
Ventilation for buildings — Performance testing of components/products for residential ventilation

Part 5: Cowls and roof outlet terminal devices

The European Standard EN 13141-5:2004 has the status of a
British Standard

ICS 91.140.30

National foreword

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The UK participation in its preparation was entrusted to Technical Committee RHE/2, Ventilation for buildings, heating and hot water services, 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 UK interests informed;
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Partie 5 : Extracteurs statiques et dispositifs de sortie en
toiture

Lüftung von Gebäuden - Leistungsprüfung von
Bauteilen/Produkten für die Lüftung von Wohnungen - Teil
5: Hauben und Dach-Fortluftdurchlässe

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Foreword

This document (EN 13141-5:2004) has been prepared by Technical Committee CEN/TC 156 "Ventilation for buildings", the secretariat of which is held by BSI.

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Introduction

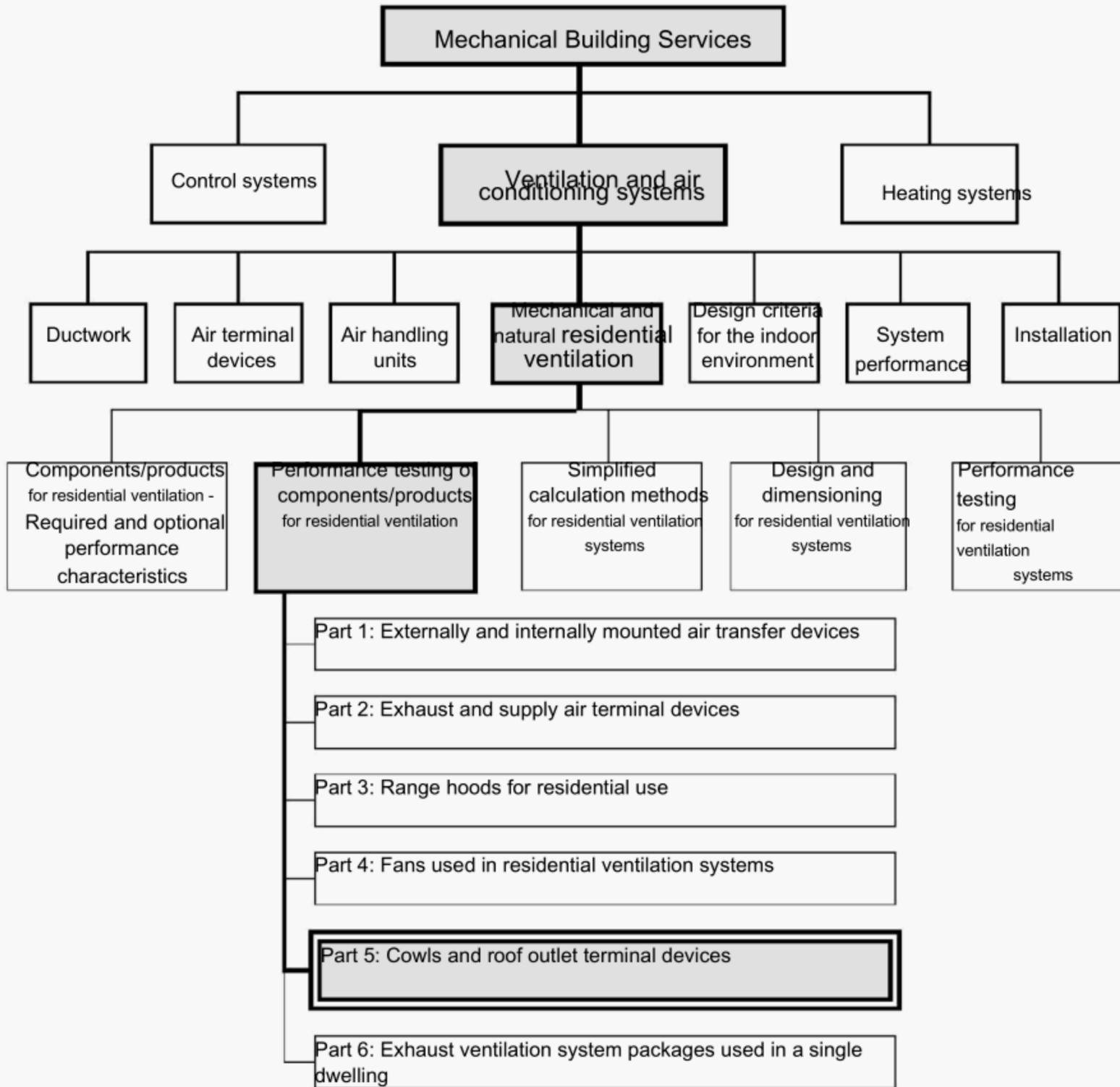


Figure 1 - Position of EN 13141-5 in the field of the mechanical building services

1 Scope

This document specifies methods for measuring the aerodynamic and acoustic characteristics of cowls and roof outlets used in both natural and mechanical ventilation. Only those cowls and roof outlets fitted onto ducts which project above the roof surface are covered by the present standard.

Regarding the assisted cowls, only the fan assisted cowls are covered by the present standard, other types (such as injection assisted cowls) being too recent to be adequately considered for the time being.

The performance testing of the "assistance" provided by the auxiliary fan of an assisted cowl is excluded for the scope of this standard.

2 Normative references

The following referenced documents are indispensable for the application 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 1506:1997, *Ventilation for buildings - Sheet metal air ducts and fittings with circular cross-section – Dimensions.*

EN 12792:2003, *Ventilation for buildings - Symbols, terminology and graphical symbols.*

EN 13141-4:2004, *Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 4: Fans used in residential ventilation systems.*

ISO 5801, *Industrial Fans - Performance testing using standardized airways.*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12792:2003 and the following apply.

3.1

cowl

air terminal device with or without moving component, intended to be fitted on top of an exhaust duct, with aim, by creating negative pressure depending of the wind speed, to avoid reverse flow and to increase the extracted flow rate in presence of wind

3.2

assisted cowl

cowl fitted with an auxiliary device using other energy source than wind to compensate for lack of suction effect

3.3

fan assisted cowl

assisted cowl where the auxiliary device is a fan

3.4

roof outlet

air terminal device used for mechanical ventilation systems

3.5

pressure factor

measure of the suction effect due to the wind. Ratio of the measured pressure difference to the dynamic pressure of the wind at a given vertical wind approach angle

3.6

test-voltage

voltage to be used for supplying the motorised cowl during the testing

4 Performance testing of aerodynamic characteristics

4.1 Pressure drop

4.1.1 Test installation

The pressure drop characteristics of the cowl or roof outlet shall be tested in a test installation such as is shown in Figure 2 but without the wind tunnel. The test installation shall comprise the following :

an adjustable air supply incorporating an air flow rate measuring device with an uncertainty in accordance with 4.1.2 (e.g. orifice plate or venturi tube conforming with EN ISO 5167-1, or other flow meter such as a rotameter). The air supply passes via an airtight duct;

means to stabilize the flow and pressure upstream the test duct, for example an airtight plenum chamber (side length at least 4 times the smallest diameter of the test duct) containing flow settling screens at the air entry zone and a smooth outlet;

an airtight test circular duct to carry the cowl or roof outlet under test, of diameter D chosen according to EN 1506:1997, Table 1 to suit this cowl or roof outlet and of length :

$$L = 6D .$$

4.1.2 Test procedure

When testing a fan assisted cowl, the auxiliary fan shall be switched-off.

The test shall be carried out by varying the air flow rate through the cowl or roof outlet to give static pressure differences between the test duct and the room in which the test is carried out, of 5 Pa, 10 Pa, 20 Pa and 50 Pa.

The parameters to be measured are:

air volume flow rate through the cowl or roof outlet;

total pressure difference between the test duct and the room in which the test is carried out. The pressure tapping in the test duct shall be $3D$ upstream of the cowl or roof outlet under test (D being the smallest diameter of the test duct). The total pressure in the duct is calculated by measuring the static pressure and the averaged air velocity in the duct (the volume flow rate divided by the duct area)

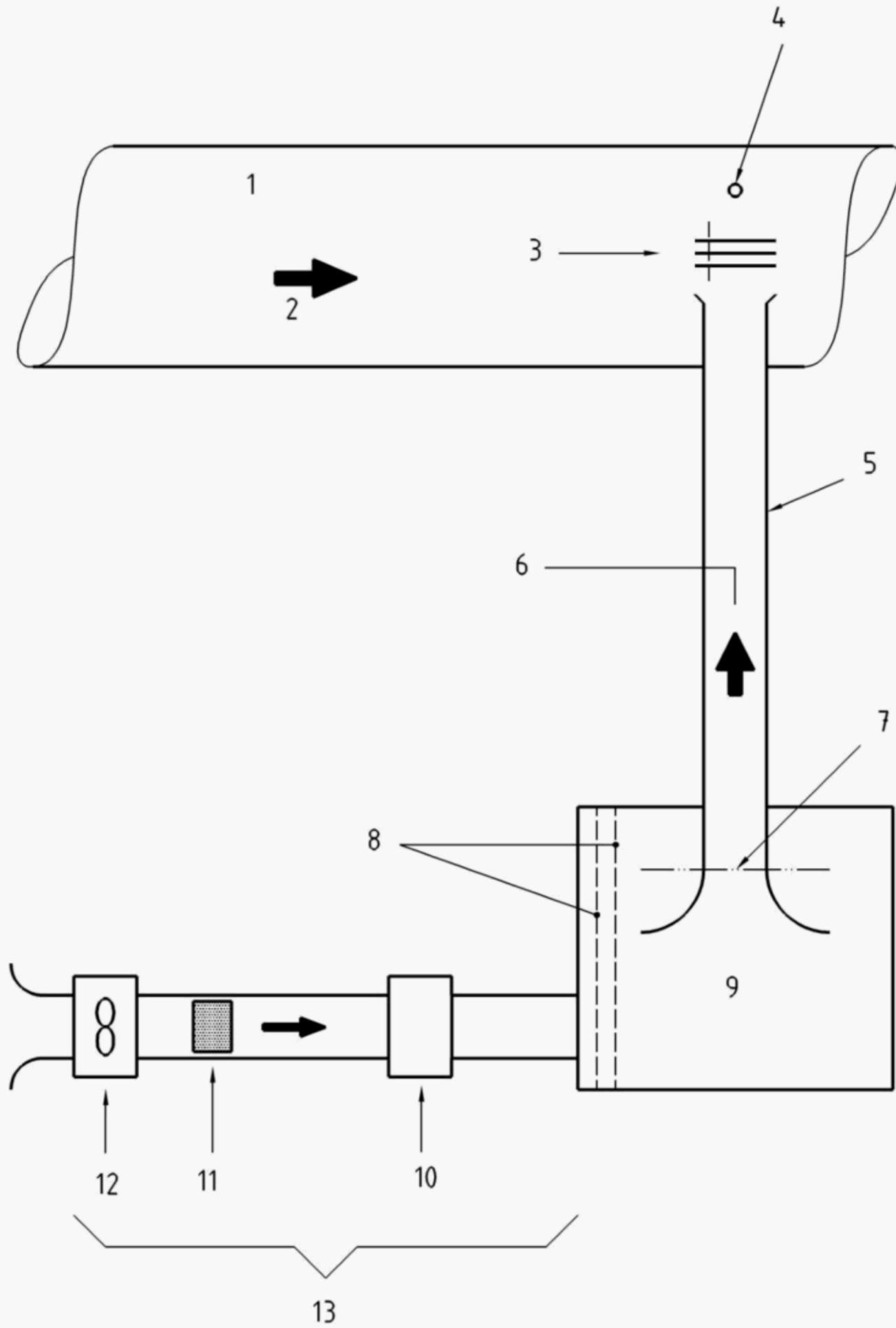
The uncertainty of the air flow measurement shall be lower than :

$$0,3 + 0,03 \times (\text{measured value}), \text{ in } \text{dm}^3/\text{s}.$$

The uncertainty of the pressure measurement shall be lower than :

$$0,5 + 0,03 \times (\text{measured value}), \text{ in Pa}.$$

The environmental conditions existing during the tests such as temperature, air pressure shall be recorded.



Key

- | | | | | | |
|---|------------------------------------|----|-------------------------------------|----|-------------------------------------|
| 1 | Wind tunnel | 7 | Sealed for preliminary suction test | 12 | Fan with flow rate adjusting device |
| 2 | Wind velocity | 8 | Flow setting screens | 13 | Air supply |
| 3 | Cowl | 9 | Plenum chamber | | |
| 4 | Pressure sensor in the wind | 10 | Flow measuring device | | |
| 5 | Test duct | 11 | Flow straightener | | |
| 6 | Static pressure measurement device | | | | |

Figure 2 - Typical example of a test installation

4.1.3 Analysis of results

The measured result shall be corrected if temperature and barometric pressure are different from the standard conditions (20 °C and 101325 Pa), as follows:

$$q_{v\text{ cor}} = q_{v\text{ meas}} \frac{293}{(273 + \theta_a)} \frac{p_a}{101325}$$

where:

q_v is the volume flow rate, in dm³/s

$q_{v\text{ cor}}$ is the corrected volume flow rate, in dm³/s

$q_{v\text{ meas}}$ is the measured volume flow rate, in dm³/s

p_a is the ambient pressure, in Pa

θ_a is the ambient temperature, in °C

4.2 Suction effect of a cowl

4.2.1 Test installation and conditions

The suction effect characteristics of the cowl shall be tested in a test installation such as shown in Figure 2 and described in 4.1.1. For the suction effect test the wind tunnel is required.

Static pressure shall be measured with two pressure probes (and more) located in the working section far enough the cowl, at each side of the wind cross section. Reference pressure is the pneumatic average of the two static pressure ambiances.

If the tests are carried out in a confined working section as shown in Figure 2, then the cross-sectional area of the working section shall be at least twenty times the cross section area (in projection along the axis of the wind tunnel) of the cowl and duct in the wind.

If the tests are carried out using an open jet type wind tunnel, then the cross section area of the jet shall be at least ten times the cross-sectional area (in projection along the axis of the wind tunnel) of the cowl and duct in the wind.

Because of the interactions between the duct wake and the aerodynamic behaviours of the cowl, the duct length blown by the wind is more than 5 times its diameter. More over roughness shall be fitted on the duct surface in the wind. Squared ribs ($e/D > 0,01$) is an example of solution.

The turbulence intensity of the wind shall be less than 5 %.

To simulate varying vertical wind approach angles, it shall be possible to rotate the cowl and test duct about an axis perpendicular to the wind tunnel axis and test duct axis, the cowl remaining near the same test point located at the wind tunnel axis to remain in the homogenous wind stream (see Figure 3).

In addition, where the test duct axis is perpendicular to the wind tunnel axis, it shall be possible to rotate the cowl about the test duct axis to simulate varying horizontal wind approach angles (see Figure 4).

When the mounting parts which supported the duct and the cowl are in the wind, they shall be far from the cowl and transparent from an aerodynamic point of view. Make sure than the approach angles are maintained during the wind blowing.

The following parameters shall be measured:

difference between total pressure in the test duct approaching the cowl and the static pressure in the wind tunnel; The total pressure in the duct is calculated with measured static pressure and the averaged air velocity in the duct. Static pressure difference shall be corrected as follows :

$$\Delta p_s = p_{6 \text{ testpoint}} - p_{4 \text{ testpoint}} = p_s - p_{4 \text{ testpoint}} + \Delta p_s, \text{ where } \Delta p_s = p_s - p_{4 \text{ testpoint}}$$

measured before the cowl set up.

The dynamic pressure of the wind p_d is calculated with the velocity measured at the point 2. Difference of velocity between the point 2 and the test point shall be included in the final calculation.

$$p_d = \frac{1}{2} \rho U_a^2 + \Delta p_d, \text{ where } \Delta p_d \text{ is the dynamic pressure difference between the test point and the point 2}$$

horizontal and vertical wind approach angles.

The pressure tapping in the test duct shall be $3D$ upstream of the cowl under test (D being the smallest diameter of the test duct).

4.2.2 Measurement conditions and uncertainties

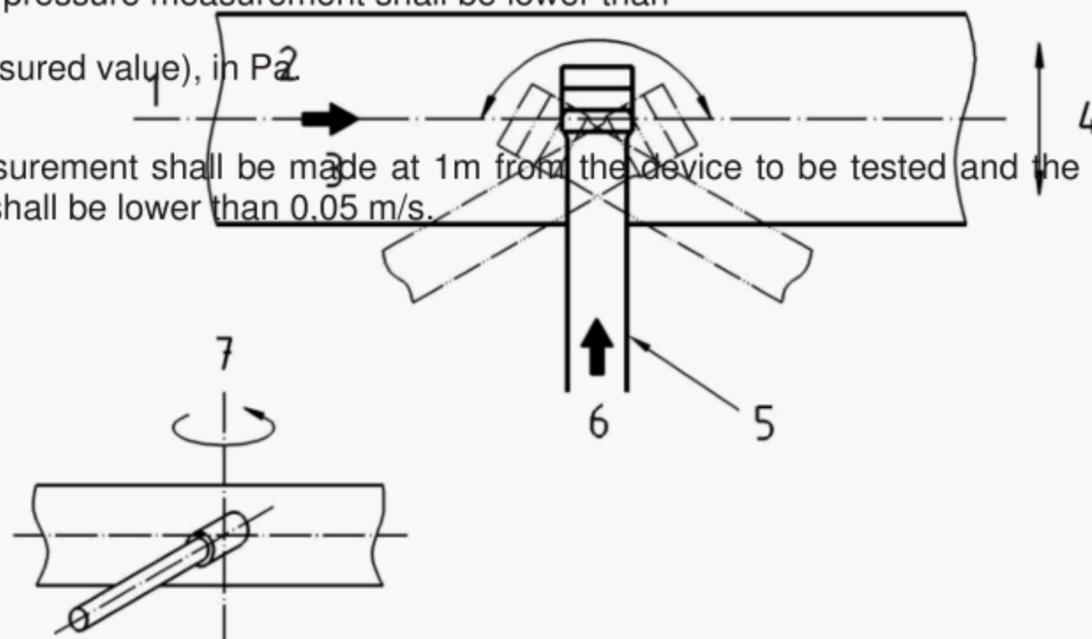
The uncertainty of the air flow measurement shall be lower than

$$0,3 + 0,03 \times (\text{measured value}), \text{ in } \text{dm}^3/\text{s}.$$

The uncertainty of the pressure measurement shall be lower than

$$0,5 + 0.03 \times (\text{measured value}), \text{ in Pa}$$

The wind speed measurement shall be made at 1m from the device to be tested and the uncertainty of the wind speed measurement shall be lower than 0.05 m/s.



Key

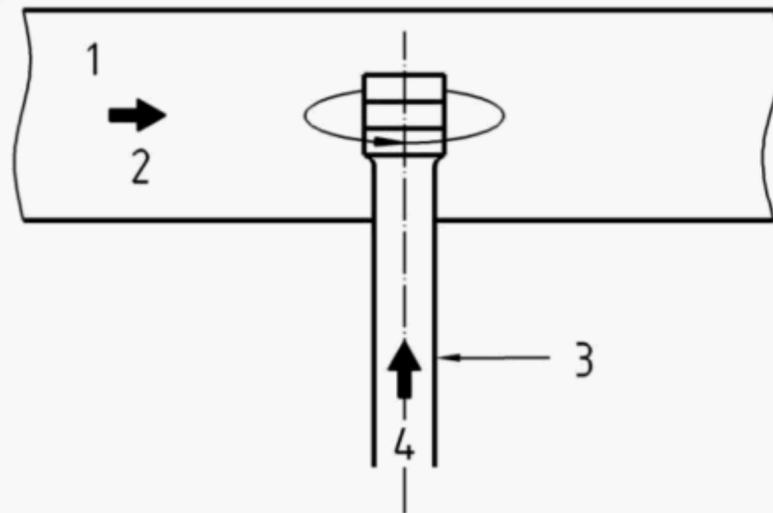
- 1 Axis of tunnel
- 2 Wind tunnel
- 3 Pressure tapping
- 4 Wind speed measurement probe
- 5 Test duct
- 6 Axis of test duct
- 7 Probe

3 Wind velocity

7 Axis of rotation

4 Homogeneous part of the wind flow

Figure 3 - Rotation to simulate varying vertical wind approach



Key

- 1 Wind tunnel
- 2 Wind velocity
- 3 Test duct
- 4 Axis of rotation

Figure 4 - Rotation to simulate varying horizontal wind approach

4.2.3 Preliminary test

The aim of this preliminary test is to select the wind approach angle corresponding to the least favourable condition for the suction effect.

A set of measurements shall be made with the test duct sealed at the plenum chamber end and fixed with its axis perpendicular to the wind tunnel axis. A wind of sufficient speed to give easily measurable pressure differences shall be provided.

The cowl shall be rotated about the test duct axis, and the static pressure difference between the test duct and the wind tunnel shall be measured for wind angle steps of 15 °.

The tests in 4.2.3 to 4.2.5 shall be carried out at the angle about the test duct axis which results in the smallest pressure difference (i.e. the least favourable suction effect).

4.2.4 Wind effect and flow rate tests

In use the cowl performance will combine both the suction effect due to the wind and the pressure drop due to the air flowing through the cowl. The following tests measure the performance of the cowl when these two effects are combined.

The combined pressure drop and suction effect characteristics of the cowl shall be tested in a test installation as shown in Figure 2 and described in 4.2.1.

During the tests the air volume flow rate in the test duct shall not exceed 2 % of the air volume flow rate from the wind tunnel.

4.2.5 Test procedure

4.2.5.1 General

When testing fan assisted cowl, switch-off the auxiliary fan.

4.2.5.2 Test of the flow rate effect

a) test with "horizontal" wind 8 m/s

set to 0 the vertical wind approach angle (i.e. the test duct axis being perpendicular to the wind tunnel axis)

set the angle about the test duct axis to the angle which results in the smallest pressure difference in the preliminary test in 4.2.2

set to $8 \text{ m/s} \pm 0,2 \text{ m/s}$ the wind speed and measure the exact wind speed. with an uncertainty of less than $0,05 \text{ m/s}$

starting from 0 m/s , raise progressively the mean air speed V in the test duct up to when $\Delta p = 0$ is reached :
The corresponding speed will be called $V_{\Delta p = 0}$

perform measurements of Δp and p_d for the following 9 measurement points :

$V = 0 \text{ m/s}$ (flow rate 0), 0.5 m/s , 1 m/s , 1.5 m/s , 2 m/s , 4 m/s , 8 m/s and 16 m/s (with a deviation of $\pm 1^\circ$).

NOTE The single value of 8 m/s is adopted as wind speed in order to reduce the measurement uncertainties. The values of pressure difference and air flow rate for other wind speed may be derived through the similitude law (see Annex A) from the values measured at 8 m/s .

b) If the test installation does not allow an air speed V of 16 m/s in the test duct, it is acceptable to perform the last point measurement with a mean air speed $V = 8 \text{ m/s}$ in the test duct, but the "horizontal" wind being reduced to $4 \pm 0,2 \text{ m/s}$. The results for this last point shall be converted through the "similitude law" to the wind 8 m/s conditions.

4.2.5.3 Test for wind effect

This time only the vertical wind approach angle is varied, the wind speed and the mean air speed V in the test duct being maintained unchanged.

Eight wind approach angles are tested : -45° , -30° , -15° , $+15^\circ$, $+30^\circ$, $+45^\circ$,

NOTE 0° has been already tested in 1a)

Three series of measurement shall be performed, all with a wind speed of 8 m/s : one at $V = 0 \text{ m/s}$ (flow rate 0), and two other at V values selected according the manufacturer specification.

4.2.6 Analysis of results

For each set of readings of pressure difference, air flow rate and vertical wind approach angle, the value of the pressure factor $C_{(\text{angle } x^\circ)}$ for a vertical wind approach angle of x° is calculated as follows.

$$C_{(\text{angle } x^\circ)} = \frac{\Delta p}{\rho \cdot v^2}, \text{ with } \Delta p = p_d + \Delta p_s$$

where:

Δp is the difference between the total pressure in the test duct approaching the cowl under test and the static pressure in the tunnel (or the room if it is an opened tunnel) (in Pa),

$$\Delta p = p_{\text{dyn}}(\text{duct}) + \Delta p_s$$

p_d is the dynamic pressure of the flow in the wind tunnel (in Pa).

ρ is the air density in the wind tunnel (in $\text{kg}\cdot\text{m}^{-3}$).

v is the mean air speed in wind tunnel (in $\text{m}\cdot\text{s}^{-1}$)

$P_{\text{dyn}}(\text{duct})$ is the dynamic pressure in the duct

4.3 Presentation of results

The report shall give a description of the cowl or roof outlet tested, including the size and shape of duct which was used for the aerodynamic testing.

The report shall also contain the following:

The pressure drop characteristics in graphical and tabular form.

The pressure factors C as a function of vertical wind approach angle and test duct air speed in tabular and graphical form.

5 Additional testing for fan assisted cowls

5.1 General

Additional tests shall be performed using the same unit as for the previous test.

For all these tests the motor shall be switched on and supplied with the test voltage $\pm 1\%$.

When a single value is assigned by the manufacturer as the rated voltage, this shall be the test voltage. Where a voltage range is assigned to the product by the manufacturer that includes 230 V, the test voltage shall be 230 V $\pm 6\%$.

5.2 Aerodynamic testing

The aerodynamic characteristics of a fan assisted cowl shall be measured and the results presented according to the test method in 4.2.3 of EN 13141-4:2004.

5.3 Acoustic testing

The method specified in 5.2.1 of EN 13141-4:2004, for category C installation, shall be used to determine the sound power level of a fan assisted cowl emitted into the duct for at least 3 operating points for which the aerodynamic performance characteristics have been determined, including the two extreme working air flows.

5.4 Effective power input

5.4.1 Test Method

The effective power input for the fan assisted cowl shall be determined according to ISO 5801.

5.4.2 Analysis of results

This effective power input shall be used to calculate the effective power input per unit of air flow rate.

5.4.3 Presentation of results

The results shall be presented in tabular and graphical form (effective power input per unit of air flow rate VS air flow rate).

Annex A (normative)

Derivation of values through the similitude law

A dimensionality rules of component characteristics

$$C(V_{\text{windref}}, V_{\text{duct}}) = \frac{\Delta p}{\rho V_{\text{windref}}^2}$$

where : —

$$p_d = \frac{1}{2} \rho V_{\text{windref}}^2$$

V_{windref} is the wind tunnel velocity (m/s)

V_{duct} is the duct air flow velocity (m/s)

Δp is the difference between the total pressure in the test duct approaching the extractor or roof outlet under test and the static pressure in the test room (in Pa);

ρ is the air density in the wind tunnel (kg/m^3).

For a different wind speed V_{windact} , the coefficients remains the same if the V_{duct} if multiplied by $V_{\text{windact}}/V_{\text{windref}}$

$$C(V_{\text{windact}}, V_{\text{duct}} \cdot V_{\text{windact}}/V_{\text{windref}}) = C(V_{\text{windref}}, V_{\text{duct}})$$

EXAMPLE $V_{\text{windref}} = 8 \text{ m/s}$

$V_{\text{duct}} = 2 \text{ m/s}$

$C(8,2) = -0,12$

For a wind $V_{\text{windact}} = 4 \text{ m/s}$ the corresponding V_{duct} is equal to $2 \cdot 4/8 = 1 \text{ m/s}$

Which gives : $C(4,1) = C(8,2) = -0.12$

The corresponding Δp is

$$\Delta p = C(4,1) \cdot \frac{1}{2} \rho V_{\text{windact}}^2$$

Bibliography

- [1] XP P50-413:1993, *Ventilation – Natural ventilation ducts and smoke ducts – Test code and rating of static cowls.*
- [2] EN ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 1: General principles and requirements (ISO 5167-1:2003)*

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