



BSI Standards Publication

Ventilation for buildings — Measurement of air flow rates on site — Methods

National foreword

This British Standard is the UK implementation of EN 16211:2024. It supersedes BS EN 16211:2015, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/2, Ventilation for buildings, heating and hot water services.

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

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European foreword

This document (EN 16211:2024) 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of an identical text or by endorsement, at the latest by May 2025, and conflicting national standards shall be withdrawn at the latest by May 2025.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 16211:2015.

In addition to a number of editorial revisions, the main changes compared with EN 16211:2015 are as follows:

- the whole document has been rearranged;
- the method described previously in EN 12599:2012 to measure air (volume) flow rate in ductwork has been included;
- the tracer gas method has been moved in Annex A (informative);
- two new methods to measure air flow rate at exhaust and intake grille have been added in Annex A (informative);
- parts dealing with uncertainty have been replaced by Annex B (informative);
- requirements on measuring devices are now expressed in MPME (maximum permissible measurement error).

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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Introduction

Measurement of the air (volume) flow rate in a ventilation system is of general interest that is not related to a specific operation or stage (e.g. installation, inspection, commissioning or handover). It was therefore agreed to take advantage of the simultaneous revision of EN 16211:2015 and EN 12599:2012 to address this subject in a single document (EN 16211:2024) rather than scattering or repeating it in various documents.

In this document, all types of measurements are air (volume) flow rate. For the sake of readability, the term "air (volume) flow rate" is replaced in the text by the contracted term "air flow rate".

1 Scope

This document specifies methods for the measurement of air flow rates on site. It provides a description of the air flow rate measurement methods and how measurements are performed within the margins of stipulated method uncertainties. It gives the necessary measurement conditions (e.g. length of straight duct, uniform velocity profile) to achieve the stipulated measurement uncertainties.

The methods for measuring the air flow rate inside ducts do not apply to:

- ducts that are not circular or rectangular (e.g. oblong ducts);
- flexible ducts.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12792, *Ventilation for buildings — Symbols, terminology and graphical symbols*

EN 14277, *Ventilation for buildings — Air terminal devices — Method for airflow measurement by calibrated sensors in or close to ATD/plenum boxes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12792 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp/>

3.1

measuring interval

set of values of quantities of the same kind that can be measured by a given measuring instrument or measuring system with specified instrumental measurement uncertainty, under defined conditions

Note 1 to entry: In some fields, the term is “measuring range” or “measurement range”.

[SOURCE: JCGM 200:2012, 4.7, modified – Note 2 has not been reproduced.]

3.2

maximum permissible measurement error

extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument or measuring system

Note 1 to entry: More information on the calculation of the measurement uncertainty based on the maximum permissible measurement error is given in Annex B.

[SOURCE: JCGM 200:2012, 4.26, modified – The accepted terms “maximum permissible error” and “limit of error” have been removed, NOTE 1 and NOTE 2 have been removed, a Note 1 to entry has been added.]

3.3**standard uncertainty**

measurement uncertainty expressed as a standard deviation

Note 1 to entry: More information on the use of standard uncertainty in measurement uncertainty is given in Annex B.

[SOURCE: JCGM 200:2012, 2.30, modified – The preferred term and the first accepted term have been removed and a Note 1 to entry has been added.]

3.4**calibration**

operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

[SOURCE: JCGM 200:2012, 2.39, modified — NOTE 1 and NOTE 2 have been removed.]

3.5**correction**

compensation for an estimated systematic effect

[SOURCE: JCGM 200:2012, 2.53, modified — NOTE 1 and NOTE 2 have been removed.]

3.6**hypothetical**

<value> obtained by making hypothesis on the existing conditions

3.7**dynamic pressure**

velocity pressure

pressure equivalent of the kinetic energy of the fluid at a point

3.8**static pressure**

pressure exerted, in a moving fluid, on an element moving at the same velocity as the fluid

3.9**total pressure**

sum of *static pressure* (3.8) and *dynamic pressure* (3.7) at any point of a fluid

4 Symbols and abbreviated terms

For the purposes of this document, the symbols given in Table 1 and the abbreviated terms given in Table 2 apply.

Table 1 — Symbols

Symbol	Description	Unit
a, b, c, d, e, f	Dimensions of length	mm
a/D_h	Relative distance	—
A	Cross-section area	m ² , mm ²
A_g	Effective cross-section area of the probe	m ² , mm ²
C_i	Initial tracer gas concentration	cm ³ /m ³
C_s	Tracer gas concentration in the sampling cross-section	cm ³ /m ³
D	Diameter	mm
D_h	Hydraulic diameter	mm
D_i	Diameter of the centroidal ring of the annulus	mm
D_{so}	Probe diameter	mm
e	Device's flow exponent given by the manufacturer (usually 0,5)	—
H	Height of the duct	mm
i	Ordinal number	—
I	Irregularity of the velocity profile	%
k (k -factor)	Characteristic of the fixed device depending on its setting	—
K	Coverage factor	—
K	Correction factor (for method IN2 and EX2)	—
k_1	Correction factor for density	—
k_2	Correction factor for duct shape	—
L	Length of head of the pitot static tube	mm
L	Mixing length for the tracer gas	mm
L_1	Smaller dimension of a rectangular duct cross section	mm
L_2	Larger dimension of a rectangular duct cross section	mm
n	Number	—
n_{L1}	Number of measuring points along the smaller dimension	—
n_{L2}	Number of measuring points along the larger dimension	—
p_{atm}	Atmospheric pressure	Pa
$p_{atm,act}$	Atmospheric pressure in actual conditions	Pa
$p_{atm,hyp}$	Atmospheric pressure in device hypothetical condition	Pa
$p_{atm,std}$	Atmospheric pressure in standardized conditions (101 325 Pa)	Pa
p_d	Dynamic pressure	Pa
p_s	Static pressure	Pa

Symbol	Description	Unit
p_t	Total pressure	Pa
P	Perimeter of the cross-section	m, mm
q	Air flow rate	m ³ /s, m ³ /h, l/s
q_s	Tracer gas flow rate	m ³ /s, m ³ /h, l/s
$q_{s\theta\text{duct}}$	Tracer gas flow rate at duct temperature	m ³ /s, m ³ /h, l/s
$q_{s\theta\text{tracer}}$	Tracer gas flow rate at rotameter temperature	m ³ /s, m ³ /h, l/s
$q_{v,\text{act}}$	Actual air flow rate (in actual conditions)	m ³ /s, m ³ /h, l/s
$q_{v,\text{hyp}}$	Hypothetical air flow rate assuming device default conditions	m ³ /s, m ³ /h, l/s
$q_{v,m}$	Measured air flow rate	m ³ /s, m ³ /h, l/s
$q_{v,\text{std}}$	Standardized air flow rate (in standard conditions)	m ³ /s, m ³ /h, l/s
t	Time	s
T_{act}	Air temperature in actual conditions	K
T_{hyp}	Air temperature in device default condition	K
T_{std}	Air temperature in standardized conditions (293,15 K)	K
u	Standard uncertainty	—
u_c	Combined standard uncertainty	—
U	Expanded uncertainty	—
v	Air velocity	m/s
v_{act}	Actual air velocity	m/s
v_g	Air velocity reading	m/s
v_k	Air velocity for measuring point k	m/s
v_m	Average air velocity	m/s
v_{max}	Maximum of the arithmetic mean of velocities in a quarter of the cross-section or at a radius	m/s
v_{min}	Minimum of the arithmetic mean of velocities in a quarter of the cross-section or at a radius	m/s
v_q	Air velocity for a given quarter	m/s
v_r	Air velocity for a given radius	m/s
V	Volume of the measuring bag	m ³
W	Width of the duct	mm
x_i	Distance from the duct wall	mm
y_i	Distance from the duct wall	mm
Δl	Tolerance for the probe location	mm
Δp	Measured pressure difference	Pa
θ_{act}	Air temperature in actual conditions ($= T_{\text{act}} - 273,15$)	°C

Symbol	Description	Unit
ρ	Air density	kg/m ³
ρ_{act}	Air density in actual conditions	kg/m ³
ρ_{hyp}	Air density in device default condition	kg/m ³
ρ_{std}	Air density in standardized conditions	kg/m ³
$\rho_{\vartheta_{duct}}$	Air density at the temperature inside the duct	kg/m ³
$\rho_{\vartheta_{tracer}}$	Air density at the temperature of tracer gas	kg/m ³
ϑ	Temperature of air	°C
ϑ_{duct}	Temperature inside the duct	°C
ϑ_{tracer}	Temperature of tracer gas	°C

Table 2 — Abbreviated terms

Abbreviated terms	Description
ATD	Air terminal devices
MPME	Maximum permissible measurement error
RH	Relative humidity of the air

5 Expression of air flow rate and parameters of influence

5.1 Hydraulic diameter

The hydraulic diameter, D_h , is the diameter of a circular duct which causes the same pressure drop, at equal air velocity and equal roughness factor, than the considered duct and is defined by Formula (1).

$$D_h = 4 \cdot \frac{A}{P}$$

(1)

where

- A is the area of the cross-section, in mm²;
- P is the perimeter of the cross-section, in mm.

For a rectangular duct, Formula (1) becomes Formula (2).

$$D_h = 2 \cdot \frac{L_1 \cdot L_2}{(L_1 + L_2)}$$

(2)

where

- L_1 is the smaller dimension of the rectangular duct, in mm;
- L_2 is the larger dimension of the rectangular duct, in mm.

For a circular duct, Formula (1) becomes Formula (3).

$$D_h = D \quad (3)$$

5.2 Flow disturbances

Within an air flow, disturbances result in irregular velocity profiles. Irregular velocity profile can induce additional measurement errors and complicate the measurement. Away from any disturbance the velocity profile gets more and more regular. For some methods, requirements are set regarding the position of the measurement device from flow disturbances.

NOTE Flow seldom has a symmetrical appearance except after long straight sections. The symmetry is often disturbed by varying resistance, for example after a bend, an area decrease or an area increase. The velocity profile also becomes disturbed by singularities such as damper and branch as well as before and after a fan.

5.3 Stability of the air flow rate

Measurement methods described in this document are based on the assumption that the air flow rate does not change during the measurement time.

NOTE Variation of the air flow rate increases the measurement uncertainty.

5.4 Air density

The density of dry air, ρ , varies with atmospheric pressure and temperature in accordance with Formula (4).

$$\rho = 1,293 \cdot \frac{p_{\text{atm}}}{101\,325} \cdot \frac{273,15}{273,15 + \vartheta} \quad (4)$$

where

p_{atm} is the atmospheric pressure, in Pa;

ϑ is the temperature of the air, in °C.

The relative humidity of the air (RH) has very little influence on the density of air at room temperature. The density of air at 20 °C and 101 325 Pa which is saturated with water vapour is only approximately 1 % less than equivalent dry air.

If the static pressure of the ventilation system is above about 2 000 Pa, the influence of the static pressure on air density should be considered and the calculation is then performed using Formula (5).

$$\rho = 1,293 \cdot \frac{p_{\text{atm}} + p_s}{101\,325} \cdot \frac{273,15}{273,15 + \vartheta} \quad (5)$$

where

p_s is the static pressure in the ductwork, in Pa.

5.5 Conversion of dynamic pressure into air velocity

Dynamic pressure within an air flow can be measured with a Pitot static tube connected to a manometer (see Figure 1 in 6.4.3).

Air velocity can be calculated from dynamic pressure using Formula (6).

$$v_{\text{act}} = \sqrt{\frac{2p_d}{\rho_{\text{act}}}} \quad (6)$$

where

- v_{act} is the actual air velocity (in prevailing conditions);
- p_d is the dynamic pressure;
- ρ_{act} is the air density (in prevailing conditions).

5.6 Correction and conversion of measured air flow rate

5.6.1 General

By nature, air flow rate measurements on site are done in actual conditions (i.e. conditions existing in a particular place and at a particular time).

The actual conditions refer to the place where measurements are made. For measurements in ducts, atmospheric pressure may be measured outside the duct for practical reasons. In this case, the static pressure in the duct should be added to the atmospheric pressure for calculation purpose. When the static pressure in the duct is below 2 000 Pa in absolute value it may be neglected.

However, depending on their settings, some measuring systems may:

- give uncorrected air flow rate, $q_{v,\text{hyp}}$, by making the hypothesis that the air is at the device default condition (e.g. 1,204 kg/m³ corresponding to 293,15 K and 101 325 Pa). This hypothetical air flow rate is neither the actual air flow rate nor the standardized air flow rate and corrections given in 5.6.2 shall be done;
- automatically calculate or convert quantity values into different than actual conditions (e.g. standard conditions). In this case, conversion to actual conditions, as given in 5.6.3, shall be done.

In any case, the technical data sheet should be consulted to find out to which conditions (actual, standard, etc.) the indicated quantity values correspond and how to correct or convert them into actual conditions.

5.6.2 Correction of the air flow rate

The formula to convert hypothetical air flow rate into actual air flow rate (air flow rate occurring in actual conditions) depends on the measuring device used.

To obtain the actual air flow rate, the user shall refer to manufacturer specifications to determine whether:

- the correction is done automatically, in this case no further corrections shall be done, the read value is equal to the actual value; or
- the correction shall be done by the user.

If formulae to perform the correction are available in the manufacturer specifications they should be used.

If the correction is not done automatically and no correction's formula is available on manufacturer specifications the following corrections should be used:

- When the air flow rate varies with the inverse of the square root of the air density (e.g. for Pitot static tubes or fixed measuring device with exponent (reference of the measurement method ID3X)), Formula (7) shall be used.

$$q_{v,\text{act}} = q_{v,\text{hyp}} \cdot \sqrt{\frac{\rho_{\text{hyp}}}{\rho_{\text{act}}}} = q_{v,\text{hyp}} \sqrt{\left(\frac{p_{\text{atm,hyp}}}{p_{\text{atm,act}}}\right) \left(\frac{T_{\text{act}}}{T_{\text{hyp}}}\right)} = q_{v,\text{hyp}} \sqrt{\left(\frac{p_{\text{atm,hyp}}}{p_{\text{atm,act}}}\right) \left(\frac{\theta_{\text{act}} + 273,15}{T_{\text{hyp}}}\right)} \quad (7)$$

- When the air flow rate varies with the inverse of the air density (e.g. for hot-wire anemometers) Formula (8) shall be used.

$$q_{v,act} = q_{v,hyp} \cdot \frac{\rho_{hyp}}{\rho_{act}} = q_{v,hyp} \left(\frac{p_{atm,hyp}}{p_{atm,act}} \right) \left(\frac{T_{act}}{T_{hyp}} \right) = q_{v,hyp} \left(\frac{p_{atm,hyp}}{p_{atm,act}} \right) \left(\frac{\theta_{act} + 273,15}{T_{hyp}} \right) \quad (8)$$

where

- $q_{v,hyp}$ is the hypothetical air flow rate assuming device default conditions;
- $q_{v,act}$ is the actual air flow rate (in actual conditions);
- ρ_{hyp} is the air density in device default condition;
- ρ_{act} is the air density in actual conditions;
- $p_{atm,hyp}$ is the atmospheric pressure in device default condition;
- $p_{atm,act}$ is the atmospheric pressure in actual conditions;
- T_{hyp} is the air temperature in device default condition, in K;
- T_{act} is the air temperature in actual conditions, in K;
- θ_{act} is the air temperature in actual conditions, in °C.

NOTE The multiplier of $q_{v,hyp}$ is sometimes termed “ k_1 ”.

- For vane anemometers no corrections are needed for temperature and atmospheric pressure (air density). In this case, the hypothetical air flow rate is equal to the actual air flow rate.

5.6.3 Conversion of the air flow rate

Standardized air flow rate (air flow rate converted to standardized conditions) can be converted into actual air flow rate (air flow rate occurring in actual conditions) using Formula (9).

$$q_{v,act} = q_{v,std} \cdot \frac{\rho_{std}}{\rho_{act}} = q_{v,std} \left(\frac{p_{atm,std}}{p_{atm,act}} \right) \left(\frac{T_{act}}{T_{std}} \right) = q_{v,std} \left(\frac{p_{atm,std}}{p_{atm,act}} \right) \left(\frac{\theta_{act} + 273,15}{T_{std}} \right) \quad (9)$$

Conversely, actual air flow rate can be converted into standardized air flow rate using Formula (10).

$$q_{v,std} = q_{v,act} \cdot \frac{\rho_{act}}{\rho_{std}} = q_{v,act} \left(\frac{p_{atm,act}}{p_{atm,std}} \right) \left(\frac{T_{std}}{T_{act}} \right) = q_{v,act} \left(\frac{p_{atm,act}}{p_{atm,std}} \right) \left(\frac{T_{std}}{\theta_{act} + 273,15} \right) \quad (10)$$

where

- $q_{v,std}$ is the standardized air flow rate (in standard conditions);
- $q_{v,act}$ is the actual air flow rate (in actual conditions);
- ρ_{std} is the air density in standardized conditions;
- ρ_{act} is the air density in actual conditions;
- $p_{atm,std}$ is the atmospheric pressure in standardized conditions (101 325 Pa), in Pa;
- $p_{atm,act}$ is the atmospheric pressure in actual conditions, in Pa;
- T_{std} is the air temperature in standardized conditions (293,15 K), in K;
- T_{act} is the air temperature in actual conditions, in K;
- θ_{act} is the air temperature in actual conditions, in °C.

6 Measuring instruments requirements

6.1 General

The present clause provides good practices values for maximum permissible measurement error (MPME) of measuring instruments. For estimating the overall uncertainty of the measurement see Annex B and be consistent with the purpose of the test.

In order to reduce measuring uncertainty, instruments with a mean value calculation function (e.g. according to EN 13182) should be used.

EXAMPLE Instruments can calculate the mean value from 15 readings with 0,1 s apart.

6.2 Air flow rate measuring instruments

The MPME of an air flow rate measuring instrument, that provides air flow rate directly (such as flow hood), should be lower or equal to $3,6 \text{ m}^3/\text{h} + 5 \%$ of the measured value for the measuring interval that includes the measured quantity value.

6.3 Differential pressure measuring instruments (manometers)

The MPME of manometers should be lower or equal to $0,4 \text{ Pa} + 3 \%$ of the measured value, for the measuring interval that includes the measured quantity value.

Manometers should be zeroed before each sequence of measurement according to manufacturer instructions.

6.4 Air velocity measuring instruments

6.4.1 General

Air velocity is usually measured by anemometers or by Pitot static tubes.

The MPME of air velocity measuring instrument shall be lower or equal to $0,1 \text{ m/s} + 5 \%$ of the measured value, for the measuring interval that includes the measured quantity value.

For in duct measurements, the projected area of the device obstructing the duct passage area should not exceed 1/10th of the duct cross-section area.

Directional probes shall be oriented into the direction of the flow.

6.4.2 Anemometers

Anemometers, e.g. hot-wire anemometers or vane anemometers, provide a direct measurement of air velocity values.

The MPME of the instrument shall be consistent with the MPME given in 6.4.1.

Hot wire anemometers usually show a better accuracy at low velocities, vane anemometers are less temperature dependent and show a better accuracy at higher velocities. The velocity where there is a transition between the two types of instruments is usually within range 1 m/s to 3 m/s, this information is given in the manufacturer instructions.

6.4.3 Pitot static tubes

Pitot static tubes are described in EN ISO 16911-1 and ISO 3966. The principle of measurement with a Pitot static tube is given in Figure 1.

Pitot static tubes are used with a manometer complying with 6.3 to measure the dynamic or the static pressure within the duct. From the dynamic pressure measurement, air velocity can be calculated as described in 5.5.

The derived MPME of the air velocity shall be consistent with the MPME of the air velocity measurement devices given in 6.4.1 and this shall be checked using Formula (11).

$$MPME(p_d) \leq 0,1 \cdot \rho \cdot v + 0,05 \cdot \rho \cdot v^2 \quad (11)$$

where

$MPME(p_d)$ is the maximum permissible measurement error at the measured dynamic pressure.

In general, Pitot static tubes are best to measure velocity from 2 m/s and above if the MPME of the manometer is consistent with 6.3.

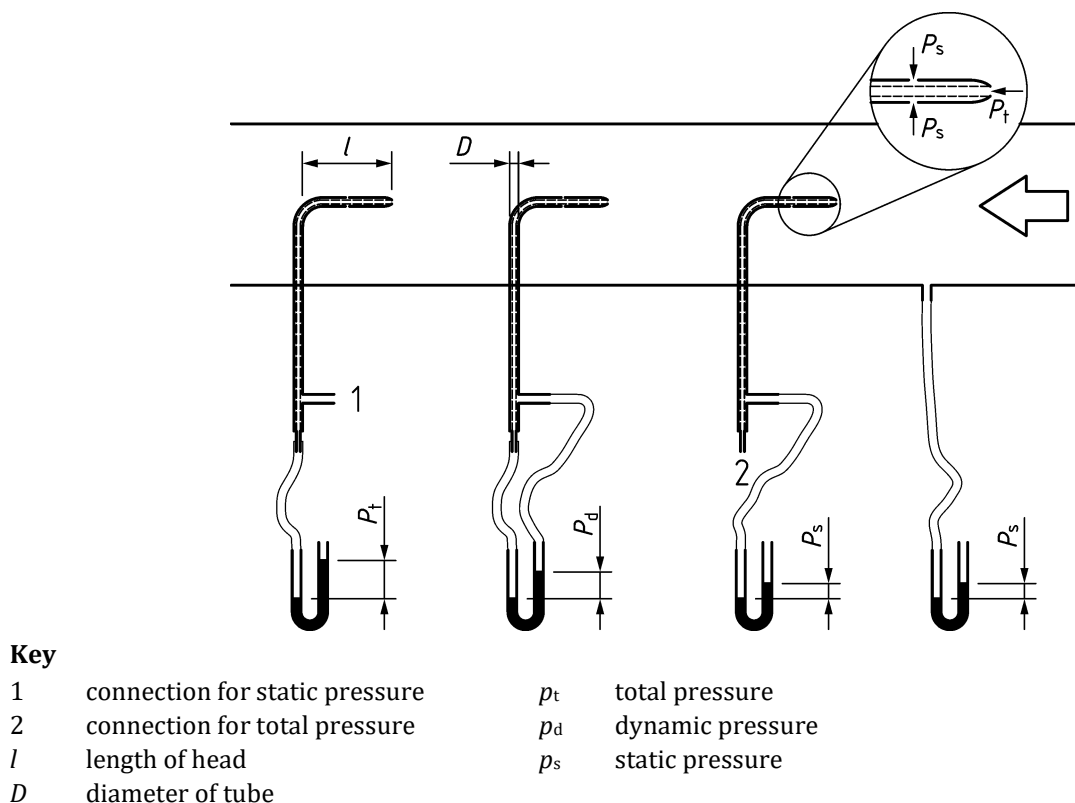


Figure 1 — Measurement principle of Pitot static tube

Some measuring instruments display directly velocity or air flow rate while they are measuring dynamic pressure.

6.5 Temperature measuring instruments (thermometers)

Thermometers shall have a MPME of ± 1 °C for the measuring interval that includes the measured quantity value.

The duration of measurement should be consistent with the response time of the thermometer.

6.6 Atmospheric pressure measuring instruments (barometers)

Barometers shall have a MPME of ± 500 Pa for the measuring interval that includes the measured quantity value.

7 Methods for measurement of air flow rates

7.1 Overview of described methods

The methods described in this document are summarized in Table 3.

The following abbreviations are used in Table 3 and also in the document:

- ID: In duct;
- ST: Supply terminal;
- ET: Extract terminal;
- EX: Exhaust;
- IN: Intake.

Table 3 — Summary of the methods described in this document

Measurement method	Measurement location designation						Clause(s)/ subclause(s) of this document
	In duct	At supply	At extract	At fan	At exhaust vent	At intake vent	
Multi-point measurement in the duct cross-section – with measurement plane criteria	ID1XX						7.2
Multipoint measurement in the duct cross-section – without measurement plane criteria	ID2XX						7.3
Fixed devices for air flow rate measurement	ID3X	ST1X	ET1X	ID31			7.4
Measurement with tight bag		ST2					7.5
Measurement with flow hood		ST3X	ET2X				7.6
Measurement with tracer gas	ID4						Annex A (informative)
Measurement at intake vents or exhaust vents					EX1	IN1	Annex A (informative)
Point measurements using hot wire anemometer at rectangular grilles			ET3			IN2	Annex A (informative)

To determine the measurement conditions of the ventilation system the air temperature and atmospheric pressure should be measured. For in duct measurement, the static pressure in the duct (at measurement plane) should be measured.

Additional information, such as wind speed and outdoor temperature, might also be of interest for uncertainty evaluation.

7.2 Multi-point measurement in the duct cross-section – with measurement plane criteria (ID1)

7.2.1 Principle

Method ID1 involves the air flow rate being calculated from a series of air velocities determined by measurements in the duct cross-section. The determination of velocity is carried out using a Pitot static tube or an anemometer.

The air flow rate is then calculated by multiplying the average air velocity with the duct area and correction factors (given in 5.6).

Table 4 gives method numbers according to the kind of ductwork and the kind of measurement device, together with the standard method uncertainty.

Table 4 — Methods ID1 for measurement of air flow rates

Method/measurement device/kind of ductwork	Method number	Standard method uncertainty ^a
Multi-point measurement in the duct cross-section – with measurement plane criteria	ID1	
Pressure measurements using a Pitot static tube	ID11	
a) Circular cross-section	ID111	4 % (case A) 6 % (case B)
b) Rectangular cross-section	ID112	4 %
Velocity measurement using a hot-wire anemometer or a mechanical anemometer	ID12	
a) Circular cross-section	ID121	4 % (case A) 6 % (case B)
b) Rectangular cross-section	ID122	4 %
^a See Annex B for more information on standard uncertainty.		

Random method uncertainties can arise, e.g. as a result of oblique velocity profile in the measurement cross-section and oblique setting of the probe. The standard method uncertainty with a coverage probability of approximately 68 % is given in Table 4.

7.2.2 Apparatus

For all methods, the equipment that shall be used is:

- a thermometer;
- a barometer;

and for:

- ID11 a manometer with Pitot static tube;

- ID12 an anemometer.

In both cases, the Pitot static tube or the anemometer shall include an indication of:

- insertion length;
- the orientation of the probe (to be aligned with the flow direction).

7.2.3 Measurement procedure

7.2.3.1 Preparations to be made at the site of measurement

7.2.3.1.1 Selection of the plane of measurement

The flow profile has a distorted appearance after certain disturbances to the flow, e.g. section change, bends or dampers. If measurement takes place directly after a flow disturbance, there is a risk of low accuracy.

The plane of measurement is accepted if it meets the following criteria:

- duct sections are free from disturbances for a distance, both before and after the plane of measurement: see Table 5 for values;
- the highest dynamic pressure (ID11) in the measurement plane:
 - is located more than $0,1 D_h$ from all duct walls;
 - is less than twice the dynamic pressure in the centre;
- the highest velocity (ID12) in the measurement plane:
 - is located more than $0,1 D_h$ from all duct walls;
 - is less than 1,4 times the velocity in the centre;
- the likeliness of backflow in the cross-section is small.

If these three criteria are not met, a new plane of measurement shall be selected and tested.

To determine if there is a risk of backflow in the cross-section, insert the anemometer in the duct in the measuring plane and sweep slowly to determine maximum value location. If negative or close to zero values are noticed, there is a high possibility of backflow.

For rectangular ductwork, the “centre” is the intersection of diagonals.

NOTE A Pitot static tube can normally not detect velocities below approximately 0,5 m/s and a hot-wire anemometer is not able to detect the direction of the flow.