INTERNATIONAL STANDARD

ISO 13350

First edition
1999-10-01

Industrial fans — Performance testing of jet fans

Ventilateurs industriels — Essai de performance des ventilateurs accélérateurs

Reference number
ISO 13350:1999(E)

Contents

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Printed in Switzerland

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 13350 was prepared by Technical Committee ISO/TC 117, *Industrial fans*.

Annexes A, B, C and D of this International Standard are for information only.

Introduction

The need for this new standard has been evident for some time. The use of the so-called jet fan to assist in controlling the quality of air in vehicle and train tunnels has become increasingly popular. The longitudinal method of ventilation can show advantages in initial cost and running cost compared to alternative systems, and smoke control in emergency conditions can be readily provided. At present, there is no published national or international standard for the performance testing of jet fans.

This International Standard, which forms part of the ISO/TC 117 series of fan standards, deals with the determination of those performance criteria essential to the correct application of jet fans. In describing the test and rating procedures, numerous references are made to ISO 5801 as well as to other relevant International Standards.

Industrial fans — Performance testing of jet fans

1 Scope

This International Standard deals with the determination of those technical characteristics needed to describe all aspects of the performance of jet fans as defined in ISO 13349. It does not cover those fans designed for ducted applications, nor those designed solely for air circulation, e.g. ceiling fans and table fans.

The test procedures described in this International Standard relate to laboratory conditions. The measurement of performance under on-site conditions is not included.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Member of IEC and ISO maintain registers for currently valid International Standards.

ISO 1940-1:1986, *Mechanical vibration — Balance quality requirements of rigid rotors — Part 1: Determination of permissible residual unbalance*.

ISO 5801:1997, *Industrial fans — Performance testing using standardized airways*.

ISO 13347:—[1], *Industrial fans — Determination of fan sound power level under standardized laboratory conditions.*

ISO 13349:—[1], *Industrial fans — Vocabulary and definitions of categories.*

ISO 14695:—[1], *Industrial fans — Vibration measurement method.*

IEC 60034-2:1972, *Rotating electrical machines — Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicules).*

IEC 60034-14:1996, *Rotating electrical machines — Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher — Measurement, evaluation and limits of the vibration severity.*

[1] To be published.

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 13349, ISO 5801 and the following apply.

3.1
effective fan dynamic pressure
p_d
conventional quantity representative of the dynamic component of the fan output, calculated, in the particular case of a jet fan, from the effective fan outlet velocity and the inlet density

NOTE The effective fan dynamic pressure will not be the same as the average of the dynamic pressures across the section because it excludes from consideration that part of the dynamic energy flux which is due only to departures from uniform axial velocity distribution.

3.2
effective fan outlet area
A_{eff}
in the particular case of a jet fan, outlet area with deductions for motors, fairings or other obstructions

NOTE 1 If the silencer centrebody reaches the outlet plane of the fan, then the effective fan outlet area is defined as the annulus area at the fan outlet plane as shown in figure 1a).

NOTE 2 If the fan has a silencer without centrebody [see figure 1 b)], the effective fan outlet area will be close to the cross-sectional area inside the silencer in order to clear any exit bellmouth form.

NOTE 3 If the centrebody (motor or silencer core) does not extend to the outlet plane, the effective fan outlet area will approach the annulus area between the casing and the motor, but with some increase, as defined in figure 1c), for the distance between the centrebody and the outlet. Where the motor is on the upstream side, figure 1c) is applied to the impeller hub rather than the motor, as illustrated.

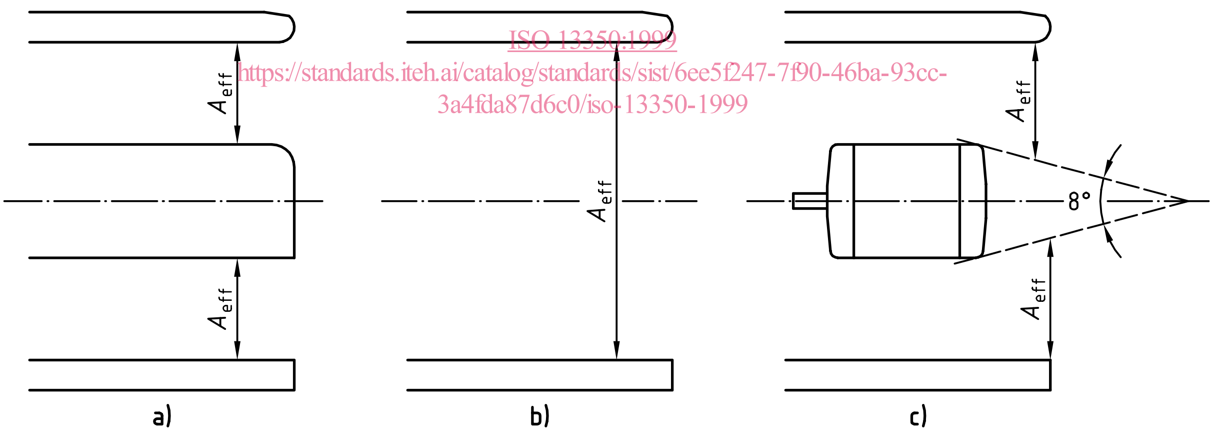


Figure 1 — Effective fan outlet area

3.3
effective fan outlet velocity
v_{eff}
calculated from the thrust, the inlet density and the effective fan outlet area as detailed in 11.2

3.4
fan outlet velocity
in the particular case of a jet fan, inlet volume flow divided by effective fan outlet area, A_{eff}

3.5
fan air power
conventional power output; in the particular case of a jet fan, product of inlet volume flow and effective fan dynamic pressure

3.6
impeller tip speed
u
peripheral speed of the impeller blade tips

3.7
thrust
T_m, T_c
fan thrust measured or calculated in accordance with this International Standard

3.8
thrust/power ratio
r_t
thrust divided by impeller power

NOTE An alternative definition of thrust/power ratio which has sometimes been used: thrust divided by motor input power. This definition is deprecated, as it will vary according to the motor manufacturer used. It also results in a lower value, as the motor losses are included.

3.9
fan guard
guard designed to prevent the ingestion of relatively large foreign bodies, such as drink cans, and sometimes fitted to the inlet and outlet of jet fans

NOTE Guards can have a marked effect on the thrust performance and noise level. Where they are specified, measurements should be made with these guards in place.

3.10
chamber
airway in which the air velocity is small compared with that at the fan inlet or outlet

3.11
test enclosure
room, or other space protected from draught, in which the fan and test airways are situated

3.12
impeller balance grade
grade G as specified in ISO 1940-1

3.13
fan vibration velocity
unfiltered r.m.s. vibration velocity over the frequency range 10 Hz to 10 kHz measured in accordance with this International Standard and with ISO 14695

3.14
fan impeller efficiency
η_R
fan air power divided by impeller power

3.15
overall efficiency
η_E
fan air power divided by motor input power

3.16
sound pressure level
L_p
ten times the logarithm to the base 10 of the ratio of the square of the sound pressure radiated by the sound source under test to the square of the reference sound pressure

3.17
sound power level
L_W
ten times the logarithm to the base 10 of the ratio of the sound power radiated by the sound source under test to the reference sound power

3.18
inlet sound power level
L_{W1}
sound power level of the fan determined at the fan inlet

3.19
outlet sound power level
L_{W2}
sound power level of the fan determined at the fan outlet

3.20
frequency range of interest
for general purposes, the frequency range including the octave bands with centre frequencies between 63 Hz and 8 000 Hz and the one-third octave bands with centre frequencies between 50 Hz and 10 000 Hz

4 Symbols and abbreviations

The following symbols and units shall apply for the parameters listed.

Parameter	Symbol	Unit
Effective fan outlet area	A_{eff}	m^2
Nominal fan diameter	D_R	m
Length of upstream chamber side	D_3	m
Sound pressure level	L_p	dB (ref. 20 µPa)
Sound power level	L_W	dB (ref. 1 pW)
Inlet sound power level	L_{W1}	dB (ref. 1 pW)
Outlet sound power level	L_{W2}	dB (ref. 1 pW)
rotational speed	N	r/s
Differential pressure across a flow measuring device	p	P_a
Effective fan dynamic pressure	p_d	P_a
Volume flow	q_V	m^3/s
Impeller balance grade (ISO 1940-1)	G	µm
Thrust/power ratio	r_t	N/kW
Calculated thrust	T_c	N
Measured thrust	T_m	N
Impeller tip speed (see 3.6)	u	m/s
Effective fan outlet velocity	v_{eff}	m/s
Mean throughflow velocity in a tunnel at a specified section	v_t	m/s
Inlet density taken as equal to the density in the test enclosure	ρ_a	kg/m^3
Overall efficiency	η_E	—
Motor efficiency	η_M	—
Fan impeller efficiency	η_R	—

5 Characteristics to be measured

5.1 General

In order that a jet type fan be correctly applied and give satisfactory performance and reliability in service, it is necessary to determine a number of technical performance characteristics in addition to knowing the more obvious mechanical features such as mass, overall dimensions and installation dimensions.

5.2 Thrust

Friction on the tunnel walls, inlet and outlet losses and sometimes traffic drag, combined with climatic effects at tunnel portals, create a pressure drop through the tunnel. The pressure drop is matched by the sum of the pressure increases by the jet fans due to the momentum transfer between fan discharge airflow and airflow in the tunnel. As it is impossible to measure the momentum of the fan discharge airflow, and the rate of change in momentum is equal and opposite to the thrust, thrust is measured instead.

5.3 Input power

In order to calculate the cost of operating the jet fans in a tunnel, and there may be a substantial number, it is necessary to know the input power to the fan motor.

5.4 Sound levels

Sound levels, usually at inlet and outlet, are established in order to ensure that the jet fan and silencer combination is optimized to match the tunnel sound level requirements.

NOTE The fan manufacturer can only guarantee the sound power level of the fan. The sound pressure in the tunnel will depend on the size and sound absorption characteristics of the tunnel, which are outside the fan manufacturer's responsibility.

5.5 Vibration velocity

For reasons of safety, reliability and maintainability, it is essential that a realistic vibration velocity is specified and recorded on tunnel fans. These shall be measured at the support points in accordance with ISO 14695.

5.6 Volume flowrate

Volume flowrate need only be measured if required for contractual reasons. It is the effective fan outlet velocity which is used to evaluate the optimum number, size and spacing of jet fans in a tunnel, and is calculated in accordance with 11.2.

6 Instrumentation and measurements

6.1 Dimensions and areas

The measurement of dimensions and the determination of areas shall be in accordance with clause 10 of ISO 5801:1997.

6.2 Rotational speed

The rotational speed of the impeller shall be determined in accordance with clause 8 of ISO 5801:1997.

6.3 Thrust

6.3.1 Force balance systems

By the use of calibrated weights, force balance systems shall permit the determination of force or thrust with an uncertainty of ± 5 %.

6.3.2 Force transducers

After calibration by the use of calibrated weights, force transducers shall permit the determination of thrust with an uncertainty of ± 5 %.

6.4 Input power

Determination of the power input to the electric motor or to the impeller shall be carried out in accordance with clause 9 of ISO 5801:1997.

6.5 Sound level

The sound-level measuring system, including microphones, windshields, cables, amplifiers and frequency analyser, shall be in accordance with the requirements given in ISO 13347.

6.6 Vibration velocity

Instruments to measure r.m.s. vibration velocity shall be used to record fan vibration velocities. These shall be in accordance with ISO 14695.

6.7 Volume flowrate

6.7.1 Instruments for the measurement of pressure.

Manometers for the measurement of differential pressure, and barometers for the measurement of atmospheric pressure in the test enclosure, shall comply with the requirements of clause 5 of ISO 5801:1997.

6.7.2 Instruments for the measurement of temperature.

Thermometers shall comply with the requirements of clause 7 of ISO 5801:1997.

7 Determination of thrust

7.1 General

There are two basic configurations acceptable for the determination of fan thrust: suspended configuration and supported configuration. In addition to the need to measure force accurately, the first method requires that the suspension elements be kept precisely vertical and parallel with a vertical plane(s) passing through the fan axis, whilst the second method requires accurate construction and levelling of the support assembly. In either case, thrust shall be determined by the use of calibrated weights, spring balance or force transducer.

7.2 Suspended configuration

Figures 2 and 3 show typical arrangements of suspended configurations. The fan is suspended from a framework or gantry with the suspension elements at least one fan-diameter long. The frame should allow free airflow, particularly at the fan inlet. Below or surrounding the fan is a rigid framework which serves a threefold function:

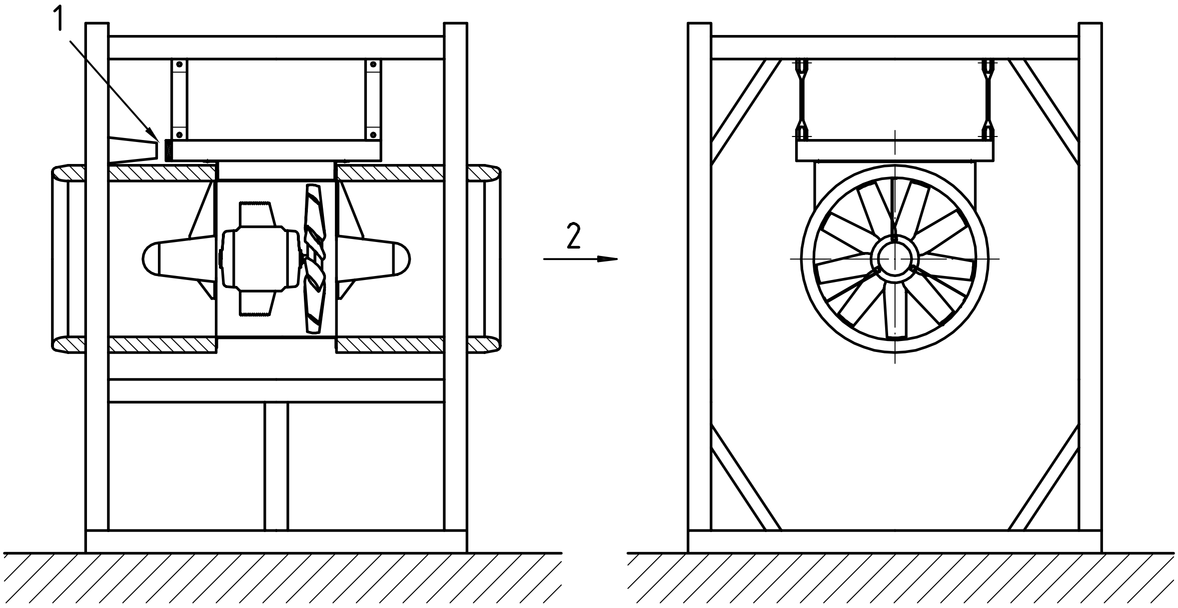
a) provide the reference point for the fan test assembly under static conditions,

b) provide support for a pulley system to take calibrated weights or a spring balance, and

c) provide a reaction point for a force transducer.

Under operating conditions, the measuring system loads are adjusted to return the fan to the static positions, to within ± 2 mm, and thus ensure that the suspension elements are precisely vertical. The thrust can then be measured directly.

NOTE It should be noted that with the thrust/weight ratios typical a of jet fan, it is doubtful whether the desired accuracy of thrust measurement can be attained by other means, such as measuring the angle of the suspension elements from the vertical or the change in height between the fan switched off and operational, and then calculating the thrust.



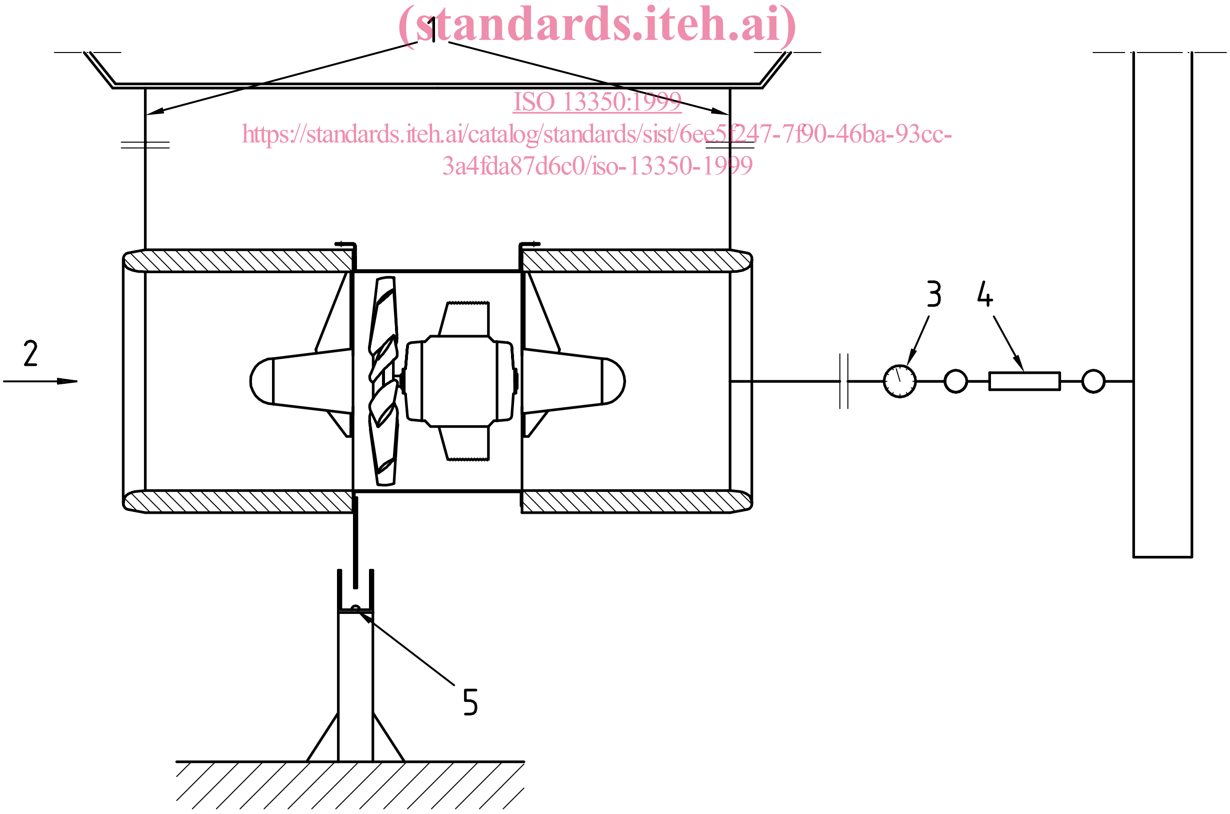
Key

1 Adjustable position of transducer/measuring system

2 Air flow

NOTE The fan should be accurately levelled prior to testing.

Figure 2 — Thrust measuring layout (suspended method 1)



Key

1 Suspension cables

2 Air flow

3 Spring balance

4 Adjustable restraint

5 Reference point

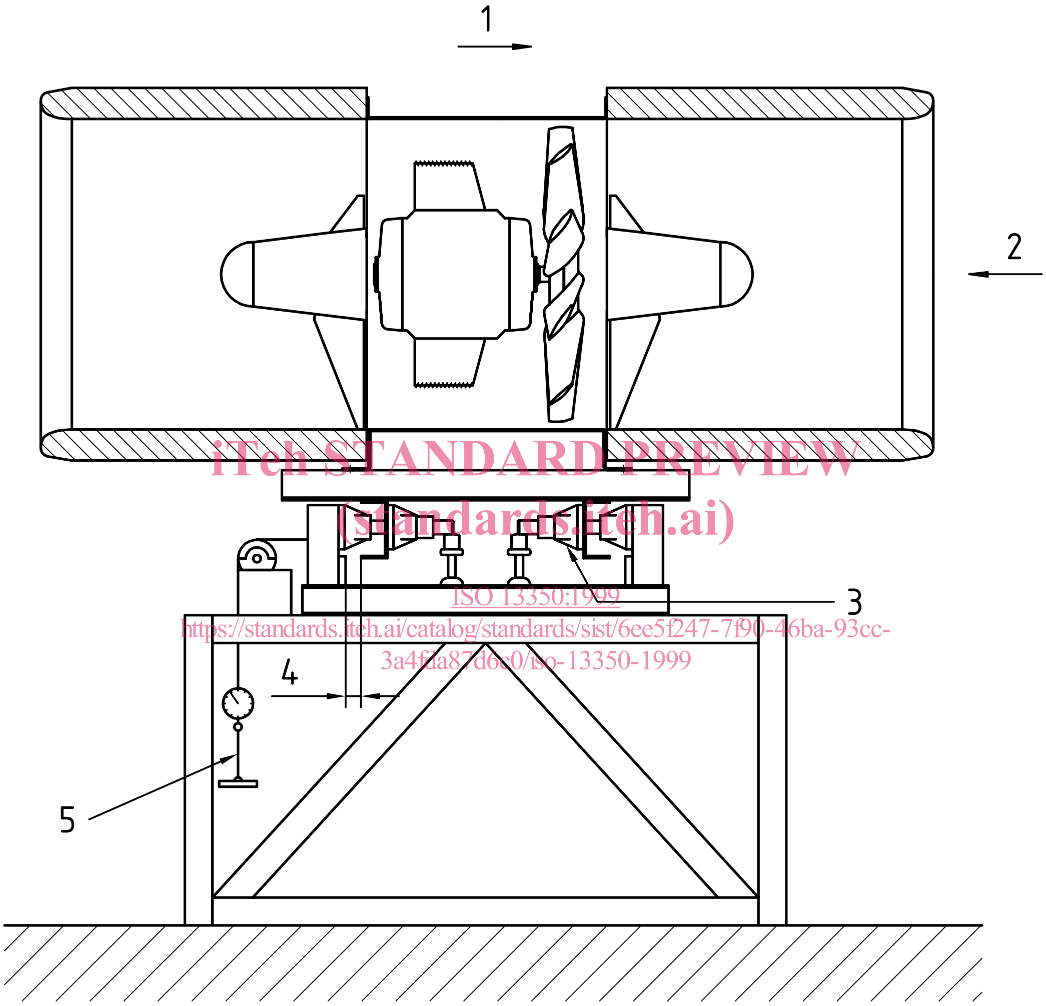
NOTE The fan should be accurately levelled prior to testing.

Figure 3 — Thrust measuring layout (suspended method 2)

7.3 Supported configuration

Arrangements of the supported configuration are shown in figures 4, 5 and 6. The fan is supported, via low-friction linear bearings or leaf springs, on a rigid framework. The fan, to an extent limited by stops, is free to move in either direction. Before commencing any tests, the assembly shall be carefully levelled, in each direction, such that the same effort is required to move the assembly along the axis of the fan in either direction.

Under operating conditions, the measuring system loads are adjusted to ensure the movement is not being restrained by the stops. Thrust can then be measured directly. In the case of the use of a force transducer, the fan can be allowed to abut the sensor directly.



Key

1 Direction of fan movement
2 Air flow
3 Linear bearings
4 Fan movement possible
5 Thrust gauge (measurement in kg direct off gauge + mass of gauge in suspension = thrust)

NOTE The fan should be accurately levelled prior to testing.

Figure 4 — Thrust measuring layout (supported method 1)