maximum velocity of the air stream remains practically unchanged.

Zone 2: A transition zone, extending to about eight diameters for round supply air terminal devices or for rectangular supply air terminal devices of small aspect ratio, over most of which maximum velocities vary inversely as the square root of the distance from the supply air terminal device. For rectangular supply air terminal devices of large aspect ratio, this zone is elongated and extends from about four widths to a distance approximately equal to the width multiplied by four times the aspect ratio.

Zone 3: A long zone, of major engineering importance, in which the maximum velocity varies inversely as the distance from the supply air terminal device. This zone is often called the zone of fully established turbulent flow and may be 25 to 100 diameters long (or equivalent diameters of equal areas), depending on the shape and area of the supply air terminal device, the initial velocity and the dimensions of the space into which the supply air terminal device discharges.

Zone 4: A terminal zone in which, in the case of confined spaces, the maximum velocity decreases at an increasing rate, or, in the case of large spaces free from wall effects, the maximum velocity decreases rapidly in a few diameters to the velocity range below 0,25 m/s which is usually regarded as still air.

4.5.5 The plot shall be drawn through the test points with the slope of the plot equal in angle to the reference slope lines (zones 2 and 3) in figure 8. This shall be repeated for all tests in this product series. For low v_x velocities the zone 4 slope shall be drawn. The slope lines shall be drawn through the test points; the intersections of the zone slope lines shall be determined by the best possible match of the test points and the slope line. The line for each tested ATD shall be plotted and identified and a median line determined which shall be representative of the product series. If the difference between a throw interpolated by the median line and the experimental throw does not exceed ± 20%, then this correlation can be used to interpolate the throw for a product series.

4.5.6 The throw distance X for a given air flow rate may be based on any appropriate terminal velocity v_x. The v_x selected shall be referenced in the recorded data.

4.5.7 The ratio of throw to spread shall be determined from the plot of the loci of uniform velocity used to establish the plane of maximum velocity. This ratio shall be used to calculate the spread at other flow rates and v_x values for the ATD under test.

4.5.8 The drop shall be determined and qualified in the manner as described in 4.5.7.

NOTE — In cases of non-symmetrical jets, additional measurements shall be made in varying planes to determine the envelope velocities.

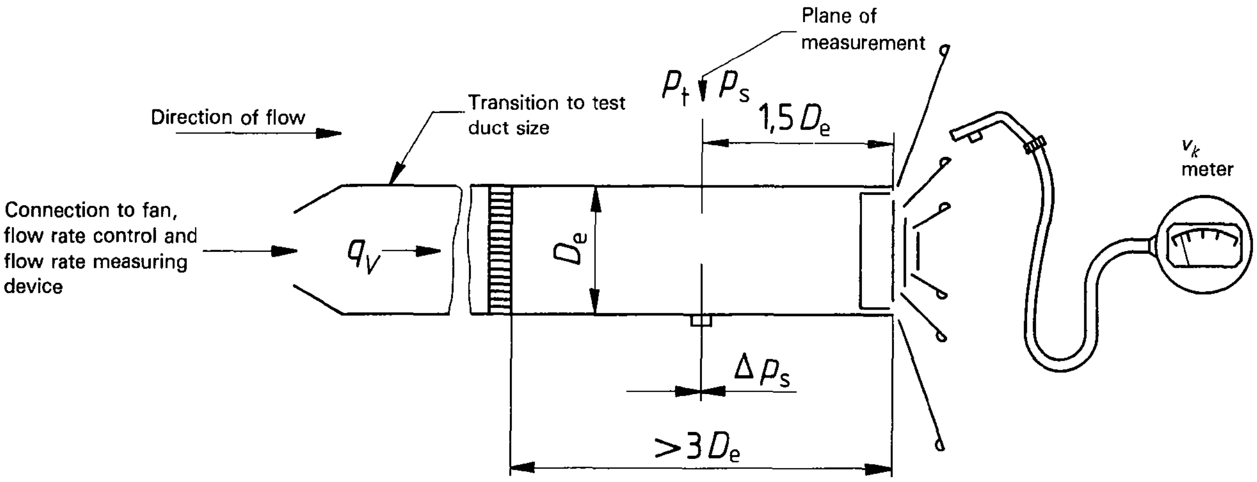


Figure 1 — First test installation "A" for supply ATD

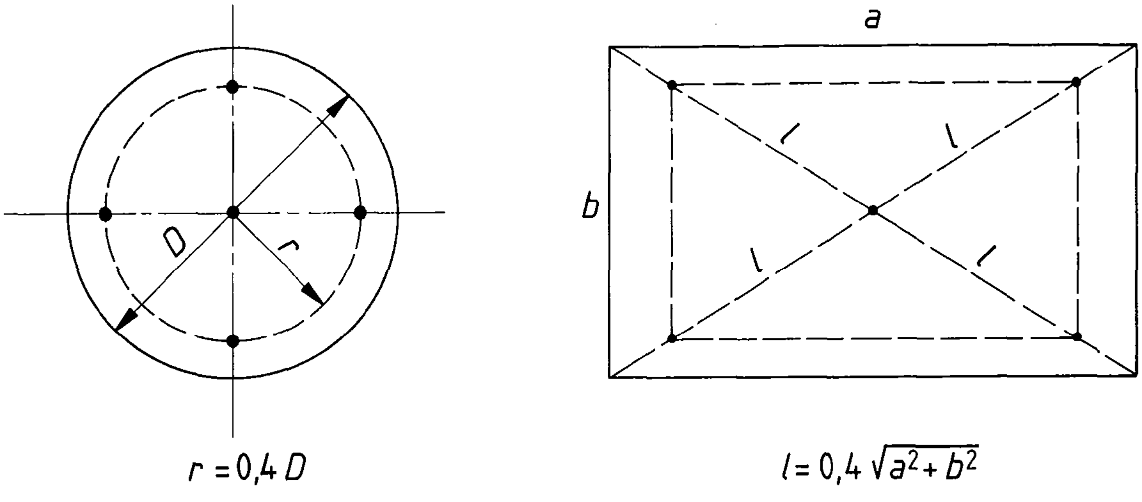
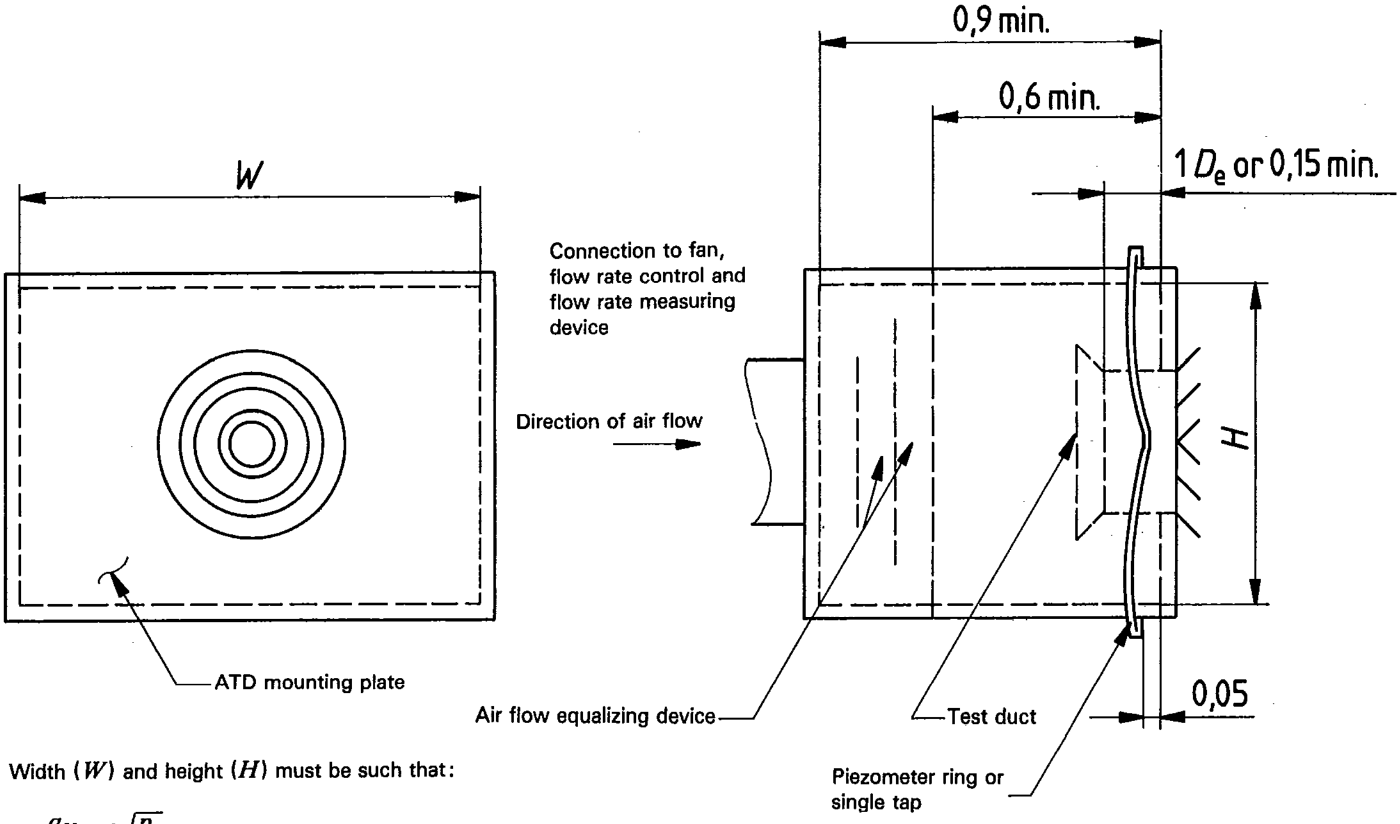


Figure 2 — Direct measurement of total pressure pitot tube location in first test installation "A" for supply or "C" for exhaust

Dimensions in metres



Width (W) and height (H) must be such that:

$$\frac{q_V}{A} < \sqrt{\frac{p_s}{6}}$$

Figure 3 — First test installation: "B" for supply ATD

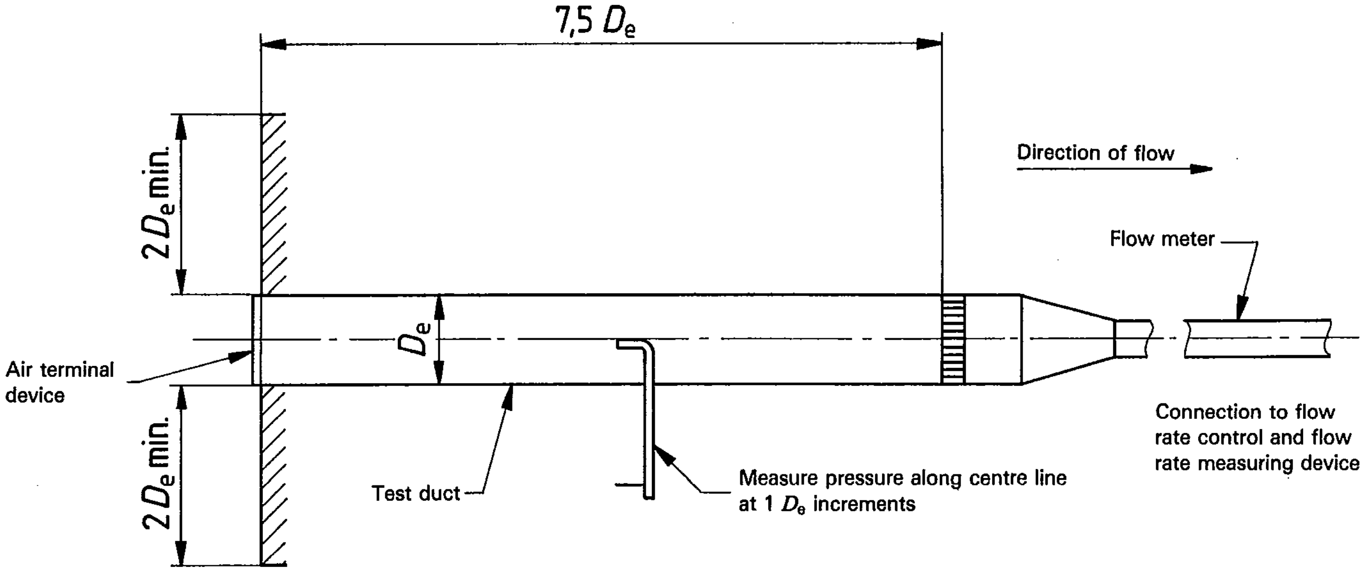
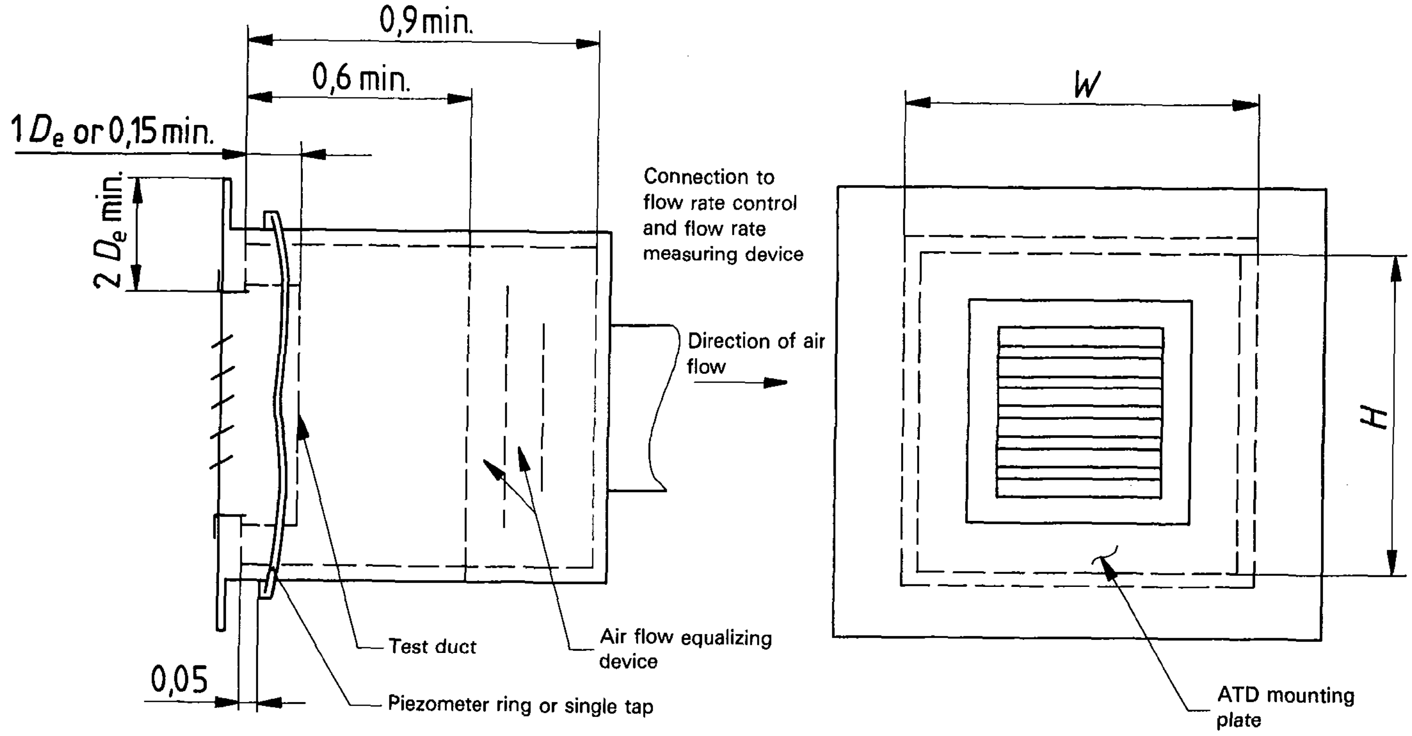


Figure 4 — First test installation "C" for exhaust ATD

Dimensions in metres



Width (W) and height (H) must be such that:

$$\frac{q_V}{A} < \sqrt{\frac{p_s}{6}}$$

Figure 5 — First test installation "D" for exhaust ATD

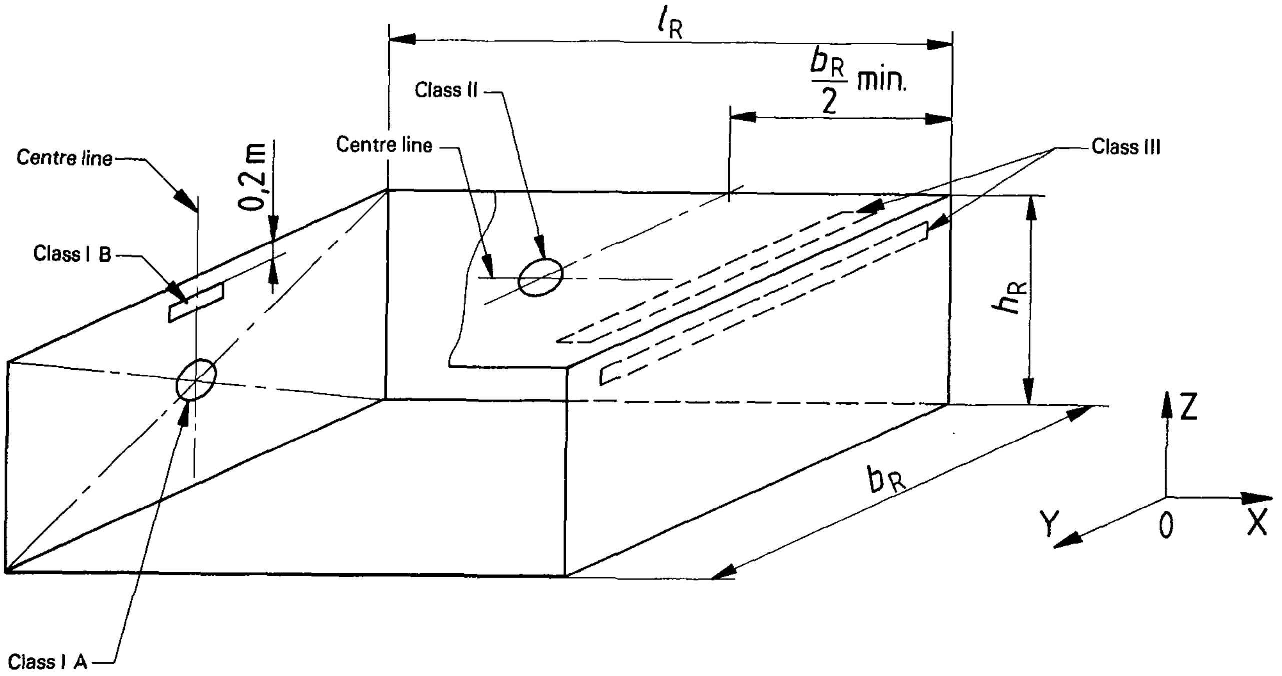


Figure 6 — ATD position for second test installation

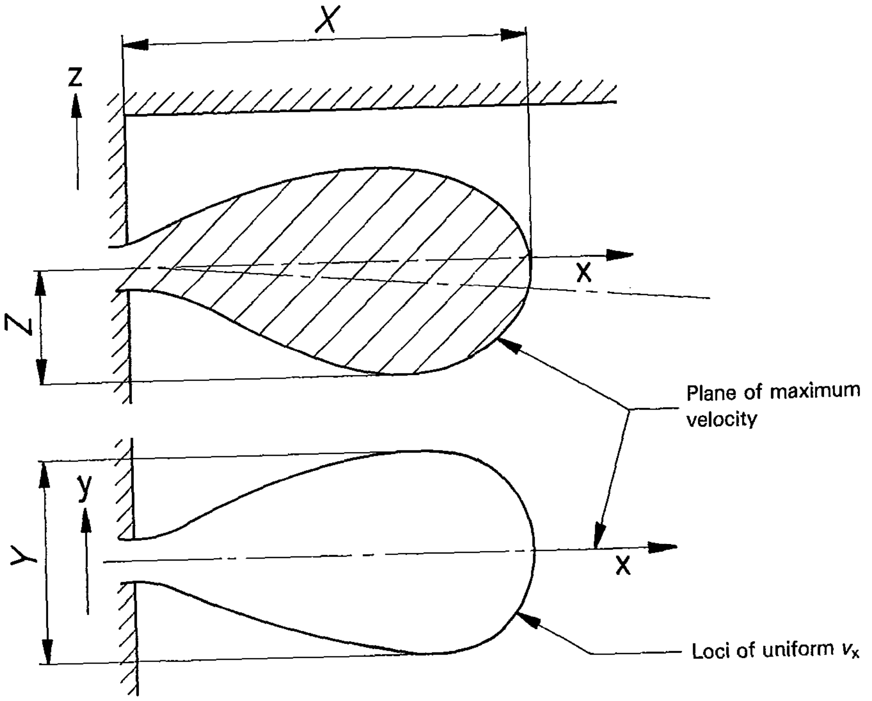


Figure 7A — Class I A

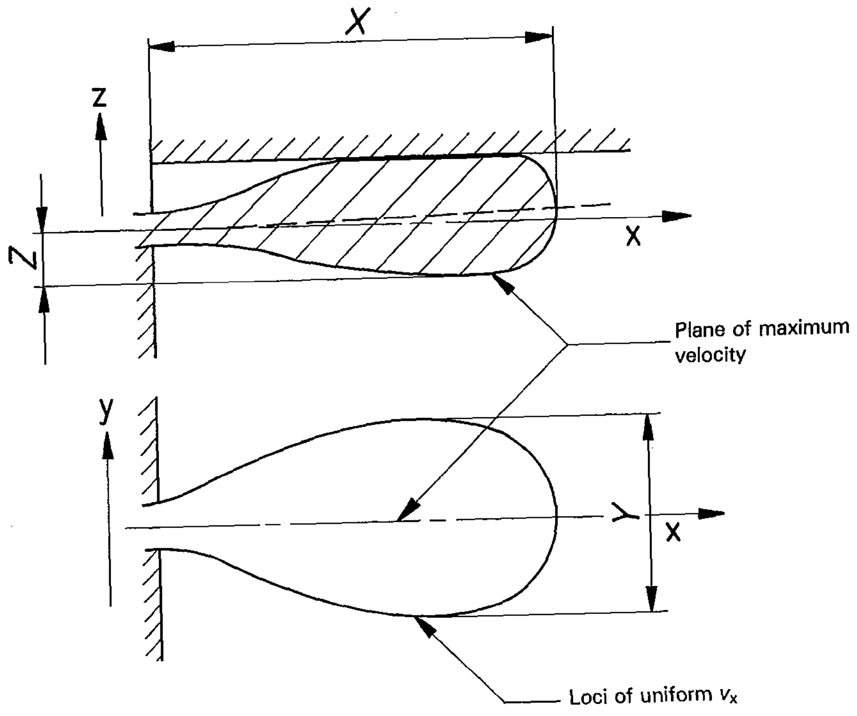


Figure 7B — Class I B

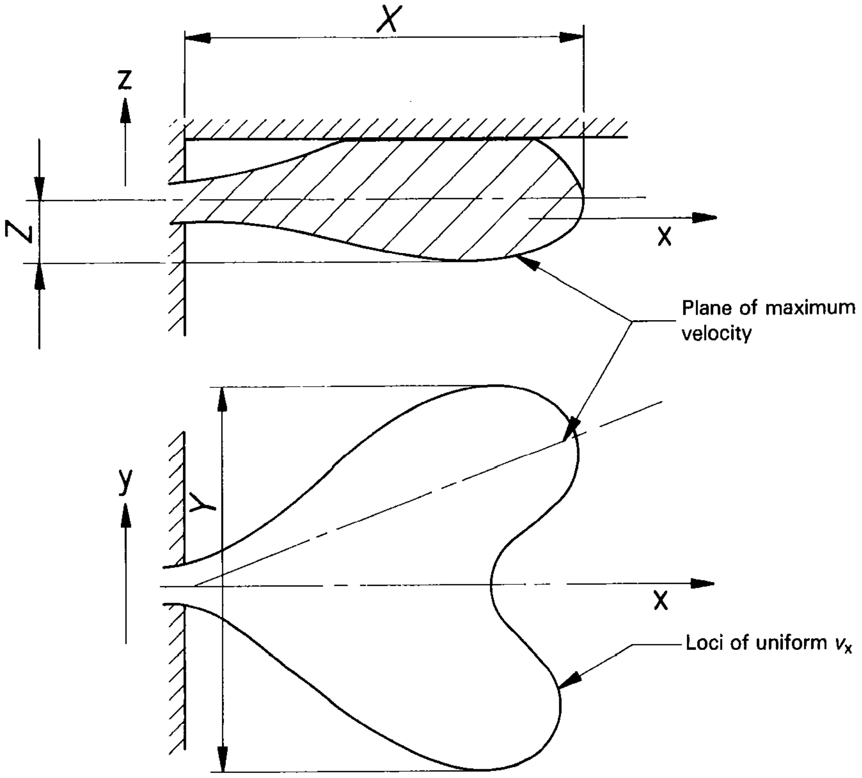


Figure 7C — Class I B

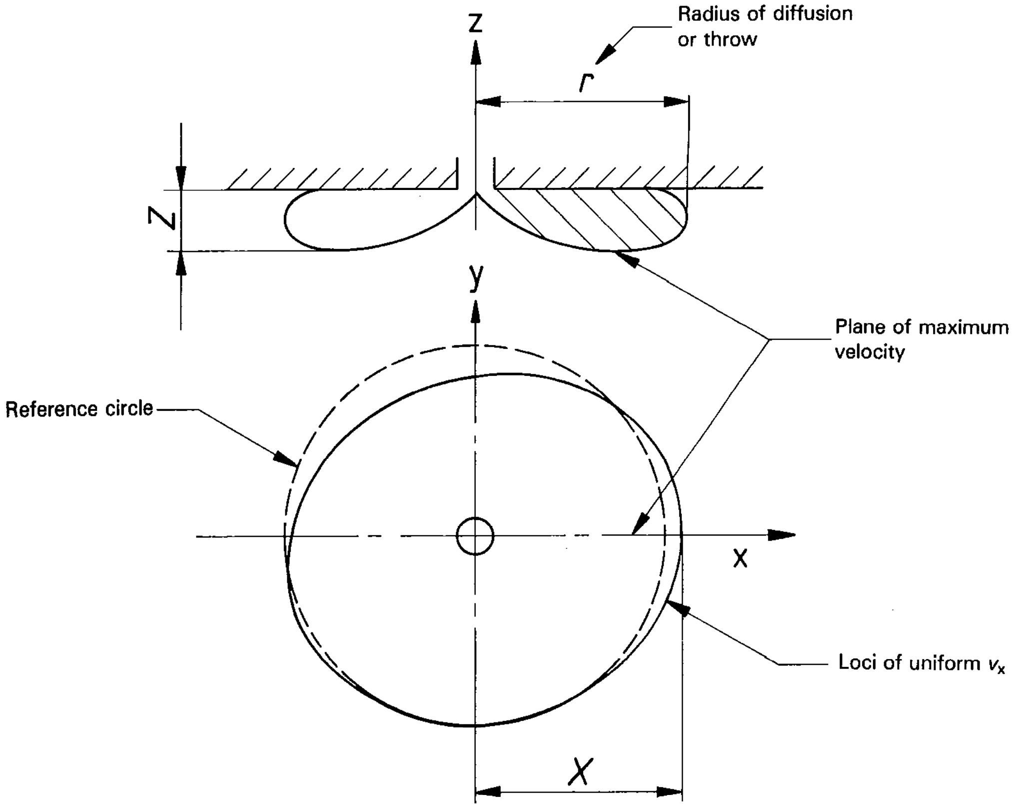


Figure 7D — Class II — Radial discharge

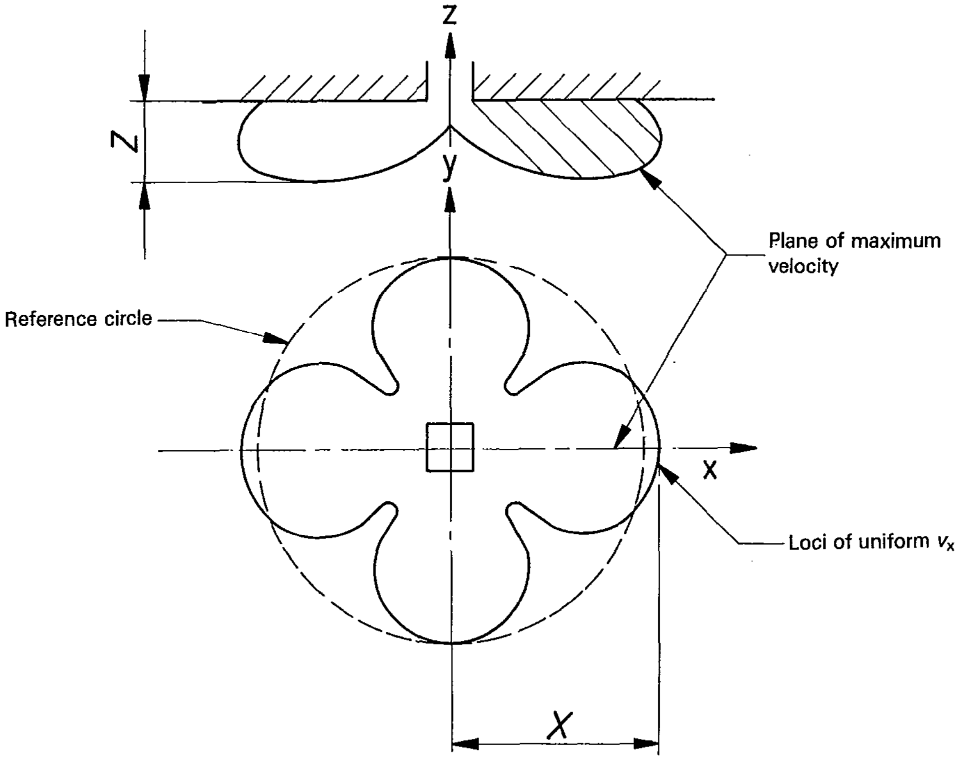


Figure 7E — Class II — Directional discharge

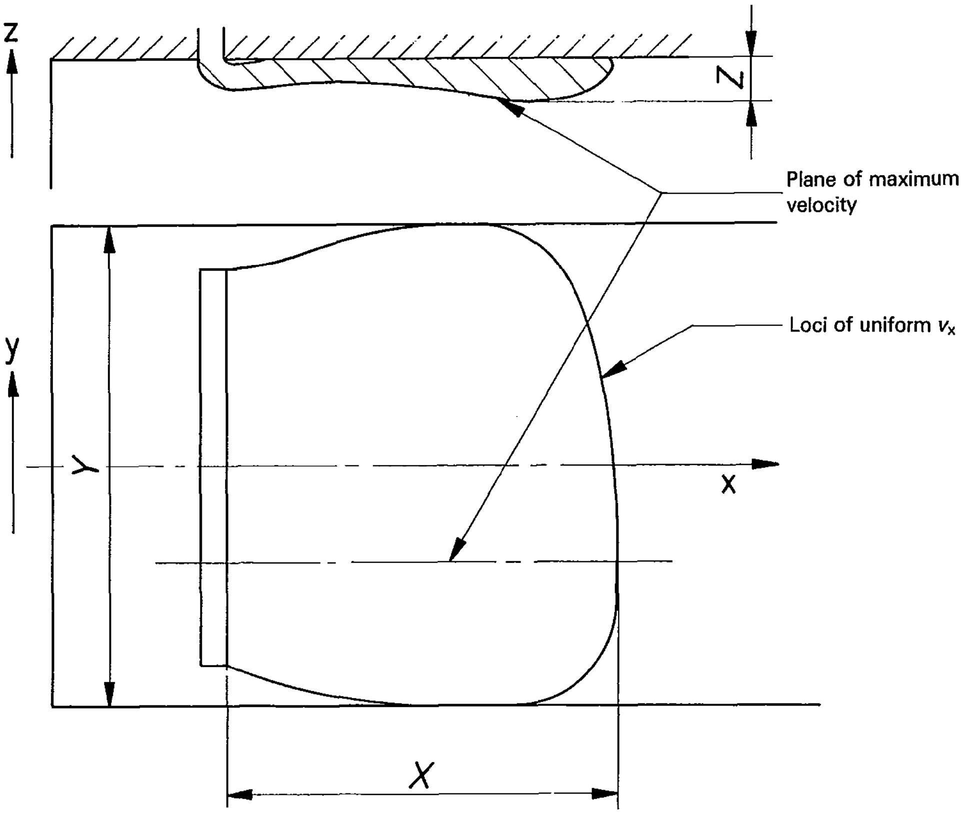


Figure 7F — Class III — Linear diffuser

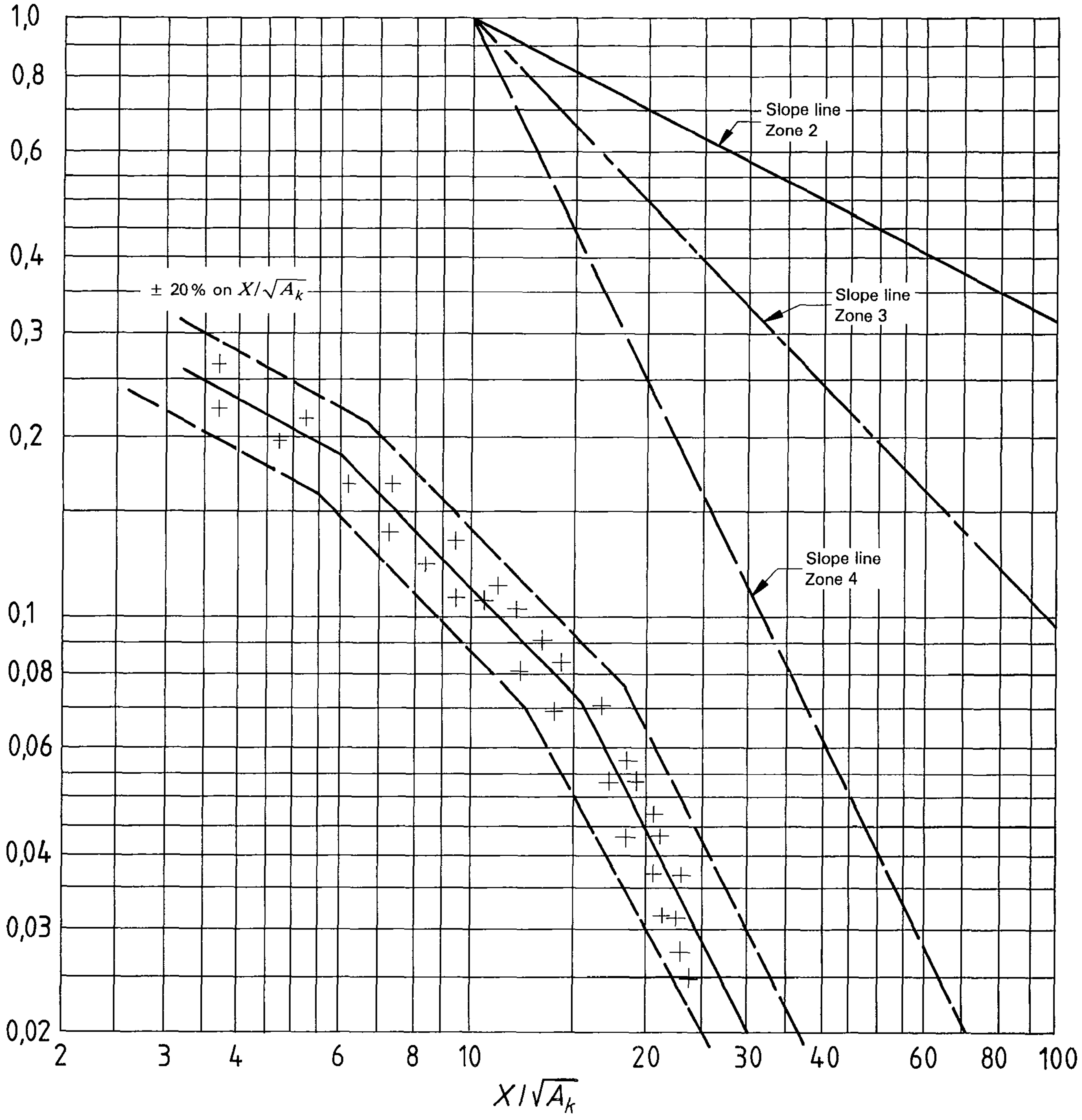


Figure 8 — Typical graph for a family of air terminal devices showing the relationship between throw, reference terminal velocity and air flow rate

Annex A

Measurement of low air velocities for the determination of the throw of air terminal devices

(This annex forms an integral part of the standard.)

A.0 Introduction

Of all devices used for measuring the air velocity, the pitot static tube is the only one that does not require calibration. For all other devices the relation between velocity and the response of the device is usually so complex that it is necessary to make a calibration, i.e. to determine the response in a flow of known velocity. It is not possible, as has been done in the standard for air performance testing of air terminal devices with regard to the problem of air flow rate measurement, to lay down the use of well defined methods enabling the user to make measuring devices by himself, which do not need prior calibration. A presentation of the main characteristics required from an air velocity measuring device must suffice.

A clear presentation of the various desired characteristics could also prompt the manufacturers of measuring device(s) to effect the necessary choice of one or more devices available on the market for determining air terminal device throw.

A.1 Scope and field of application

This annex defines the main characteristics of low air velocity measuring devices and the expected performance of these devices for such measurements.

A.2 Measuring range

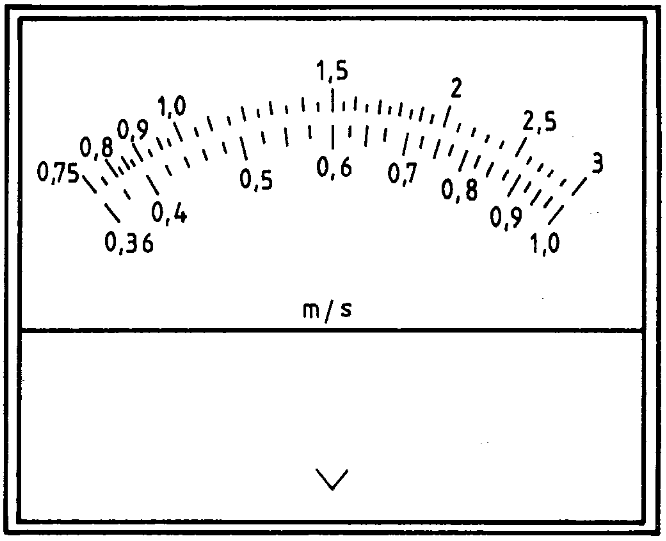
The measuring device should be capable of measuring air velocities within the range from 0,4 to 3 m/s.

It should however be noted that, if it is considered desirable to extend the range either by reducing the lower limit or by increasing the upper limit or by both methods, such a change does not necessarily affect the choice of the measuring device.

A.3 Reading scales

A.3.1 To achieve adequate accuracy of reading with measuring devices composed of a case with a dial and a pointer, it is desirable that two successive scale divisions on the dial are sufficiently remote from one another but do not correspond to two different readings of the velocity. This is the reason why it is recommended that the distance between two successive scale divisions is at least one millimetre corresponding to velocity readings differing by not more than 5% for velocities greater than 0,4 m/s.

A.3.2 The measuring devices generally have several (two or three) scales enabling easier reading over the whole measuring range. The scales should be chosen such that the higher range starts at a value not exceeding 75% of the maximum value of the lower range so that it is possible to check the agreement between the two scales and to carry out measurements in a fluctuating flow where the mean velocity is close to the limit value of one scale. A meter complying with the above requirements is illustrated as an example in figure 9.



Range 0,4 – 3,0 m/s
2 scales
5% increments (max.)
75% overlap
1 mm minimum division intervals.

Figure 9 — Specimen meter scale

A.3.3 Velocity measuring devices with digital indicators should be such that the intervals between two successive velocity readings is not more than 5% of the indicated velocity for velocities greater than 0,4 m/s.

A.4 Dimension of the probe

The overall dimension (in one direction normal to flow) of the measuring probe shall certainly not exceed 15 mm and it is desirable that the dimension is as small as possible because throw determination may involve explorations for air velocity measurement in areas with high velocity gradients.

A.5 Determination of mean air velocity

In a jet discharging from an air terminal device, the velocity is never steady but may vary considerably with time. For determining the throw of a supply air terminal device, it is on the other hand necessary to define one (or several) envelope(s) i.e. surfaces, the various points of which correspond to given values of mean air velocity. It is therefore necessary to be able to carry out measurements by integrating over a certain period to improve measuring accuracy which cannot obviously be the same as during calibration in an undisturbed and regular flow. Rather than having a sensing element with a high inertia value, the time constant[1] of which can vary considerably depending on whether the velocity is increasing or decreasing (which biases the value of the mean indicated velocity), it seems preferable to use a sensing element with low inertia incorporating a damping system to damp the signal allowing an overall time constant of several seconds.

When damping methods are used, they should be such that the mean air velocity can be easily read independently of velocity fluctuations in the jet.

A.6 Probe sensitivity to direction

The sensing element is usually shaped in such a way that the output of the device depends on the mean velocity value as well as on the relative position of the probe with respect to the mean velocity direction.

The direction of the mean velocity in a jet is known to within some degrees at the best, and it is always recommended that the probe be correctly orientated in the jet. It is, however, preferable to have a probe with low directional sensitivity to facilitate its positioning.

It is therefore desirable to use a probe for which a tilt (yaw or pitch) up to 15° does not noticeably affect velocity measurement, and subsequently to determine the probe response in a calibration wind tunnel by testing it under different well-defined tilt angles in a flow having a uniform mean velocity; consequently it is recommended that for such tilt angles (yaw or pitch), the velocity indications shall not vary by more than 5 % within the measuring range or, alternatively, to ensure that the probe is correctly positioned in the flow.

A.7 Influence of air temperature

Air temperature may influence the device readings in two ways, first because the reading does not exclusively depend on air velocity but also on air density (it may therefore be necessary to measure air pressure and temperature to calculate its density and to correct velocity readings accordingly) and secondly because in thermal devices (where velocity readings actually reflect the rate of heat exchange between the sensing element and air) a direct influence of air temperature can arise which can sometimes be automatically compensated by the device itself.

For testing under isothermal conditions, it is possible to use a temperature-sensitive device, if information on the corrections to be made is available.

A.8 Influence of natural convection

The sensing element of air velocity measuring devices operating on a thermal principle is usually heated to a temperature substantially higher than the ambient temperature. The air in the immediate proximity of the probe is heated, and an upward air flow due to natural convection develops; the velocity resulting from the superposition of this flow and of the air flow to be measured depends on the main flow direction. A probe is insensitive to the effect of natural convection, if it indicates the same velocity for an upward flow and a downward flow.

For velocities above 0,2 m/s the appreciable effect of natural convection generally disappears. However, a very small and strongly heated sensing element sensitive to this effect of natural convection up to velocities of about 0,3 to 0,4 m/s would give rise to serious practical difficulties in use.

It is recommended that a probe indicating the same value whether flow is ascending or descending be used for air velocities equal to the lowest measured velocities for determining air throw.

A.9 Measuring uncertainty

A.9.1 In addition to the reading accuracy as considered above in 4.1, the possible hysteresis of the device should also be ascertained by wind tunnel testing in order to estimate the precision of the measuring device response.

A.9.2 It is also important that the device gives stable readings during its whole period of use in order that flow conditions are as well-defined as possible so as to lessen the necessity of frequent calibrations. This characteristic also depends on the stability of measuring systems, the good condition of the probe and the possibility of cleaning the probe as often as required.

A.9.3 The overall uncertainty of air velocity measurements eventually depends on all the above-mentioned factors. It is however absolutely essential not to forget the strict necessity of a correct calibration of the device if the uncertainty is to be reduced; without such calibration even a device with very good characteristics would lose all its advantages.

A.9.4 Calibration

For all air velocity measuring devices it is necessary to know some main characteristics, which depend on the design of the

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1) The time constant here is meant as being the time interval between the obtaining of a response at approximately 63 % of the value of a velocity gradient and the time relating to this gradient.

device, the geometrical shape of the measuring probe or the actual measurement principle used. These characteristics should normally be produced by the manufacturer of the measuring device; they are determined once and for all and usually do not change with time. They are:

a) influence of flow direction;

b) influence of air temperature;

c) influence of natural convection;

d) time constant.

On the other hand, the relationship between air velocity and the device response should be checked regularly. The experimental determination of this relationship i.e. the device calibration, raises some technical problems. In fact, there is no measuring device available for low air velocities that does not itself need calibration and that could therefore be used as a primary standard. It is necessary to set up special installations on which it is tried to determine the air velocity by measuring another value or by using a theoretical method.

The following table gives a short account of some methods used and of the problems that appear when applying them (see table 1).

A.10 Other factors of choice

The following should also be considered when choosing a measuring device:

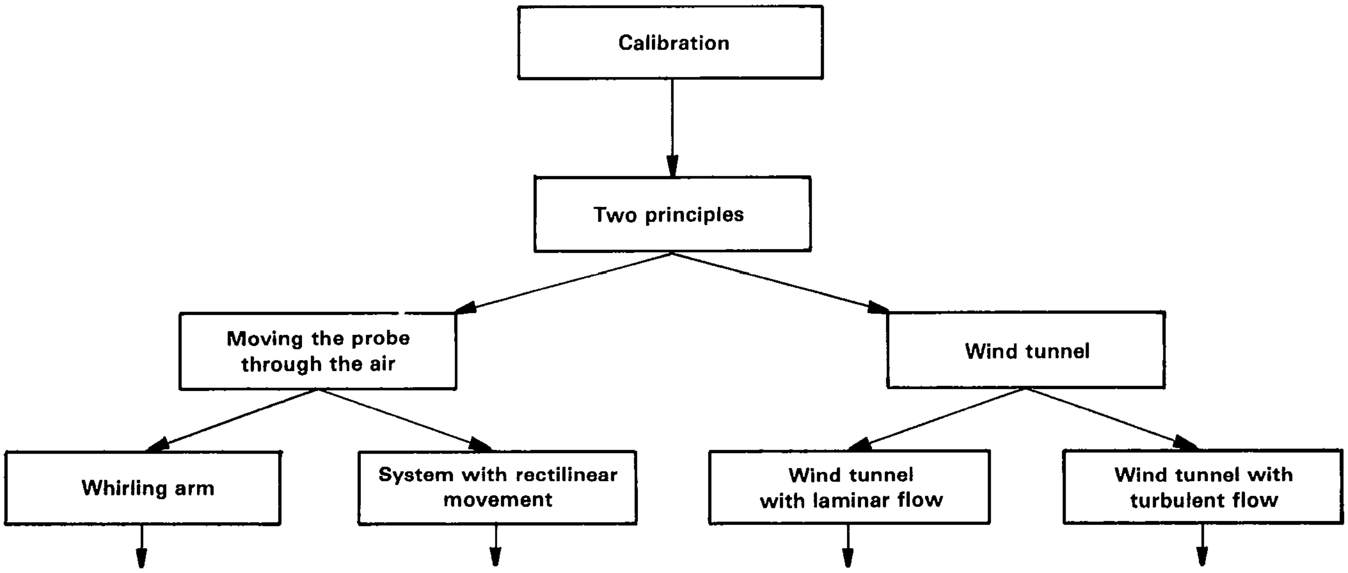
a) the robustness of the device;

b) the ease of use of the device;

c) the cost;

d) the availability on the market.

Table 1 — Calibration



a) reliable measurement of the moving velocity;

b) mechanical problems of stability, vibrations;

c) problem of air drag (The moving velocity of the probe may exceed the relative velocity by 20 %).

a) reliable measurement of the moving velocity;

b) mechanical problems of stability, vibrations;

c) no air drag, but the duct length is limited. Only devices with low time constant can be tested.

a) very high accuracy, because the flow rate can be measured to an accuracy of better than 1 %;

b) size limitation: $Re < 2\,000$ is mandatory. For air at 20 °C the maximum duct diameter D_{max} depends on the maximum velocity v_{max} required:

v_{max} m/s	D_{max} mm
1	60
1,5	40
2	30
3	20

The use is therefore limited to very small-sized probes.

a) it is not easy to obtain uniform velocity distribution to 1 % in a sufficiently large part of the section;

b) the influence of the boundary layer must be taken into account;

c) the proportion of turbulence must be small, and the flow must be steady;

d) airborne noise may effect calibration.

Annex B

Measurements of air velocities for the determination of air terminal device velocity v_k

(This annex forms an integral part of the standard.)

B.0 Introduction

ATD v_k velocity measurements may be made with instruments having the following characteristics.

The determination of v_k velocities involves the measurement of velocities over an approximate range of 1,0 to 12 m/s, in regions of high velocity gradient. The sensor must have characteristics that ensure repeatable velocity indication when measuring v_k with several instruments of the same type at the same points on duplicate ATD's.

The following conditions should be considered in the selection of a suitable instrument to measure v_k:

a) it should be commercially available;

b) it should be suitable for field use;

c) it should have a record of satisfactory field performance.

B.1 Scope and field of application

The purpose of this annex is to define the main characteristics of an air velocity measuring device and the expected performance of these devices that are desirable when used to measure the v_k values for ATD's.

B.2 Measuring range

The measuring device should be capable of measuring air velocities within the range from 1,0 to 12 m/s.

This range may be extended at either end providing the required characteristics are maintained within the above range limits.

B.3 Reading scales

B.3.1 When using devices incorporating a scale and indicator, they shall include velocity scale indications corresponding to a minimum velocity difference of 5 %, spaced at least one millimetre apart over the required range.

B.3.2 When multiple scales are used to meet the above requirement, the scales should be chosen such that the higher range starts at a value not exceeding 75 % of the maximum value of the lower range. This permits measurements at a velocity close to the limit value of one scale.

B.3.3 Velocity measuring devices with digital indicators should be such that the intervals between two successive velocity readings are not more than 5 % of the indicated velocity for velocities greater than 1 m/s.

B.4 Dimensions of the probe

It is desirable that the overall cross-sectional dimension of the probe in the direction normal to flow should be between 5 mm and 15 mm because v_k measurements may be made at locations of high velocity gradients.

B.5 Determination of mean velocity

The velocity is not steady in an air stream discharging from an ATD, therefore the v_k must be determined by integrating velocity indications over a certain period of time. To facilitate this integration, the measuring device shall incorporate a damping system that allows an overall time constant[1] of several seconds.

B.6 Probe positioning

The velocity gradient at the point(s) of measurement may be large and therefore the probe must be located at a repeatable position(s) to ensure consistent v_k measurement.

The probe shall be equipped with a positioning index(es), preferably removable, to allow the required repeatable positioning of the probe at the measurement location.

B.7 Influence of air temperature

Air temperature may influence the device readings because the indicated air velocity may depend on the air temperature and/or air density as well as actual air velocity. Therefore it may be necessary to measure the air temperature and pressure and correct the indicated velocity accordingly.

Some instruments incorporate automatic compensation and may be used without correction.

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1) The time constant here is meant as being the time interval between the obtaining of a response at approximately 63 % of the value of a velocity gradient and the time relating to this gradient.

B.8 Measuring uncertainty

B.8.1 In addition to the reading accuracy considered in 4.1, the measurement reading hysteresis should be determined by velocity calibration.

B.8.2 The velocity calibration of the device should be stable during its period of use. This characteristic is a function of the measuring system stability, the probe durability and cleanliness of the probe.

B.8.3 The overall uncertainty of velocity measurements is dependent on the above factors.

Correct velocity calibration, within close limits, is essential to reduce the uncertainty. A device with very good characteristics loses all its advantages, without this correct calibration.

B.8.4 Calibration

The following characteristics, which generally do not change with time, should be furnished by the manufacturer. These depend on the design of the device, the geometrical shape of the measuring probe and the measurement principle used:

a) influence of air flow direction;

b) influence of air density (temperature and pressure);

c) time constant;

d) influence of velocity gradient over probe face.

It is generally necessary to determine these values once only since they do not change with time.

The relationship between air velocity and the device response should be regularly checked. The experimental determination of this relationship i.e. the device calibration, raises some technical problems. It is necessary to set up a special installation for this calibration.

B.9 Other factors of choice

The following items should be considered in chosing a measuring device for v_k:

a) robustness of the device;

b) the ease of use;

c) the cost;

d) the availability on the market.

Annex C

Alternative exploratory technique for determination of throw, spread and drop

(This annex forms an integral part of the standard.)

C.1 Scope and field of application

The following section describes 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.

As described, 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.

C.2 Determination of the point of maximum velocity

C.2.1 The velocity measuring probe shall first be positioned 300 mm from the centre of the face of the device in the direction of airflow [see figure 10a)].

C.2.2 A horizontal traverse parallel to the face of the air terminal device at intervals of not more than 50 mm, shall be made at this distance to determine the point of maximum velocity. The vertical axis through this point shall be denoted Z_c [see figure 10b)].

C.2.3 A vertical traverse, at intervals in accordance with table 2 shall be made along axis Z_c and the point of maximum velocity (v_{max}) shall be established. The horizontal axis through this point shall be denoted Y_c [see figure 10c)].

C.2.3.1 In order to ensure that the location of the point of maximum velocity is not dependent on the sequence of the traverse (horizontal, then vertical), a quick check may consist of measuring the air velocity at the two points located on the horizontal axis parallel to Y_c through the point of maximum velocity and 50 mm remote from this point.

C.2.4 The probe shall then be positioned at co-ordinates (Y_c, Z_c) as determined in C.2.2 and C.2.3 and moved horizontally (parallel to X_c) in the direction of air flow away from the device by an increment no greater than 1 m [see figure 10d)].

C.2.5 The procedure described in C.2.2 and C.2.4 shall be repeated until the maximum measured velocity (v_{max}) is less than 0,5 m/s [see figure 10e)]. A minimum of five (Y_c, Z_c) co-ordinates shall be established, intermediate locations being introduced when necessary.

C.2.6 A logarithmic plot of the five values of v_{max} versus horizontal distance from the face of the air terminal device shall be made and from this plot the distance that corresponds to a velocity at 0,5 m/s shall be determined [see figure 11]. This distance shall be noted as the throw.

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

C.3 Determination of points at envelope velocity

The points at which the air stream velocities are at the envelope velocity (± 0,5 m/s) on each of the Y_c and Z_c axes shall be established as follows either during or following the traverse described above.

C.3.1 The probe shall be moved vertically downwards along one of the Z_c axis until the measured velocity falls to about 0,45 m/s. A note of the probe position and the measured velocity shall be made [see figure 12a)].

C.3.2 The probe shall then be traversed at intervals no greater than 100 mm back along the Z_c axis towards the (Y_c, Z_c) co-ordinate. At each position, the velocity shall be recorded and the traverse continued until at least four measurements have been made and the measured velocity has risen to more than 0,55 m/s [see figure 12b)].

C.3.3 This traversing procedure shall be repeated 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 12c)].

C.3.4 The procedure described in C.3.1.3.2 and C.3.3 shall be repeated at each of the Y_c and Z_c axes.

C.3.5 For each of the traverses, a plot shall be made of measured velocity versus position from which the point that corresponds to a velocity of 0,5 m/s shall be determined (see figure 13).

C.4 Determination of spread

A plot in the plane of the Y_c axis of the relevant points determined in C.3.4 and the throw shall be made and the best curve joining the points shall be drawn. The maximum width of the area bounded by the envelope curve in the direction parallel to face of the air terminal device shall be noted as the spread (see figure 14).

C.5 Determination of the rise and drop

A similar plot shall be made in the plane of the Z_c axes and the maximum vertical upward and downward distances between the envelope and a line perpendicular to the face of the air terminal device through its centre shall be noted as the rise and drop respectively (see figure 15).

C.6 Number of determinations

The procedure as described in clauses C.2 to C.5 shall be repeated for each test flow rate.

C.6.1 In cases of non-symmetrical jets, additional measurements shall be made in varying planes to determine the envelope velocities.

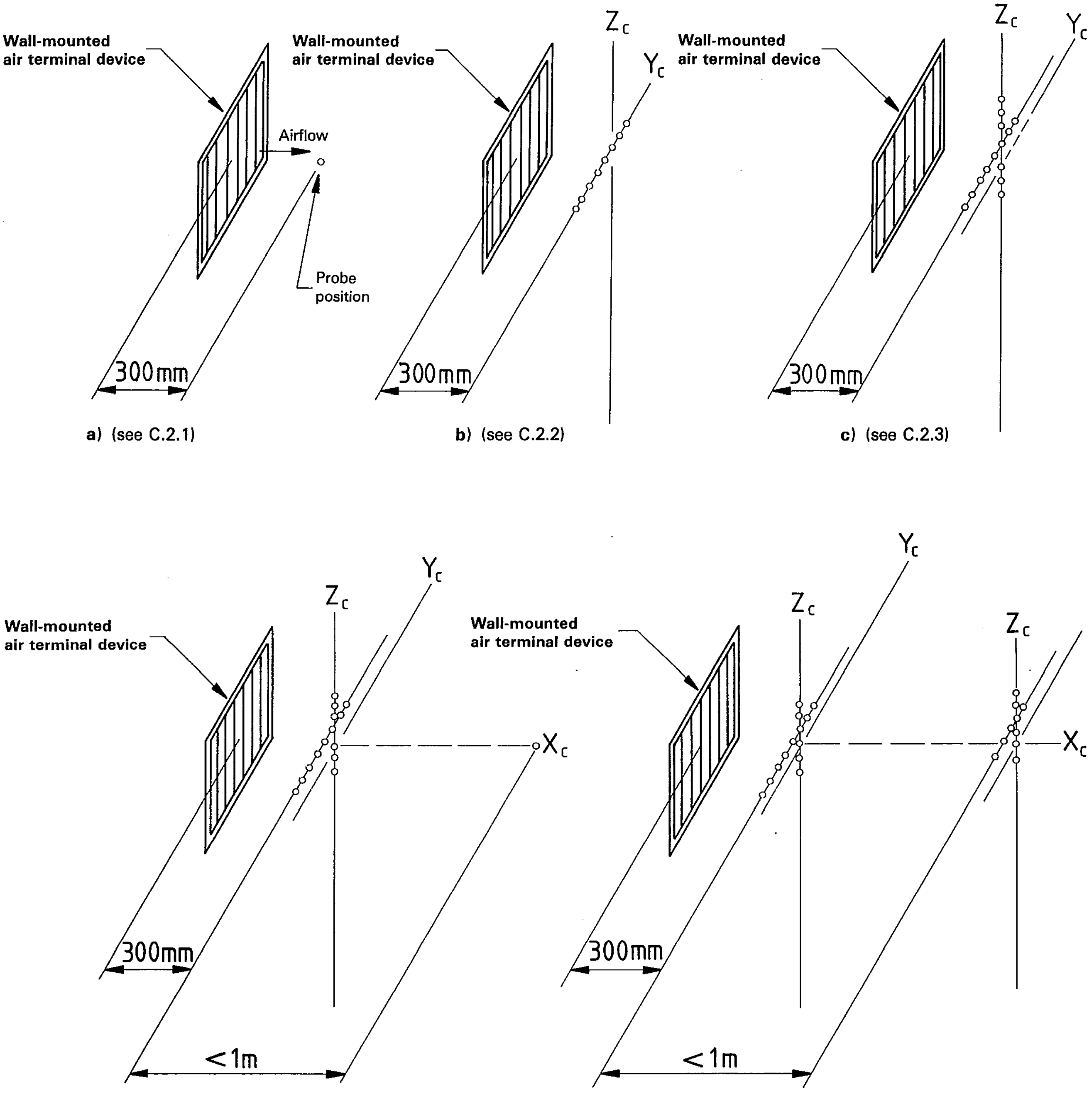
NOTE — The procedure covered in this annex is directly related to isothermal testing. It may equally well be used as a procedure for non-isothermal testing when the conditions appropriate to non-isothermal testing are included.

Table 2 — Vertical traverse interval

Dimensions in millimetres

Distance of probe sensing head below ceiling surface[1]	Maximum traverse interval
> 200	50
200 to 120	40
120 to 60	20
< 60	10

[1] Similar criteria should be used for air streams discharged close to and along other room surfaces.



a) (see C.2.1) **b)** (see C.2.2) **c)** (see C.2.3)

d) (see C.2.4) **e)** (see C.2.5)

Figure 10 — Determination of path of maximum velocity

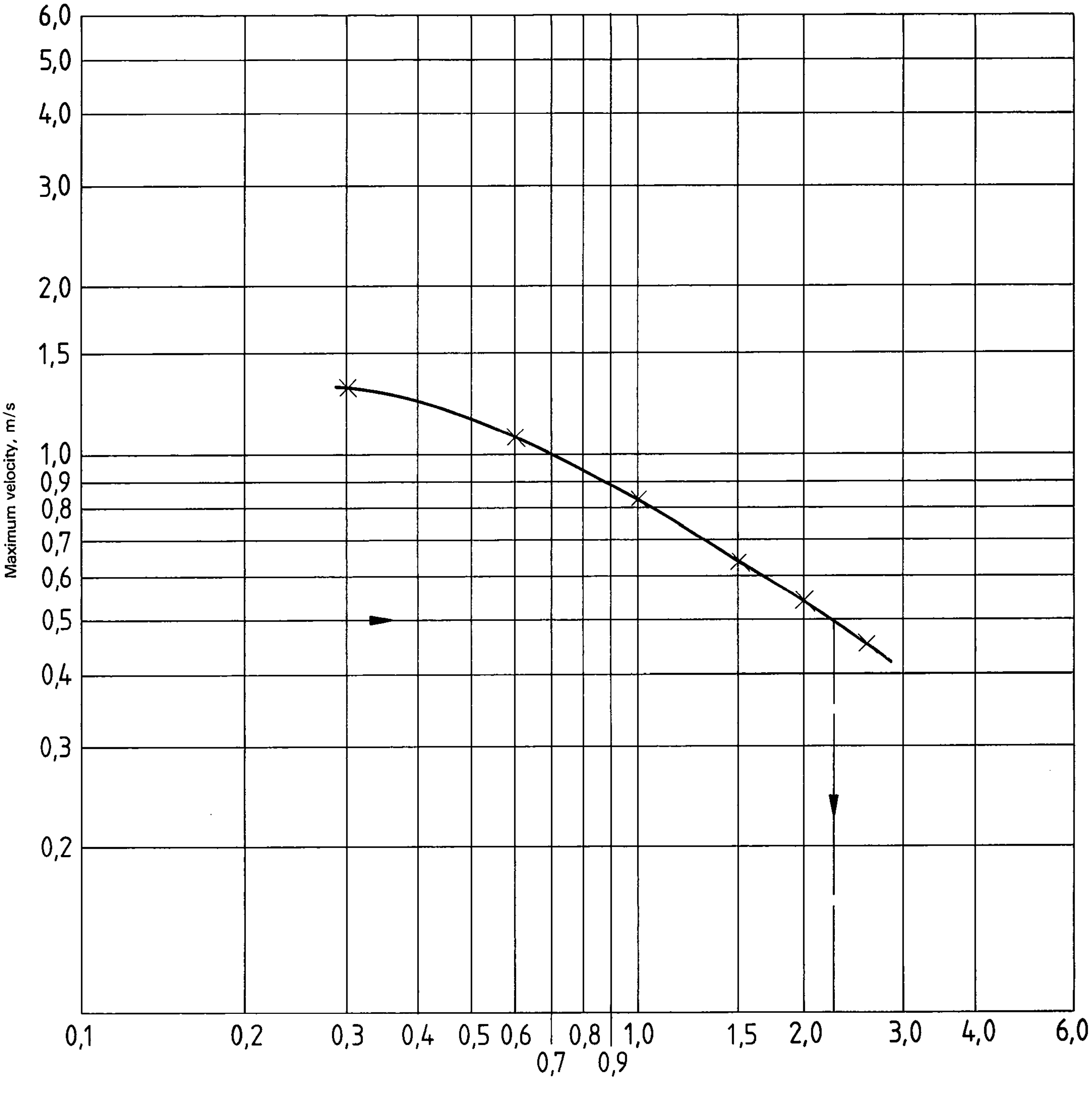


Figure 11 — Typical plot used in the determination of throw (see C.2.6)

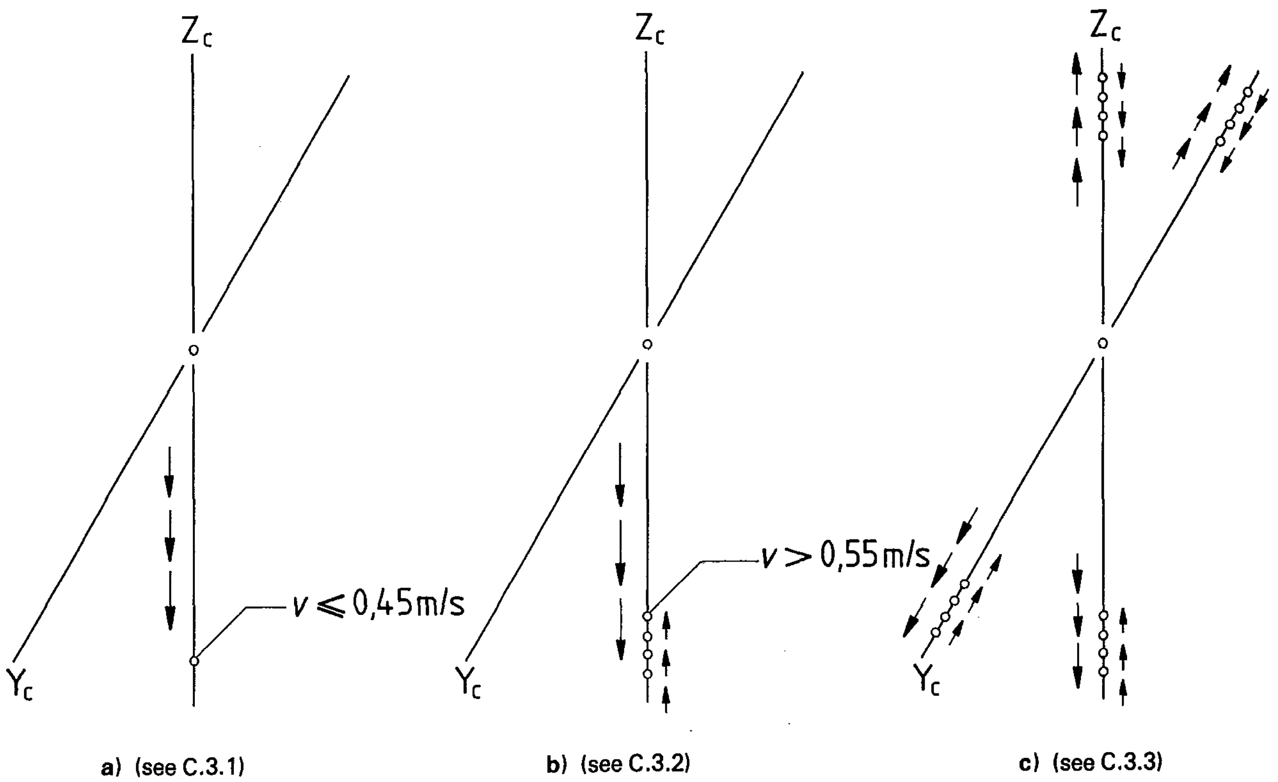


Figure 12 — Determination of envelope

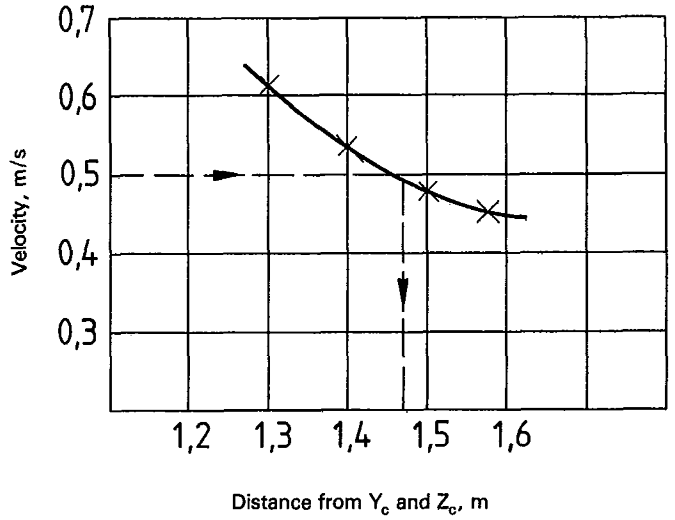


Figure 13 — Typical plot for determination of envelope location (see C.3.5)

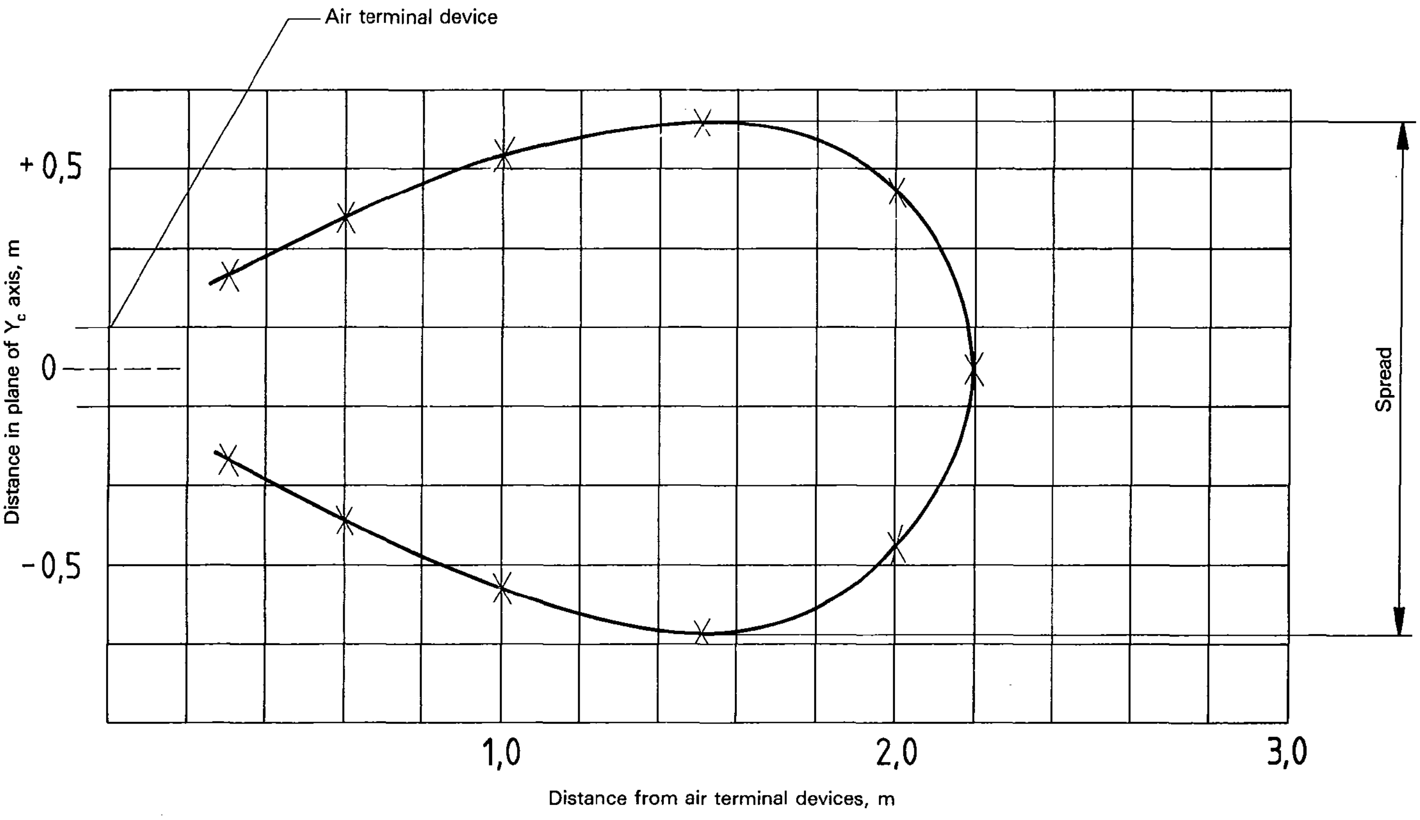


Figure 14 — Typical plot for determination of spread (see C.4)

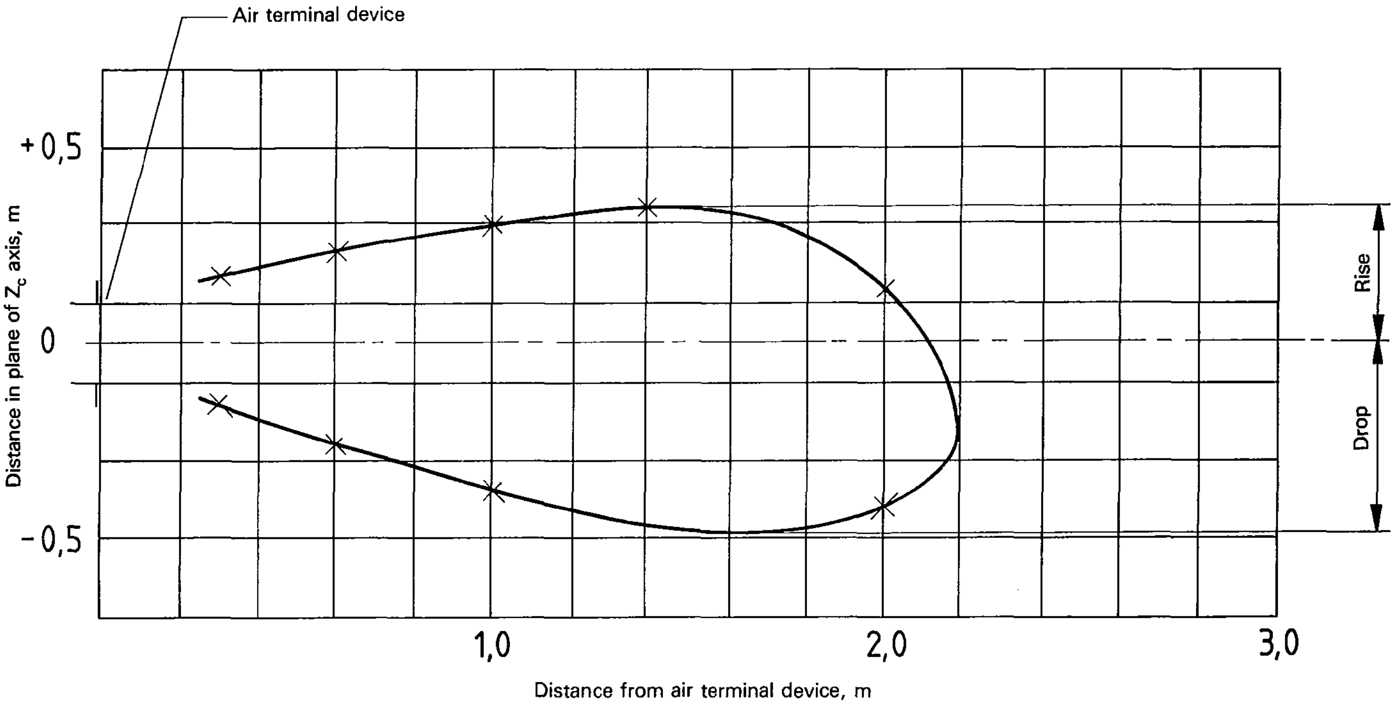


Figure 15 — Typical plot for determination of rise and drop (see C.5)