British Standard

BRITISH STANDARD

BS EN 13182:2002

Ventilation for buildings — Instrumentation requirements for air velocity measurements in ventilated spaces

The European Standard EN 13182:2002 has the status of a British Standard

ICS 23.120

British Standards

National foreword

This British Standard is the official English language version of EN 13182:2002.

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 international/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.

NOTE In preparing the EN for publication as a British Standard, it was noticed that there were typographical errors in the text. On page 7, in Figure 1, under the column headed "Upper response frequency" the figures "$\leq$ 1,0" and "1,0" should both read "$\geq$ 1,0". Similarly, on page 11, in Table 4, under the column headed "Upper response frequency", the figures "> 1,0 Hz" should both read "$\geq$ 1,0". These errors will be rectified in a future corrigendum.

Cross-references

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

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This British Standard, having been prepared under the direction of the Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 11 October 2002

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 19 cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 40564 8

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13182

April 2002

ICS 23.120

English version

Ventilation for buildings - Instrumentation requirements for air velocity measurements in ventilated spaces

Ventilation des bâtiments - Prescription d'instrumentation pour les mesures de vitesses d'air dans des espaces ventilés

Lüftung von Gebäuden - Gerätetechnische Anforderungen für Messungen der Luftgeschwindigkeit in belüfteten Räumen

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Ref. No. EN 13182:2002 E

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Foreword

This document EN 13182 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 October 2002, and conflicting national standards shall be withdrawn at the latest by October 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, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

European Standards exist which deal with the evaluation of local air velocity in ventilated spaces. This parameter is important in the assessment of comfort1). It is determined in the assessment of air terminal device performance in the laboratory1) and in the site situation (in a building) where comparisons are required in relation to specified values1) .

This standard provides a common basis for the instrumentation requirements for all the above applications.

The characteristics of instruments can vary according to their measuring and signal processing principles, their construction, and the way in which they are used. It is important that the users compare the quality of the instruments available in the market at any given time and a check is made that they conform to the requirements of this European Standard.

1 Scope

This European Standard specifies the main characteristics of air velocity measuring devices. This includes requirements for thermal velocity probes, recalibration and the signal processing of measurements in a ventilated space, including those in the air jet and in the occupied zone. Other types of velocity measuring devices should fulfil the performance parameters stated but appropriate calibration techniques should not necessarily be used which are described in this standard.

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, subsequent amendment 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 27726, *Thermal environments - Instruments and methods for measuring physical quantities (ISO 7726:1985).*

3 Terms, definitions and symbols

For the purposes of this European Standard the terms, definitions and symbols in CR 12792 apply together with those given in Table 1.

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1) See Bibliography.

Table 1 – Symbols

Symbol	Quantity	Unit
f	Frequency	Hz
f_{up}	Upper frequency	Hz
N	Total number of samples	
n	Speed of rotation	$rad \cdot s^{-1}$
n_r	Sampling rate	s^{-1}
Δp	Pressure drop	Pa
R	Radius	m
s_v	Standard deviation of velocity	$m \cdot s^{-1}$
T_u	Turbulence intensity	%
θ	Air temperature	°C
U	Output signal	V
U_v	Output signal of velocity	V
U_t	Output signal of temperature	V
v	Air velocity	$m \cdot s^{-1}$
$\overline{v}$	mean air velocity	$m \cdot s^{-1}$
v_i	Instantaneous air velocity	$m \cdot s^{-1}$
v_o	Reference air velocity	$m \cdot s^{-1}$
v_α	Air velocity reading at yaw angle	$m \cdot s^{-1}$
v_β	Air velocity reading at roll angle	$m \cdot s^{-1}$
v_{true}	True air velocity	$m \cdot s^{-1}$
Δv	Deviation of air velocity	$m \cdot s^{-1}$
α	Angle of yaw	°
β	Rotational angle (roll angle)	°
τ	Time	s

4 Main characteristics of air flow patterns

4.1 General

In ventilated spaces, there are three main zones of interest (see Figure 1), depending on the air flow distribution. Table 2 shows the range of flow characteristics, which can occur in the zones as specified in 4.2, 4.3, and 4.4.

Table 2 – Main characteristics of air flow patterns

Zone	**Range of mean air Velocity** $\bar{v}$ $m \cdot s^{-1}$	**Turbulence intensity** T_u %	**Frequency** f Hz	**Temperature range** θ °C	**Main flow direction**
A (jet)	0,3 to 10,0	10 to 50	≤ 3	10 to 50	unidirectional
B (jet)	0,1 to 0,5	5 to 50	≤ 1	15 to 25	unidirectional
C (occupied zone)	0,1 to 0,5	20 to 80	≤ 1	18 to 35	omnidirectional

4.2 Zone A

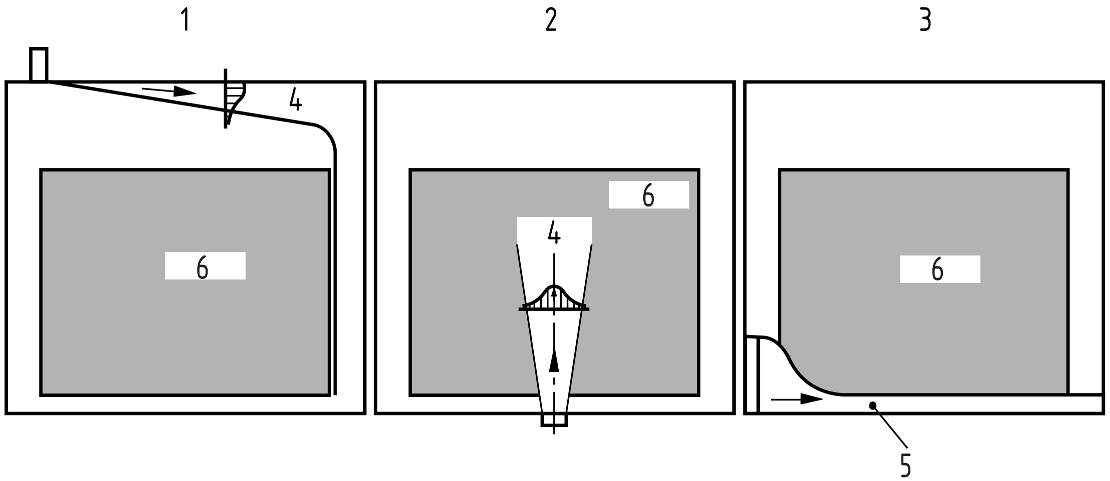
The area within the supply air jet in a mixed air flow application.

4.3 Zone B

The area within the supply air stream in an application using low velocity air terminal devices (for example; displacement ventilation).

4.4 Zone C

The occupied zone area within ventilated spaces (see prEN 13779).



Key

1	Mixed air flow – Ceiling air terminal device	4	Zone A
2	Mixed air flow – Floor air terminal device	5	Zone B
3	Displacement air flow	6	Zone C

	Main characteristics of air flow pattern					Parameter of interest		Requirements for velocity probe				Signal processing requirements	
Zone	Velocity range	Turbulence intensity	Frequency	Temperature range	Main flow direction	Mean velocity	Turbulence intensity	Instantaneous velocity range	Temperature range	Upper response frequency	Direction sensitivity minimum requirements[a]	Measuring period	Sampling Rate
		T_u	f	θ		$\bar{v}$	T_u	v	θ	f_{up}			n_r
	$m \cdot s^{-1}$	%	Hz	°C		$m \cdot s^{-1}$	%	$m \cdot s^{-1}$	°C	Hz		s	$l \cdot s^{-1}$
A (Jet)	0,3 to 10	10 to 50	$\leq 3,0$	10 to 50	uni-directional	yes	no	0,25 to 12	10 to 50	N/A[b]	uni-directional	≥ 60	≥ 1
B (Jet)	0,1 to 0,5	5 to 50	$\leq 1,0$	15 to 25	uni-directional	yes	yes	0,05 to 1,0	15 to 25	$\leq$ 1,0	uni-directional	≥ 180	≥ 5
C (Occupied zone)	0,1 to 0,5	20 to 80	$\leq 1,0$	18 to 35	omni-directional	yes	yes	0,05 to 1,0	18 to 35	1,0	omni-directional	≥ 180	≥ 5

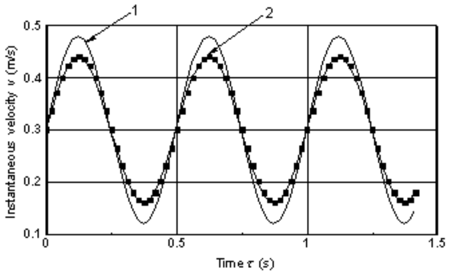
[a] Using flow visualisation to establish flow direction in all zones, two- dimensional or response sensors can be used.

[b] N/A - Not applicable because in Zone A only the mean velocity is of interest - not turbulence intensity

Figure 1 – Main characteristics of air flow and requirements of low velocity measuring instruments

5 Relevant parameters

The main relevant parameters applicable to ventilated spaces are given in Table 3.

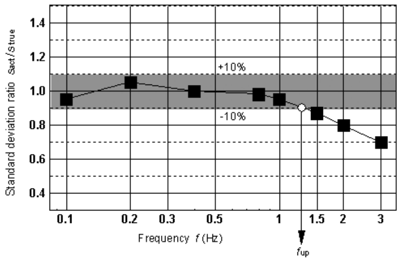


Key

1 True velocity

2 Actual velocity

Figure 2 – Example of velocity records at *f* = 2 Hz used to define the upper frequency



Key

S_{act} is the actual standard deviation of the velocity measured by the tested probe
S_{true} is the standard deviation of the velocity measured by the reference instrument

Figure 3 – Example of dynamic response curve to define the upper frequency f_{up}

Table 3 – Parameters

Zone	Mean velocity $\bar{v}$	Turbulence intensity T_u
A (Jet)	yes	no
B (Jet)	yes	yes
C (Occupied zone)	yes	yes

6 Requirements for velocity probe

6.1 Velocity and temperature range

The values for the instrument velocity range and temperature are given in Table 4.

6.2 Upper response frequency limit

The upper response frequency limit is defined as the highest frequency of sinusoidal velocity fluctuations up to which the anemometer shall be able to measure the standard deviation of the air velocity with an accuracy of ± 10 % (see 7.4 for turbulence intensity in the range of 40 % to 60 %, see also 7.5 and Figure 2).

Alternatively, the standard deviation ratio, which is the standard deviation of the velocity measured by the tested anemometer divided by the actual standard deviation of the velocity calculated or measured by a reference instrument under identical flow conditions, can be used. The standard deviation ratio can be higher or lower than 1 depending on the electrical design of the tested anemometer. The achievement of an accuracy of ± 10 % implies a standard deviation ratio of between 0,9 and 1,1 (see Figure 3).

6.3 Directional sensitivity

The extremes of instrument directional sensitivity are described as follows:

A uni-directional probe has a sensor which has a strong directional sensitivity and does not respond to flows in all directions.

An omni-directional probe will respond to flow from virtually any direction.

The directional sensitivity is investigated by measuring the velocity as a function of angle of attack and the investigation is carried out as described below.

The roll characteristics are obtained by rotation of the probe about the stem axis (see Figure 4).

The yaw characteristics are obtained by tilting the stem axis of the probe about its centre (see Figure 5).

Both the roll and yaw characteristics of the probes shall be specified.

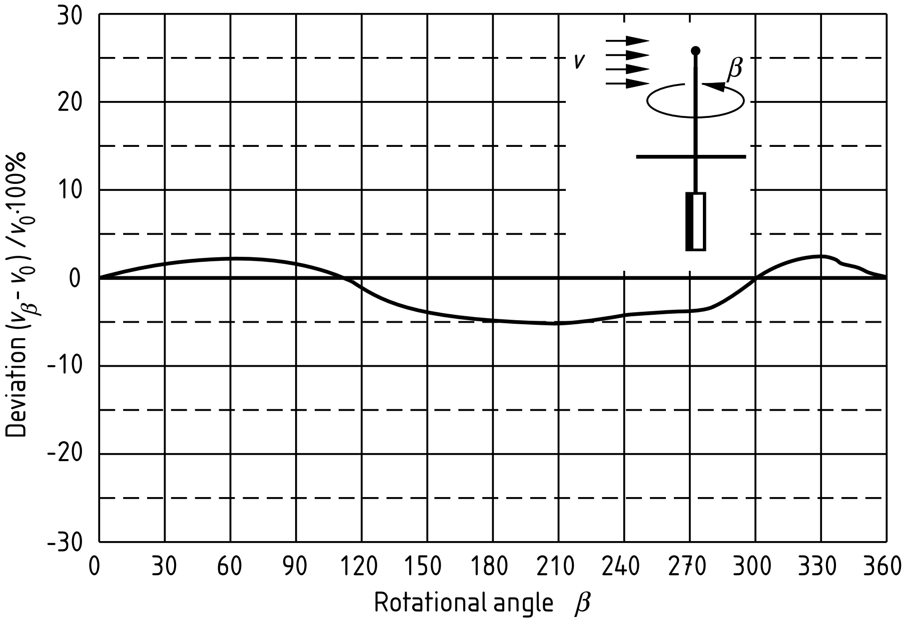


Figure 4 – Example of directional sensitivity (Roll characteristic)

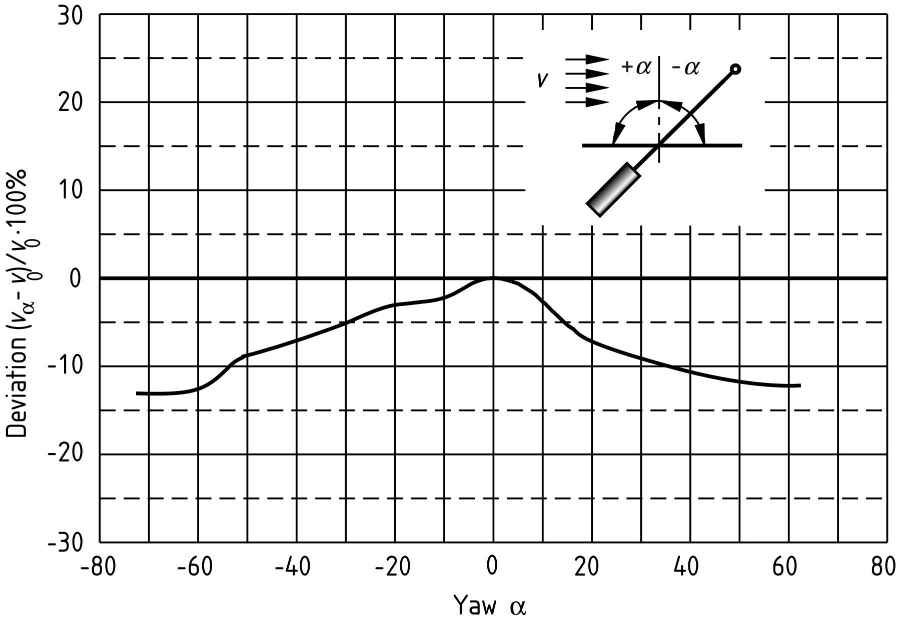


Figure 5 – Example for directional sensitivity (Yaw characteristic)

The requirements for velocity probes are given in Table 4.

Table 4 – Requirements for Velocity Probes

Zone	**Instantaneous velocity range** v_i $\mathrm{m \cdot s^{-1}}$	**Temperature range** θ °C	**Upper response frequency** f_up Hz	**Directional sensitivity**[a] **(minimum requirement)**
A **(Jet)**	0,25 to 12	10 to 50	N/A[b]	uni-directional
B **(Jet)**	0,05 to 1,0	15 to 25	> 1 Hz	uni-directional
C **(Occupied zone)**	0,05 to 1,0	18 to 35	>1 Hz	omni-directional

[a] Using flow visualisation to establish flow direction in all zones two-dimensional or plannar response sensors can be used.

[b] NA - Not applicable because in Zone A only mean velocity is of interest not turbulence intensity.

6.4 Influence of natural convection

Thermal velocity probes are influenced by the flow direction in relation to the direction of buoyancy resulting from natural convection.

The manufacturer shall specify the signal deviations from the true value for the following conditions:

a) probe horizontal, flow vertically down;

b) probe horizontal, flow vertically up;

c) probe vertical, flow horizontal.

The above values shall be specified in the range of 0,05 $\mathrm{m \cdot s^{-1}}$ to 0,25 $\mathrm{m \cdot s^{-1}}$ at intervals of approximately 0,05 $\mathrm{m \cdot s^{-1}}$ (see Figure 4), for use in Zones B and C.

6.5 Influence of ambient air temperature

The ambient temperature influences the output of a thermal sensor, and it may also influence some other types of sensor. Compensation for this shall be applied by one of the following:

a) automatically within the probe system, in which case the manufacturer shall specify the temperature range over which the compensation is applicable;

b) manually to the recording signals in which case the manufacturer shall supply details of the temperature at which the calibration was undertaken and the method to correct for temperature deviation effect on measured velocity. It is important to note, that this will also be a function of velocity value.

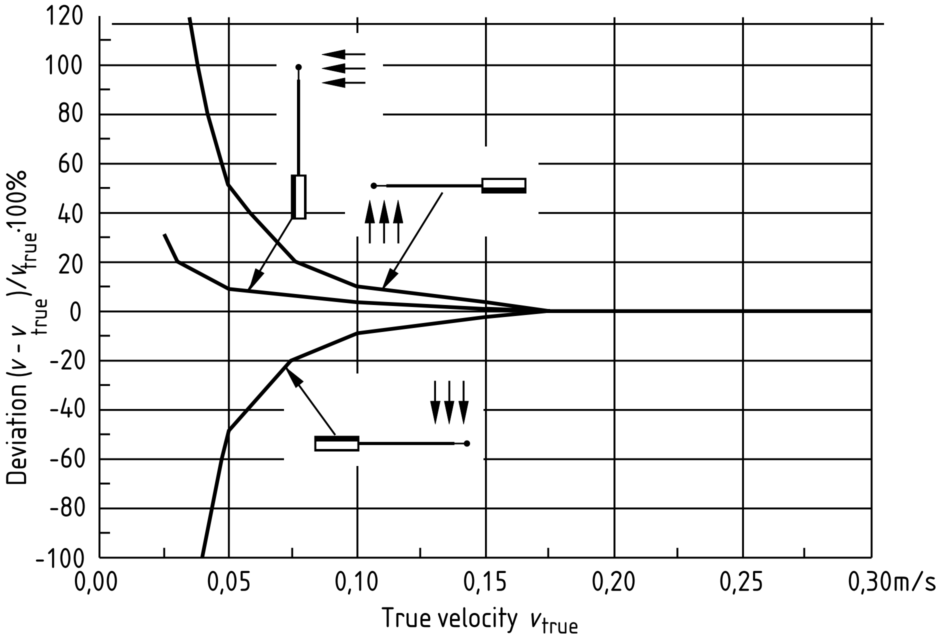


Figure 6 – Example of influence from natural convection

6.6 Influence of air density

The ambient air density influences the output of a thermal sensor, and it can also influence some other types of sensor. Compensation for this shall be applied by one of the following:

a) automatically within the probe system in which case the manufacturer shall specify the density range over which the compensation is applicable;

b) manually to the recording signals in which case the manufacturer shall supply details of the density at which the calibration was undertaken and the method to correct for density deviation effect on measured velocity. It is important to note, that this will also be a function of velocity value.

6.7 Dimensions

The measurement of velocities can involve exploration of velocities in areas with high velocity and temperature gradients and this can place restrictions on the size of the sensing head.

Both the temperature compensation sensor and the velocity sensor shall be situated in the flow field such that both sensors are at an equal temperature.

7 Signal processing requirements for air velocity measurements

7.1 General

Examples of low velocity measuring devices are shown in Figure 7.

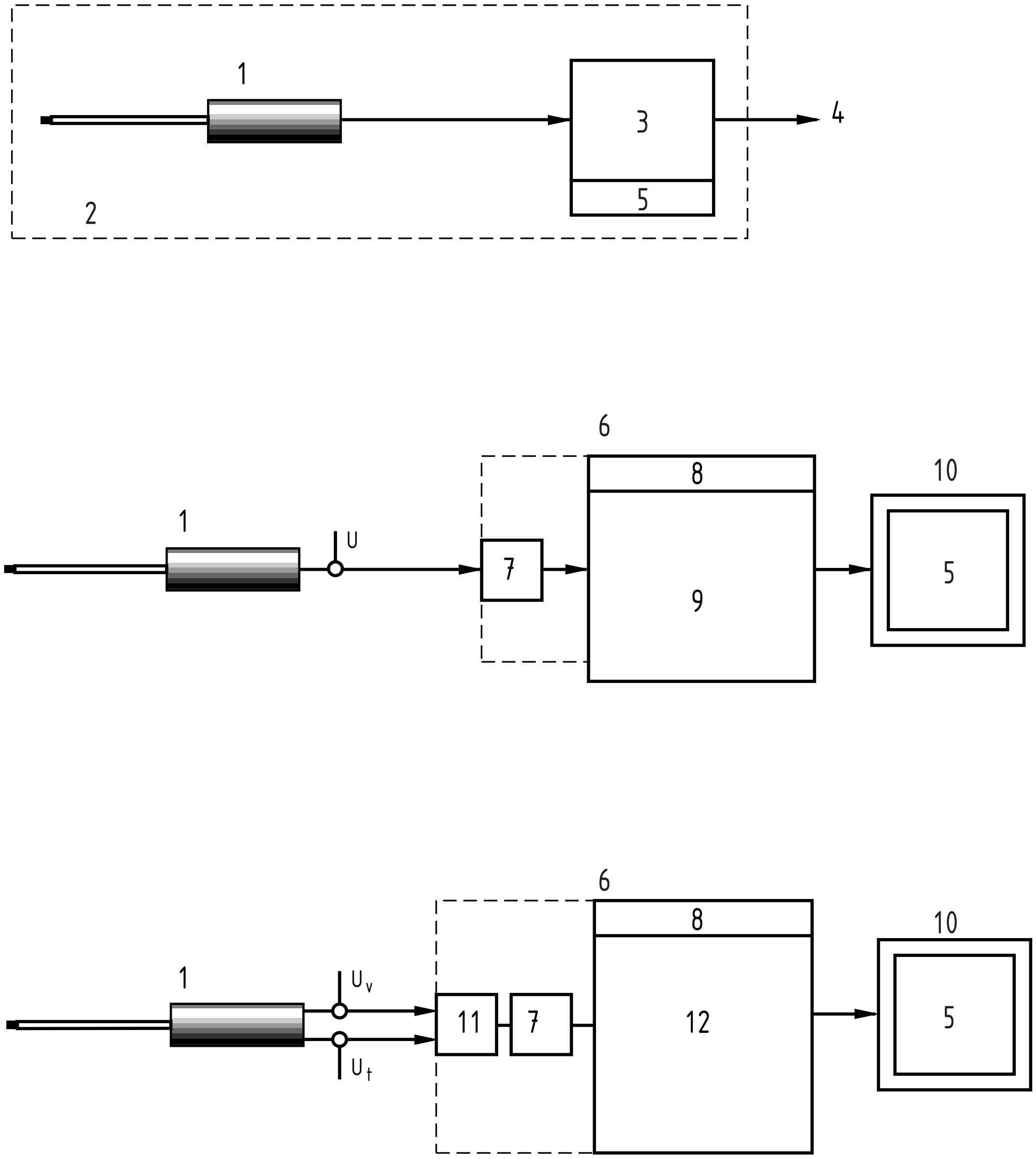
It is recommended, that devices with an integral analyser have an additional analogue output for graphical presentation and/or further signal processing.

7.2 Sampling rate and measuring period

To obtain representative mean velocity and turbulence intensity values, it is necessary to analyse the instantaneous velocity values during a minimum measuring period with a minimum sampling rate as given in Table 5.

Table 5 – Signal processing requirements

Zone	**Measuring period** s	**Sampling rate (n_r)** s^{-1}
A [a] (Jet)	≥ 60[a]	≥ 1 [a]
B (Jet)	≥ 180	≥ 5
C (Occupied zone)	≥ 180	≥ 5
[a] Requirements for Zone A differ from Zones B and C because in Zone A only mean velocity is of interest.		



Key

1	Velocity probe	7	Analogue/Digital converter
2	One equipment – one supplier	8	Program
3	Analyser [black box]	9	$v = f(U)\,\mathrm{Lin}, \quad \overline{v} = \frac{1}{N}\sum v, \quad s_v = \sqrt{\frac{1}{N-1}\sum\left(v-\overline{v}\right)^2}, \quad T_U = \frac{s_v}{\overline{v}}\cdot 100\,\%$
4	Output signal $U = f(v)$	10	Monitor
5	$\overline{v}$ T_U	11	Multiplexer
6	Microprocessor [computer]	12	$U_R = f\left(U_v\,;U_t\right), \quad v = f\left(U_R\right)\,\mathrm{Lin},$ $\overline{v} = \frac{1}{N}\sum v, \quad s_v = \sqrt{\frac{1}{N-1}\sum\left(v-\overline{v}\right)^2}, \quad T_U = \frac{s_v}{\overline{v}}\cdot 100\,\%$

Figure 7 – Example of low velocity measuring devices

7.3 Determination of mean value

The mean air velocity is given by:

$$\bar{v} = \frac{1}{N}\sum_{i=1}^{N} v_i$$

7.4 Determination of standard deviation

The standard deviation of air velocity is given by:

$$s_v = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(v_i - \bar{v}\right)^2}$$

7.5 Determination of turbulence intensity

The turbulence intensity is given by:

$$T_u = \frac{s_v}{\bar{v}} \cdot 100 \quad \%$$

8 Calibration

8.1 Instrument manufacturers

8.1.1 General

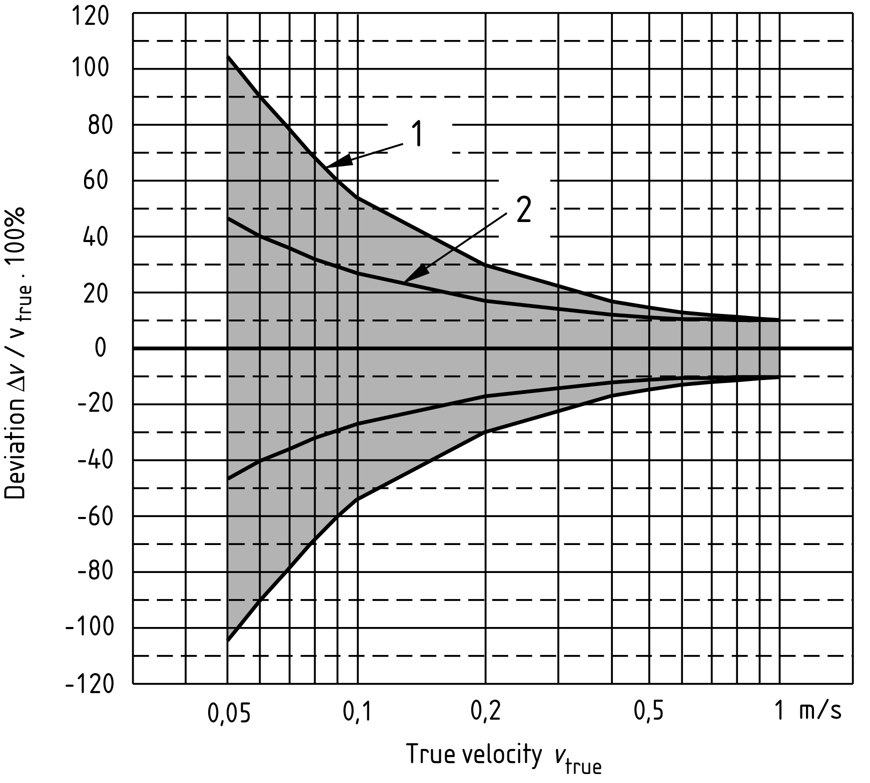
All air velocity measuring devices have important characteristics, which depend on the design of the device, the geometrical shape of the measuring probe and the actual measurement principle used. These main characteristics usually do not change with time and should consequently be established by the manufacturer.

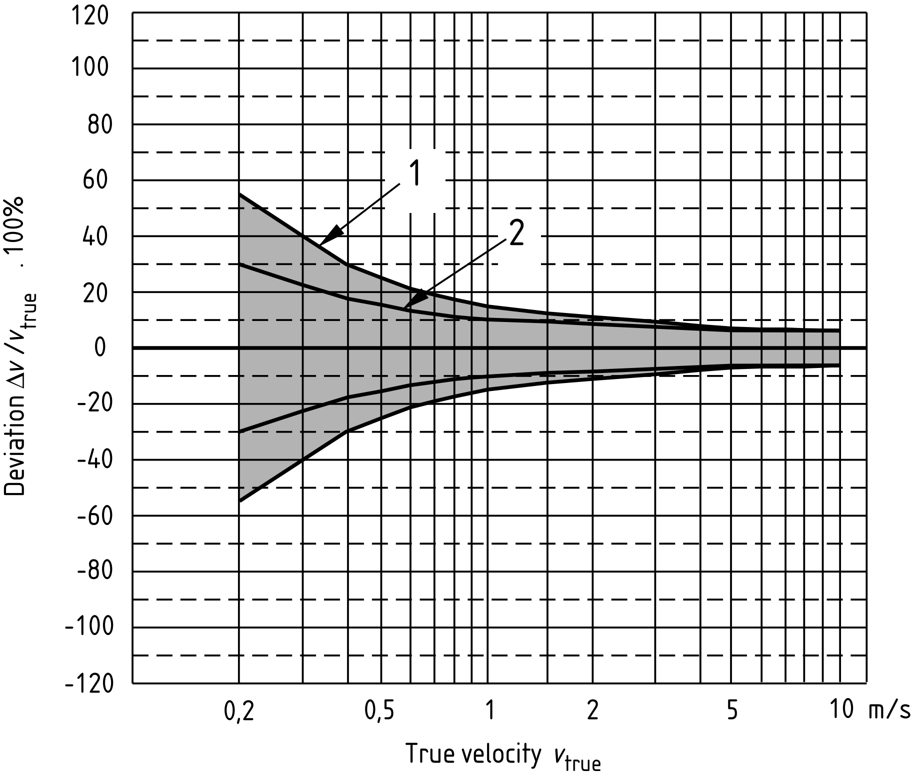
The manufacturer shall issue a certificate of calibration and full specification details to cover all characteristics that influence measurements.

8.1.2 Accuracy

A summary of different sources of inaccuracy shall be given to provide the overall accuracy for the whole measuring range of the instrument.

The manufacturer’s documentation shall record this information which shall be in accordance with EN 27726 (see Figure 8).





Key

1 Maximum deviation

2 Desirable deviation

Figure 8 – Accuracy definition according to EN 27726

8.2 Recalibration by the user

The relationship between the air velocity and the output signal of the device shall be recalibrated regularly by the user. It is recommended for thermal anemometers that re-calibration is undertaken every 6 months.

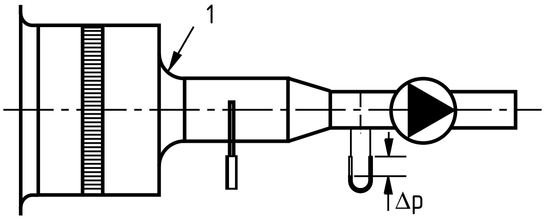
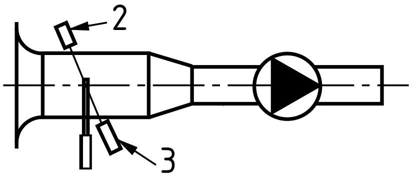
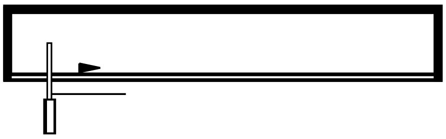
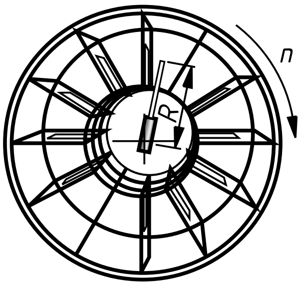
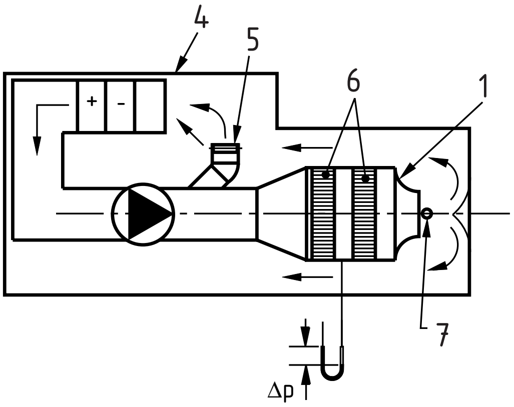
A recalibration shall be performed in an airstream with a known velocity or by generating a known relative velocity between the sensor and the air.

Calibration devices can need calibration themselves, which can be done by using velocity transducers which are accepted as reference standards. Such transducers are Prandtl tubes and Laser-Doppler anemometers. Pitot static or Prandtl tubes can be used to a minimum velocity of 2,5 $m \cdot s^{-1}$. Laser-Doppler anemometers can be used to a minimum velocity of 0,05 $m \cdot s^{-1}$.

For very low velocities one option is to move the velocity probe in a tank with still air, another is to have a stationary probe and a moving tank with still air.

For example low velocity air streams can be measured using an anemometer calibrated by moving it in a tank with still air.

Some examples of velocity calibration devices are given in Figure 9.

	Velocity reference	**Remarks**
 **a) Wind tunnel with flow meter**	$v = f(\Delta p; Corr.)$ where Δp is obtained from the flowmeter and *Corr.* is obtained from the velocity profile	The influence of the boundary layer and the velocity profile shall be taken into account by pre-measurements
 **b) Wind tunnel with laser anemometer**	$v = v_{Laser}$	
 **c) Moving probe**	$v = v_{Probe\ movement}$	The duct length depends on the probe time constant
 **d) Wind wheel**	$v = f(n; R)$ where *n* is the rotational speed of the wheel, and *R*. is the radius [i.e. the distance from the centre of the wheel to the probe sensor].	
 **e) Wind tunnel with calibration chamber**	$v = f(\Delta p; Corr.)$	

Key

1	Nozzle creating uniform velocity profile	5	Damper for recirculation
2	Detector	6	Flow straightener
3	Laser	7	Calibration point
4	Closed chamber		

Figure 9 – Examples of velocity calibration devices

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prEN 13142, *Ventilation for buildings – Components/products for residential ventilation – Required and optional performance characteristics.*

EN 12599, *Ventilation for buildings - Test procedures and measuring methods for handing over installed ventilation and air conditioning systems.*

prEN 13779, *Ventilation for buildings – Performance requirements for ventilation and air-conditioning systems.*

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