International Standard

ISO 5801

Fans — Performance testing using standardized airways

AMENDMENT 1

Ventilateurs — Essais aérauliques sur circuits normalisés

AMENDEMENT 1

Third edition
2017-09

AMENDMENT 1
2025-01

Reference number
ISO 5801:2017/Amd.1:2025(en)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 117, *Fans,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 156, *Ventilation for buildings,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Fans — Performance testing using standardized airways

AMENDMENT 1

Clause 3

Replace definitions 3.8, 3.9 and 3.15 with the following.

3.8

hydraulic diameter

D_{h}

four times the *cross-sectional area* (*3.5*) divided by the perimeter (*E)* which encloses the area

$$D_{\mathrm{h}} = \frac{4A}{E}$$

3.9

hydraulic mean depth

H_{h}

cross-sectional area (*3.5*) divided by the perimeter (*E)* which encloses the area

$$H_{\mathrm{h}} = \frac{A}{E}$$

3.15

isentropic exponent

κ

ratio of the *specific heat at constant pressure* (3.13) to the *specific heat at constant volume* (3.14)

$$\kappa = \frac{c_p}{c_V}$$

4.1 Symbols and abbreviated terms

Replace the symbol $P_{\square}$ with the following

E	Perimeter	3.8 and 3.9	m

Change the definition reference for Polytropic exponent to 15.1.9.2

n_n	Polytropic exponent	15.1.9.2	—

Delete the Perimeter P with missing subscript (Line after Fan air power)

9.3.3 Blow through verification test

Add quotation marks for "Blow through" in the subclause title and replace the content of 9.3.3. with the following.

9.3.3 "Blow through" verification test

This test evaluates the ability of the airflow settling means to provide a substantially uniform airflow ahead of a measurement plane. For this test, equally spaced measurement points are located in a plane $0{,}1D_h$ downstream of the settling means. The number of measurement points shall be in accordance with ISO 5802.

a) Nozzle wall: for tests of settling means upstream of the nozzle wall, the auxiliary fan should be set at its maximum flow rate, the entire nozzle array that induces the most distorted flow shall be open and the inlet shall be unrestricted so that the inlet area shall be equal to the largest area allowed by the cross-sectional area.

b) Test fan: for tests of settling means upstream of the test fan, the auxiliary fan shall be set at its maximum flow rate, half of the nozzle array that induces the most distorted flow shall be open and the outlet shall be open so that the outlet area shall be equal to the largest area allowed by the cross-sectional area.

The flow velocities shall be measured and the average determined. If the maximum velocity is less than 2 m/s or if the maximum velocity value does not exceed 125 % of the average, the settling screens are acceptable.

15.1.5 Simplified sets of formulae, which can be used for $v_{2 \cdot ref} \leq 65$ m/s

Replace the first sentence with the following

As for reference air velocities $v_{2.\text{ref}}$ not greater than 65 m/s, the temperature ratio θ_{sgx} / θ_x does not exceed 1,008 and the Mach factor f_{Mx} does not exceed 1,010 (see Annex P), simplified formulae can be used.

15.1.9.1 General

Replace the content of 15.1.9.1 with the following.

The fan air power can be written as Formula (47):

$$P_\text{u} = q_m \cdot y_\text{f} \tag{47}$$

There are two methods to calculate the air power:

— the first (15.1.9.2) derived from polytropic change of state to take into account the influence of air compressibility;

— the other one (15.1.9.3) for the simplified sets of formulae ($v_{2.\text{ref}} \leq 65$ m/s).

If fan impeller power, P_r, is not measured and cannot be determined from known component efficiencies such as a calibrated motor, the method in 15.1.9.3 shall be used.

NOTE In instances where there exists a strongly non-adiabatic machine, such as high-pressure fans and blowers (where the fan pressure p_f exceeds 10 000 Pa), or systems with a notable temperature disparity between the machine and the surrounding environment $(\Delta\theta > 50\,\text{K})$, the exergetic computation of the fan air power is outlined in Annex O

15.1.9.2

Replace the title and content of 15.1.9.2 with the following.

15.1.9.2 Calculation of fan air power from the polytropic change of state

$$P_u = q_m \cdot y_f \tag{48}$$

with

$$y_f = \frac{n_n}{n_n - 1} \cdot \frac{p_1}{\rho_1} \cdot \left[\left(\frac{p_2}{p_1} \right)^{\frac{n_n - 1}{n_n}} - 1 \right] + \frac{1}{2} \cdot f_{M2} \cdot \left(\frac{q_m}{\rho_2 \cdot A_2} \right)^2 - \frac{1}{2} \cdot f_{M1} \cdot \left(\frac{q_m}{\rho_1 \cdot A_1} \right)^2$$

with the polytropic exponent

$$n_n = \frac{\ln\left(\frac{p_2}{p_1} \right)}{\ln\left(\frac{p_2}{p_1} \right) - \ln\left(\frac{\theta_2}{\theta_1} \right)}$$

If the static outlet temperature θ_2 is not measured, it can be determined with

$$\theta_2 = \theta_1 + \frac{P_r}{q_m \cdot c_p}$$

15.1.9.3

Change the title of 15.1.9.3 and replace the content with the following, and delete Figure 32.

15.1.9.3 Calculation of fan air power for simplified calculation ($v_{2.ref} \leq 65$ m/s)

$$P_u = q_m \cdot y_f \tag{49}$$

with

$$y_f = \frac{p_2 - p_1}{\rho_m} + \frac{1}{2} \cdot \left(\frac{q_m}{\rho_2 \cdot A_2} \right)^2 - \frac{1}{2} \cdot \left(\frac{q_m}{\rho_1 \cdot A_1} \right)^2$$

where

$$\rho_m = \frac{\rho_1 + \rho_2}{2}$$

For $p_f \leq 2\,000$ Pa, ρ_2 can be set equal to ρ_1 and so $\rho_m = \rho_1$.

15.1.9.4

Delete 15.1.9.4.

15.2.2 Fan static air power and static efficiency

Replace the content of 15.2.2 with the following.

The fan static air power can be written as Formula (56):

$$P_{us} = q_m \cdot y_{fs} \tag{56}$$

with

$$y_{fs} = \frac{n_n}{n_n - 1} \cdot \frac{p_1}{\rho_1} \cdot \left[\left(\frac{p_2}{p_1} \right)^{\frac{n_n - 1}{n_n}} - 1 \right] - \frac{1}{2} \cdot f_{M1} \cdot \left(\frac{q_m}{\rho_1 \cdot A_1} \right)^2$$

or

$$y_{fs} = \frac{p_2 - p_1}{\rho_m} - \frac{1}{2} \cdot \left(\frac{q_m}{\rho_1 \cdot A_1} \right)^2$$

for $v_{2.ref} \leq 65$ m/s where

$$\rho_m = \frac{\rho_1 + \rho_2}{2}$$

For $p_f \leq 2\,000$ Pa, ρ_2 can be set equal to ρ_1 and so $\rho_m = \rho_1$.

The various efficiencies are calculated from P_{us} in the same way as in 15.2.1

17.3 Analysis procedure

Replace the third bullet point with the following.

— for each measurement, combine separately the element bias limits (ISO 5168 Type B) and the element precision indices (ISO 5168 Type A) by the root-sum-square (RSS) method; all bias limits and precision indices shall be returned to standard uncertainty by dividing by their coverage factors.

17.4

Replace the title of 17.4 with the following.

17.4 Propagation of uncertainty

17.5

Replace the content of 17.5 with the following.

17.5 Reporting uncertainty

The test report shall state the following for each parameter of interest:

a) the test value of the parameter, e.g. air volume flow rate q_V;

NOTE The best estimate of a parameter is the test value. This estimate can be improved by repeating the test and using the average result.

b) the expanded uncertainty (expressed in absolute or relative terms as appropriate)

c) the confidence level, which is predefined at approximately 95 %;

EXAMPLE $q_V = 5{,}23\ \mathrm{m^3/s} \pm 0{,}05\ \mathrm{m^3/s}$ with 95 % confidence level

17.6 Maximum allowable uncertainties for measurements

Replace Table 12 with the following

Table 12 — Maximum allowable uncertainties of measurement of individual parameters

Parameter	Symbol	Relative expanded uncertainty of measurement	Remarks
Atmospheric pressure	p_a	$U^*_{p_a} = 0,2\ \%$	Corrected for temperature and altitude
Ambient temperature	θ_a	$U^*_{\theta_a} = 0,2\ \%$	Measured near fan inlet or inlet duct, or in a chamber where the velocity is less than 25 m/s
Gauge pressure	p_e	$U^*_{p_e} = 1,4\ \%$	Static pressure greater than 150 Pa: combining 1 % manometer and 1 % reading fluctuation. Uncertainty may be reduced to 1 % or less for high-pressure fans as a function of fluctuations
Differential pressure	Δp	$U^*_{\Delta p} = 1,4\ \%$	As for gauge pressure
Rotational frequency of impeller	n	$U^*_n = 0,5\ \%$	
Power input	P_r	$U^*_{P_r} = 2\ \%$	Measured by torque meter or two-wattmeter method; uncertainty according to class of wattmeter and transformer
Area of a nozzle throat	A_d	$U^*_{A_d} = 0,2\ \%$	
Area of a duct	A_x	$U^*_{A_x} = 0,5\ \%$	
Mass flow rate	q_m	$U^*_{q_m}$	See Annex A for various flow-measurement methods

17.7 Maximum allowable uncertainty of results

Replace “Clause 13” with “Table 13” in the first sentences of the first and second paragraphs.

Add “expanded” in the second sentence:

Also listed is the maximum allowable relative expanded uncertainty for each result, if the test is to qualify as a test conducted under this document.

Replace Table 13 with the following

Table 13 — Maximum allowable uncertainty for the results

Parameter	Symbol	Maximum relative expanded uncertainty of result
Ambient density	ρ_a	$U^*_{\rho_a} = 0,4$ %
Fan temperature rise	$\Delta\theta$	$U^*_{\Delta\theta} = 2,8$ %
Outlet stagnation temperature	θ_{sg2}	$U^*_{\theta_{sg2}} = 0,4$ %
Outlet stagnation density	ρ_{sg2}	$U^*_{\rho_{sg2}} = 0,7$ %
Fan dynamic pressure	p_{fd}	$U^*_{p_{fd}} = 4,0$ %
Fan pressure	p_f	$U^*_{p_f} = 1,4$ %
Fan air power	P_u	$U^*_{P_u} = 2,5$ %
Fan impeller efficiency	η_r	$U^*_{\eta_r} = 3,2$ %
Fan flow rate	q_m or q_V	$U^*_{q_m}$ or $U^*_{q_V} = 2,0$ %

A.4.1 Installation

Replace the content of A.4.1 with the following.

For tests in standardized airways, multiple nozzles can be used within inlet or outlet chambers. The nozzles may be of varying sizes but shall be symmetrically positioned relative to the axis of the chamber, as to both size and radius. The simultaneous use of diametrically opposite nozzles during the test is required to avoid unbalanced flows within the downstream part. The axes of the nozzle(s) and of the chamber in which they are installed shall be parallel.

For multiple nozzles a verification test shall be made (9.3.3) and the nozzles shall be calibrated because of possible non-homogeneity of the incoming flow.

Multiple nozzles shall be positioned such that the centreline of each nozzle is not less than 1,5 *d* from the chamber wall. The minimum distance between the centres of any two nozzles in simultaneous use shall be 3 *d* where *d* is the diameter of the large nozzle.

A.4.2 Geometry

Replace the last sentence with

The nozzle interior surface shall be faired smooth so that a straightedge may be rocked over the surface without clicking and the surface waviness shall not be greater than 0,001 *d* peak-to-peak and have a roughness $R_a \leq 10^{-4} d_h$.

E.2.4 Rolling element bearing friction power

Replace Formula E.3 with

$$P_b = 2\pi \cdot \frac{N}{60} \cdot M \quad \text{(E.3)}$$

Replace the description for C_d after Formula E.4 with

C_d is the equivalent dynamic bearing load, in Newtons which depends on the type of bearing;

Annex F

Replace the content of Annex F with the following.

F.1 General

To determine the efficiency of the fan, the motor input power shall be measured correctly. This is not trivial when VFDs are used, as VFDs produce loss generating higher harmonics (that also stress the insulation of the motor windings, in particular when the cables are long and adequate filters have not been installed). Only the fundamental wave of the output voltage generates useful motor torque that in a meaningful way can be related to the pressure and flow rate produced by the fan. However, the total input power including all harmonic contents need to be taken into account when calculating losses.

F.2 Essentially sinusoidal voltage at the motor terminals

If the output from the VFD is fed to the motor via adequately dimensioned sinusoidal filters, the voltage, current and electrical power shall be measured at the motor terminals with instrumentation, as specified in 12.4.2.2, i.e. as for a motor directly fed by the grid.

However, it must be taken into consideration that the use of sinusoidal filters can result in a voltage drop of 10 % relative to the RMS voltage of the fundamental wave RMS voltage at the output of the VFD. It is the energy at this fundamental frequency that is causing the speed of rotation of the motor. Ensure that the fundamental frequency motor voltage is similar to the rated motor voltage, i.e. the voltage without sinusoidal filters. If the fundamental frequency motor voltage deviates from the rated voltage, increased motor losses will occur and so the test results are invalid.

F.3 Non-sinusoidal voltage at the motor terminals

Where sinusoidal filters are not used between the VFD and the motor terminals, conventional and broadband power analysers and digital voltmeters will capture/register unwanted high frequency switching component power components generated by the VFD, which do not contribute to useful torque at the speed of rotation. This component can register voltages that are between 20 % and 30 % higher than the RMS values of the fundamental wave. It is therefore necessary to use power analysers or voltmeters equipped with (higher order) low-pass line filters that will attenuate the unwanted frequency components of the VSD output and enable accurate measurements to be recorded, without attenuating the signal of the fundamental wave.

Care shall be taken with the installation to ensure that other instrumentation, transducers and sensors are not affected by electromagnetic interference. It may be necessary to use screened/shielded power cables and/or shielded sensor leads to guarantee the accuracy of all other recorded measurements.

F.4 Interpolation motor losses as per IEC 60034-2-3 are known

When the interpolation coefficients cL1 to cL7, first introduced in IEC 60034-2-3:2020-04 section 7, which are to be provided by the manufacturer of the machine, are known and it is practicable, then the procedure described in IEC 60034-2-3:2020-04 section 7 should be used to determine the motor losses.

Add Annex O and Annex P.

Annex O
(informative)

Exergetic calculation of the fan air power P_u

For fans with high pressure build-up ($p_\mathrm{f} > 10\,000\,\mathrm{Pa}$), where the assumption of the adiabatic machine no longer applies, the exergetic calculation of the fan air power P_u is recommended. The exergetic approach is based on the first and second law of thermodynamics. The formula for the calculation of fan air power based on exergy is given in Formula (O.1):

$$P_\mathrm{u} = q_m \cdot y_\mathrm{f} \qquad \text{(O.1)}$$

with

$$y_\mathrm{f} = \Delta ex = c_p \cdot (\theta_2 - \theta_1) - c_p \cdot \theta_a \cdot \left[\ln \frac{\theta_2}{\theta_1} - \ln \left(\frac{p_2}{p_1} \right)^{\frac{\kappa - 1}{\kappa}} \right] + \frac{1}{2} \cdot \left(\frac{q_m}{\rho_2 \cdot A_2} \right)^2 - \frac{1}{2} \cdot \left(\frac{q_m}{\rho_1 \cdot A_1} \right)^2$$

The air temperature, θ_x, at the inlet and outlet as well as the ambient temperature, θ_a, are needed for the calculation of y_f. In contrast to the calculation with isentropic change of state, the outlet temperature should not be calculated, but measured. For temperature measurement, a sensor of tolerance class 1/10 B according to IEC 60751 / DIN EN 60751 is recommended, as the measurement uncertainty increases strongly with lower accuracy.

Annex P
(informative)

Compressible flow effects

This document recognizes that in compressible flow pressure losses in fan and duct work systems are a function of the stagnation pressure. The density of air can then no longer be considered effectively constant throughout the flow field. The pressure p_{sg} has to be determined by integration of the Bernoulli equation for compressible flow. Provided that there are no shock waves, this applies not only to subsonic flow but also supersonic flow.

If we denote conditions at the stagnation point by the suffix p_{sg} we have

$$\frac{v^2}{2}+\frac{\kappa}{\kappa-1}\cdot\frac{p}{\rho}=\frac{\kappa}{\kappa-1}\cdot\frac{p_{sg}}{\rho_{sg}} \tag{P.1}$$

The stagnation or total pressure p_{sg}

$$p_{sg}=p\cdot\frac{\rho_{sg}}{\rho}\left(1+\frac{1}{2}\cdot\frac{\kappa-1}{\kappa}\cdot\rho\cdot\frac{v^2}{p}\right) \tag{P.2}$$

From:

$$\frac{\rho_{sg}}{\rho}=\left(\frac{p_{sg}}{p}\right)^{\frac{1}{\kappa}} \tag{P.3}$$

we obtain

$$p_{sg}=p\cdot\left(1+\frac{1}{2}\cdot\frac{\kappa-1}{\kappa}\cdot\varrho\cdot\frac{v^2}{p}\right)^{\frac{\kappa}{\kappa-1}}=p\cdot\left(1+\frac{\kappa-1}{2}\cdot Ma^2\right)^{\frac{\kappa}{\kappa-1}} \tag{P.4}$$

Compressibility will begin to have a significant effect on fan total pressure when it is greater than 2 kPa and approaches a maximum when the velocity reaches 65 m/s.

For further information see Reference [9].

Bibliography

Add the following entry to the bibliography.

[9] *The Measurement of Airflow by E. Ower and R.C. Pankhurst* – Pergamon Press 1977 ISBN 0080212824

ICS 23.120

Price based on 9 pages

iso.org