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Fans — Determination of airflow propelled through an open personnel door by a positive pressure ventilator

Ventilateurs — Détermination du débit d'air propulsé par un ventilateur à pression positive à travers une porte ouverte

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Foreword

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This document was prepared by Technical Committee ISO/TC 117, *Fans*.

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Introduction

This document establishes a uniform method of laboratory testing for the determination of the aerodynamic performance of a positive pressure ventilator (PPV) in terms of airflow rate, pressure, air density and rotational speed, for performance rating or guarantee purposes.

Fans — Determination of airflow propelled through an open personnel door by a positive pressure ventilator

1 Scope

This document establishes a uniform method of laboratory testing for the determination of airflow propelled through an open personnel door by a positive pressure ventilator.

NOTE The test described by this document is not entirely in accordance with ISO 5801, though it references several subclauses of ISO 5801 (such as the measurement of pressure and airflow).

This document does not specify a testing procedure for the design, production or field test of any PPV, nor is it the purpose for this document to serve as a manual for the construction, validation or calibration of the test facility.

This document does not apply to any item of equipment designed or intended for applications other than positive pressure ventilation.

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.

ISO 5801:2017, *Fans — Performance testing using standardized airways*

ISO 12499, *Industrial fans — Mechanical safety of fans — Guarding*

ISO 45001, *Occupational health and safety management systems — Requirements with guidance for use*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5801 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
height
h
vertical distance between the PPV position and the flat, horizontal surface on which the PPV is situated

3.2
hydraulic diameter
D_h
four times the cross-sectional area divided by the perimeter which encloses the area, given by:

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

3.3
engine
drive device that produces power through internal combustion and that uses a fuel such as gasoline

3.4
motor
drive device other than an internal combustion engine, such as an electric motor, water turbine, hydraulic motor, air motor and similar devices

3.5
positive pressure ventilator
PPV
portable fan that can be positioned relative to an opening of an enclosure and cause it to be positively pressurized by discharge air velocity

Note 1 to entry: PPVs are principally used by firefighters to mitigate the effect of smoke.

3.6
PPV airflow
total airflow through the doorway, including entrained airflow, propelled by a PPV, which is identical to the airflow at plane 4

Note 1 to entry: See Figure 1.

3.7
PPV position
point representing a PPV position in three-dimensional space that is taken as the intersection between the PPV axial centerline and face of the PPV hub

Note 1 to entry: All measurements pertaining to the PPV must be referenced to this point.

3.8
PPV speed
the rotational speed of the PPV impeller

3.9
PPV static pressure
static pressure in the doorway created by airflow propelled by the PPV, which can be measured at plane 4

Note 1 to entry: See Figure 1.

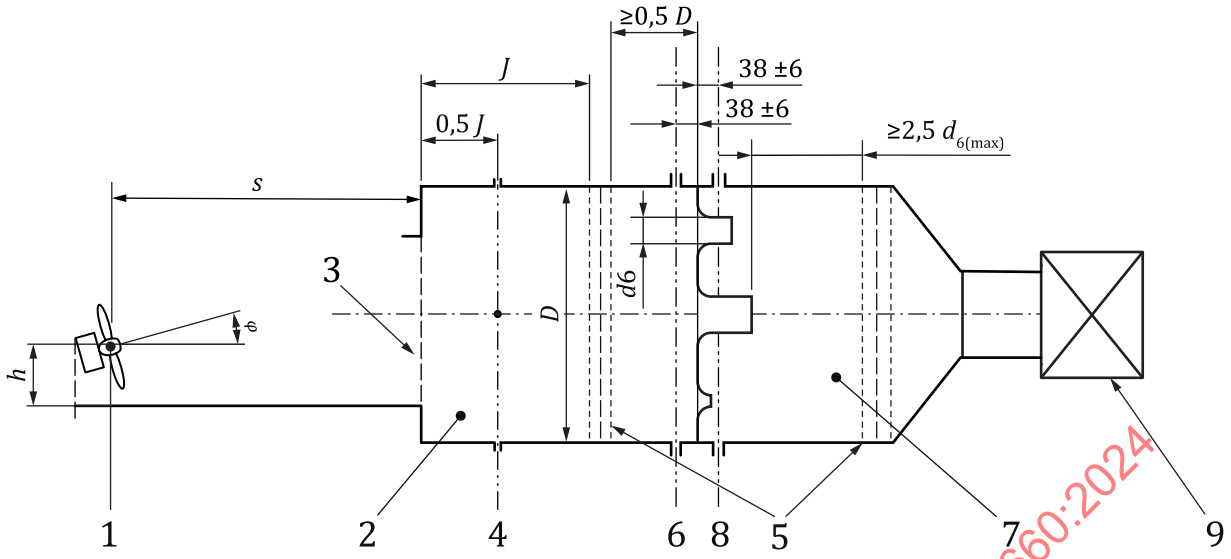
3.10
setback
s
the horizontal distance between the PPV position and the opening to the test chamber, within a vertical plane perpendicular to the plane defined by the chamber opening

3.11
test
series of determinations for various points of operation of a PPV

3.12
tilt
φ
angle between the PPV axial centreline and the horizontal plane

3.13
nominal voltage
V_N
designated or identified voltage of the cumulative batteries supplied to the PPV

Note 1 to entry: IEC 61960-3 may be referenced to find correct nominal voltage for different types of batteries.



Key

1 positive pressure ventilator (PPV) and plane 1
2 outlet test chamber (oTC)
3 doorway
4 plane 4
5 settling screens
6 plane 6
7 flow rate measurement (q_V)
8 plane 8
9 variable supply system, auxiliary fan (vss)

Dimension *J* shall be at least 2,0 times the PPV equivalent discharge diameter.

The outlet test chamber (oTC), settling screens, and variable supply system (auxiliary fan) shall meet the requirements of ISO 5801.

The flow rate measurement shall be a multi-nozzle chamber meeting the requirements of ISO 5801.

The doorway shall be an opening having a height of 1,90 m and a width of 0,98 m centered width wise across the entrance plane of the chamber.

NOTE 1 Planes 4, 6, and 8 are static pressure measurement planes.

NOTE 2 Plane 1 is a vertical plane through the centre of the propeller hub.

NOTE 3 Plane numbers correspond to planes found in ISO 5801.

NOTE 4 The value $d_{(6,max)}$ refers to the diameter of the largest nozzle in the nozzle wall.

NOTE 5 The minimum room clearances around PPV position for the PPV being tested are: a minimum of 2 PPV impeller diameters behind and to the sides of the PPV under test and 4 PPV diameters or 3 m (whichever is greater) to the ceiling.

Figure 1 — Test setup

4 Symbols, abbreviated terms and subscripts

Table 1 — Symbols and abbreviated terms

Symbol	Represented quantity	Reference sub-clause	Unit
s	PPV setback	3.10	m
h	PPV height	3.1	m
φ	PPV tilt	3.13	° (degrees)
D_h	Hydraulic diameter	3.2, 6.3	m
D	Diameter	6.3	m
oTC	Test chamber at the outlet side of the fan under test	6.3, Fig. 1	--
p_{s4}	Static pressure at plane 4	7.2	Pa
p_s	PPV static pressure	8.3	Pa
K_0, K_1, K_2	Polynomial coefficients	8.3, 8.4	dimensionless
q_V	PPV volume airflow	8.2	m^3/s
q_{Vf}	Volume flow rate at free delivery	8.4	m^3/s
ρ_0	Density of atmospheric air	9.2	kg/m^3
P	Perimeter of chamber cross section	3.2	m
V_N	Nominal voltage		V

Table 2 — Subscripts

Planes	
0	Ambient atmosphere in the test space
1	PPV position
4	Pressure measurement section in oTC
6	Upstream tapping for Δp for an outlet-side flow rate measurement
8	Downstream tapping for Δp for an outlet-side flow rate measurement

5 Measurements

5.1 General

In addition to the following, the manufacturer shall adhere to the requirements of ISO 5801:2017, Clause 12, as applicable.

5.2 Calibration

All instrumentation shall be calibrated on an annual basis with certificates traceable to International Standards.

5.3 Pressure indicating instrument – PPV static pressure

PPV static pressure shall be measured with a pressure transducer having an accuracy equal to or better than 0,5 % as stated by the manufacturer.

5.4 Other pressure measurement systems

Pressure measurement systems consisting of sensors and indicators other than manometers and static pressure taps may be used for all pressures except PPV static pressure, if the combined uncertainty of the system does not exceed the combined error for an appropriate combination of manometers and static

pressure taps. For a system used to determine pressure, the contribution to the combined uncertainty of the pressure measurement shall not exceed that corresponding to 1 % of the maximum observed pressure differential reading during a test (indicator tolerance) plus 1 % of the actual reading (averaging accuracy).

6 Test configuration

6.1 General

In addition to the following, the manufacturer shall adhere to the requirements of ISO 5801:2017, Clause 9, as applicable. All required and supplied guards shall be in place in accordance with ISO 12499 or ISO 45001.

6.2 Setup

The PPV under test shall be set up for test as shown in Figure 1.

The values for s, h, and φ are set to simulate the intended application.

6.3 Chamber

A chamber shall be incorporated in the laboratory setup to provide a measurement station and to simulate a condition the PPV is expected to encounter in service. The chamber shall meet the proportionality and performance requirements of the oTC in ISO 5801. The chamber may have a circular or rectangular cross-sectional shape. The dimension, D, in the test setup diagram corresponds to the hydraulic diameter of the cross-section given in Formula (1):

$$D = D_{\mathrm{h}} \tag{1}$$

The chamber shall have a cross-sectional area at least 5 m^2.

6.4 Chamber entrance

The entrance to a chamber shall be completely sealed with the exception of a “doorway” opening having a height of 1,9 m ± 1 cm and a width of 0,98 m ± 1 cm cantered width wise across the entrance plane of the chamber. The aspect ratio shall be 1,94 % ± 1 %.

A flat, horizontal surface shall extend from the rear of the test unit to the front edge of the chamber entrance. This surface shall be level with the bottom edge of the chamber entrance and shall have a minimum width equal to or exceeding the width of the chamber entrance or the width of the test unit, whichever is greater.

6.5 Fuel

A PPV driven by a gasoline engine shall be tested with standard fuel as recommended by the engine manufacturer. No additional chemical(s) shall be added.

7 Carrying out the test

7.1 General

In addition to the following, the manufacturer shall adhere to the requirements of ISO 5801:2017, Clause 7, as applicable.

Each test shall be limited to one PPV per test. A PPV tested in accordance with this document shall be freestanding and without a ductwork connection to the test chamber, thereby allowing for the measurement of entrained airflow. The maximum nominal propeller diameter of a PPV tested in accordance with this document is 0,80 m.

7.2 Determinations

To determine the aerodynamic performance of a PPV at free delivery, determinations shall be taken for chamber static pressures, p_{s4}, ranging from 25 Pa to -25 Pa. If a chamber static pressure of 25 Pa cannot be obtained, the highest obtainable static pressure shall be used as the upper limit, and the negative of this value shall be considered the lower limit. Plans shall be made to vary the throttling device such that the test points will be well spaced in terms of static pressure. At least 10 determinations shall be taken per test. Half of these determinations shall be taken at a positive static pressure and half shall be taken at a negative static pressure.

To build up negative pressure in the chamber a variable supply system (vss) consisting of an auxiliary fan is required.

7.3 PPV internal combustion engine test speed

For a PPV powered by an internal combustion engine, the maximum loaded engine r/min allowed by the manufacturer is the maximum engine r/min allowed during the test. The maximum loaded r/min for the engine shall be attested to by letter or certificate from the engine manufacturer's corporate offices. Only stock or production model engines shall be used for testing.

7.4 PPV motor test speed

For a PPV powered by a motor, the maximum speed obtainable by the motor as determined by the fan manufacturer is the maximum motor speed allowed during the test.

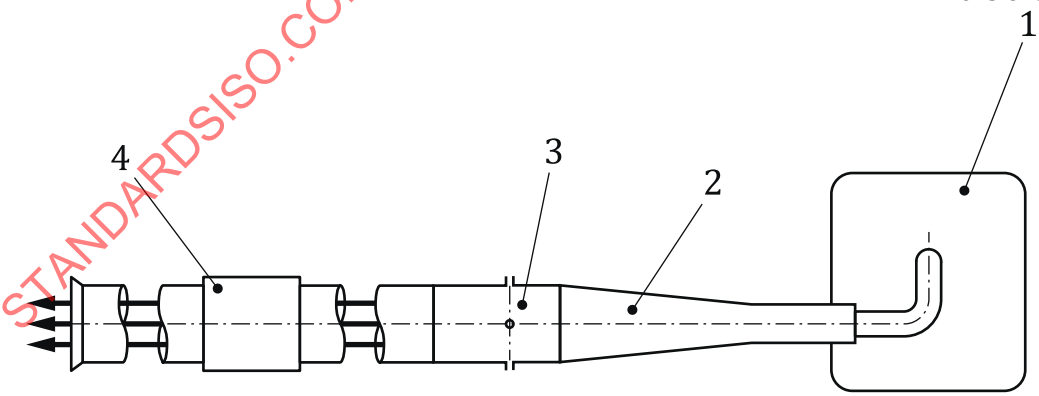
NOTE Either an electric, hydraulic or pneumatic motor can be used.

7.5 Exhaust venting

A PPV driven by an internal combustion engine shall have exhaust fumes vented away from the test area.

Proper precautions shall be taken to minimize the inhalation of fuel or motor exhaust fumes during testing. Any type of fume exhaust system shall be designed so as to not interfere with the airflow in the test area or affect motor performance. The exhaust venting system shall maintain zero static pressure at the exhaust port throughout the test. Figure 2 illustrates a fume exhaust setup.

Dimensions in millimetres



Key

1 PPV Engine
2 exhaust adapter piece
3 connection fitting with piezometer ring
4 variable exhaust system

Figure 2 — Laboratory fume exhaust setup

7.6 Battery powered PPV test

When the PPV is capable of being powered by a battery, the following steps and requirements must be met.

— First, the PPV shall run at the maximum PPV speed under battery power, with a speed (r/min) measurements taken every 5 min, starting at 0 min, until the unit runs out of power.

  — The final measurement should be recorded while the PPV is under power and nearest to the end of life for the batteries.

— Second, when the fan is equipped with a shore power connection, the PPV shall run at the maximum PPV speed and the speed (r/min) will be measured

— Third, a DC power supply shall be used as the power source at the nominal voltage, V_N, stated by the manufacturer.

  — The DC power supply is to be connected to the same location as the battery(-ies) in the previous step.

  — The DC power supply shall not limit the current supplied to the PPV.

— The PPV speed (r/min) shall be measured and flow rate shall be measured according to 7.2 at the nominal voltage, V_N, powered by the DC power supply.

— PPVs shall be tested with fully-charged batteries.

— Charging process of the batteries shall be specified by the battery manufacturer.

8 Calculations

8.1 General

In addition to the following, the manufacturer shall adhere to the requirements of ISO 5801:2017, Clause 15, as applicable.

8.2 Volume flow rate of the PPV

Volume flow rate shall be obtained using ISO 5801:2017, A.4. The PPV airflow rate, q_V, at test conditions is given by Formula (2):

$$q_V = q_{V4} \tag{2}$$

8.3 Static pressure as a function of volume flow rate

The relationship between PPV static pressure and PPV volume flow rate for the range of static pressure tested is represented by the second order polynomial:

$$p_s = K_2 q_{V1}^2 + K_1 q_{V1} + K_0 \tag{3}$$

Coefficients K_0, K_1, and K_2 are provided by the formulae of the trend curve passing through the measured data.

8.4 Volume flow rate at free delivery

Figure 3 shows graphically the curve defined by Formula (3) to the determinations taken in an example test. The free air point of operation is the point where the curve intersects the X axis (p_s = 0).

Mathematically, the PPV volume flow rate at free delivery, q_{Vf}, is calculated from Formula (4):

$$q_{Vf} = \left(\frac{-K_1 - \sqrt{K_1^2 - 4K_0K_2}}{2K_2} \right) \tag{4}$$