INTERNATIONAL STANDARD

ISO 5801

Second edition
2007-12-15

Industrial fans — Performance testing using standardized airways

Ventilateurs industriels — Essais aérauliques sur circuits normalisés

Reference number
ISO 5801:2007(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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

ISO 5801 was prepared by Technical Committee ISO/TC 117, *Industrial fans*.

This second edition cancels and replaces the first edition (ISO 5801:1997), which has been technically revised.

Introduction

This International Standard is the result of almost 30 years of discussion, comparative testing and detailed analyses by leading specialists from the fan industry and research organizations throughout the world.

It was demonstrated many years ago that the codes for fan performance testing established in different countries do not always lead to the same results.

The need for an International Standard has been evident for some time and Technical Committee ISO/TC 117 started its work in 1963. Important progress has been achieved over the years and, although the International Standard itself was not yet published, the successive revisions of various national standards led to much better agreement among them.

It has now become possible to complete this International Standard by agreement on certain essential points. It must be borne in mind that the test equipment, especially for large fans, is very expensive and it was necessary to include in this International Standard many setups from various national codes in order to authorize their future use. This explains the sheer volume of this document.

Essential features of this International Standard are as follows:

a) Categories of installation

Since the connection of a duct to a fan outlet and/or inlet modifies its performance, it has been agreed that four standard installation categories should be recognized (see 18.2).

A fan adaptable to more than one installation category will have more than one standardized performance characteristic. Users should select the installation category closest to their application.

b) Common parts

The differences obtained by testing the same fan according to various test codes depend chiefly on the flow pattern at the fan outlet and, while often minor, can be of substantial significance. There is general agreement that it is essential that all standardized test airways to be used with fans have portions in common adjacent to the fan inlet and/or outlet sufficient to ensure consistent determination of fan pressure.

Geometric variations of these common segments are strictly limited.

However, conventional agreement has been achieved for some particular situations:

1) For fans where the outlet swirl is less than 15°, i.e. centrifugal, cross-flow or vane-axial fans, it is possible to use a simplified outlet duct without straightener when discharging to the atmosphere or to a measuring chamber. If there is any doubt about the degree of swirl, then a test should be performed to establish how much is present.

2) For large fans (outlet diameter exceeding 800 mm), it may be difficult to carry out the tests with standardized common airways at the outlet including a straightener. In this case, by mutual agreement between the parties concerned, the fan performance may be measured using a duct of length $3D$ on the outlet side. Results obtained in this way may differ to some extent from those obtained using the normal category D installation, especially if the fan produces a large swirl. Establishment of a possible value of differences, is still a subject of research.

c) Calculations

Fan pressure is defined as the difference between the stagnation pressure at the outlet of the fan and the stagnation pressure at the inlet of the fan. The compressibility of air must be taken into account when high accuracy is required. However, simplified methods may be used when the reference Mach number does not exceed 0,15.

A method for calculating the stagnation pressure and the fluid or static pressure in a reference section of the fan, which stemmed from the work of the ad hoc group of Subcommittee 1 of ISO/TC 117, is given in Annex C.

Three methods are proposed for calculation of the fan power output and efficiency. All three methods give very similar results (difference of a few parts per thousand for pressure ratios equal to 1,3).

d) Flow rate measurement

Determination of flow rate has been completely separated from the determination of fan pressure. A number of standardized methods may be used.

Industrial fans — Performance testing using standardized airways

1 Scope

This International Standard deals with the determination of the performance of industrial fans of all types except those designed solely for air circulation, e.g. ceiling fans and table fans.

Estimates of uncertainty of measurement are provided and rules for the conversion, within specified limits, of test results for changes in speed, gas handled and, in the case of model tests, size, are given.

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.

ISO 3966, *Measurement of fluid flow in closed conduits — Velocity area method using Pitot static tubes*

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 5168, *Measurement of fluid flow — Procedures for the evaluation of uncertainties*

ISO 5221, *Air distribution and air diffusion — Rules to methods of measuring air flow rate in an air handling duct*

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 vehicles)*

IEC 60051-2, *Direct acting indicating analogue electrical measuring instruments and their accessories — Part 2: Special requirements for ammeters and voltmeters*

IEC 60051-3, *Direct acting indicating analogue electrical measuring instruments and their accessories — Part 3: Special requirements for wattmeters and varmeters*

IEC 60051-4, *Direct acting indicating analogue electrical measuring instruments and their accessories — Part 4: Special requirements for frequency meters*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5168 and the following apply.

NOTE All the symbols used in this International Standard are listed with their units in Clause 4.

3.1
area of the conduit section
A_x
area of the conduit at section x

3.2
fan inlet area
A_1
surface plane bounded by the upstream extremity of the air-moving device

NOTE Fan inlet area is, by convention, taken as the gross area in the inlet plane inside the casing.

3.3
fan outlet area
A_2
surface plane bounded by the downstream extremity of the air-moving device

NOTE Fan outlet area is, by convention, taken as the gross area in the outlet plane inside the casing.

3.4
temperature
T
air or fluid temperature measured by a temperature sensor

NOTE Temperature is expressed in degrees Celsius.

3.5
absolute temperature
Θ
thermodynamic temperature

$$\Theta = T + 273{,}15$$

NOTE In this document, Θ represents the absolute temperature in kelvin and T the temperature in degrees Celsius.

3.6
specific gas constant
R
for an ideal dry gas, the equation of state is written

$$\frac{p}{\rho} = R\Theta$$

NOTE For dry air, $R = 287\ \text{J·kg}^{-1}\text{·K}^{-1}$.

3.7
isentropic exponent
κ
for an ideal gas and an isentropic process

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

$$\frac{p}{r^{\kappa}} = \text{constant}$$

NOTE For atmospheric air, $\kappa = 1{,}4$.

3.8
specific heat capacity at constant pressure
c_p
for an ideal gas

$$c_p = \frac{k}{k-1} R$$

NOTE Specific heat capacity is normally expressed in joules per (kilogram kelvin).

3.9
specific heat capacity at constant volume
c_V
for an ideal gas

$$c_V = \frac{1}{\kappa - 1} R$$

NOTE Specific heat capacity is normally expressed in joules per (kilogram kelvin).

3.10
compressibility factor
Z

NOTE 1 For an ideal gas, $Z = 1$.

NOTE 2 For a real gas,

$$Z = \frac{p}{\rho R \Theta}$$

where

Z is a function of the ratios p/p_c and Θ/Θ_c where:

p_c is the critical pressure of the gas;

Θ_c is the critical temperature of the gas.

3.11
stagnation temperature at a point
Θ_{sg}
absolute temperature which exists at an isentropic stagnation point for ideal gas flow without addition of energy or heat

NOTE 1 The stagnation temperature is constant along an airway and, for an inlet duct, is equal to the absolute ambient temperature in the test enclosure.

NOTE 2 Stagnation temperature is expressed in degrees Celsius.

NOTE 3 For Mach numbers less than 0,122 obtained for standard air with duct velocities less than 40 m/s, the stagnation temperature is virtually the same as the total temperature.

3.12
fluid temperature at a point
static temperature at a point
Θ
absolute temperature registered by a thermal sensor moving at the fluid velocity

NOTE 1 For real gas flow

$$\Theta = \Theta_{sg} - \frac{v^2}{2c_p}$$

where v is the fluid velocity, in metres per second, at a point.

NOTE 2 These temperatures are expressed in degrees Celsius.

NOTE 3 In a duct, when the velocity increases, the static temperature decreases.

3.13
dry bulb temperature
T_d
air temperature measured by a dry temperature sensor in the test enclosure, near the fan inlet or airway inlet

NOTE This temperature is expressed in degrees Celsius.

3.14
wet bulb temperature
T_w
air temperature measured by a temperature sensor covered by a water-moistened wick and exposed to air in motion

NOTE 1 When properly measured, it is a close approximation to the temperature of adiabatic saturation.

NOTE 2 This temperature is expressed in degrees Celsius.

3.15
stagnation temperature at a section x
Θ_{sgx}
mean value, over time, of the stagnation temperature averaged over the area of the specified airway cross-section

NOTE This temperature is expressed in kelvin.

3.16
static or fluid temperature at a section x
Θ_x
mean value, over time, of the static or fluid temperature averaged over the area of the specified airway cross-section

NOTE This temperature is expressed in kelvin.

3.17
absolute pressure at a point
absolute pressure
p
pressure, measured with respect to absolute zero pressure, which is exerted at a point at rest relative to the air around it

NOTE This pressure is normally expressed in pascals.

3.18
atmospheric pressure
p_a
absolute pressure of the free atmosphere at the mean altitude of the fan

NOTE This pressure is normally expressed in pascals.

3.19
gauge pressure
p_e
value of the pressure when the datum pressure is the atmospheric pressure at the point of measurement

NOTE 1 Gauge pressure may be negative or positive

$$p_e = p - p_a$$

NOTE 2 This pressure is normally expressed in pascals.

3.20
absolute stagnation pressure at a point
p_{sg}
absolute pressure which would be measured at a point in a flowing gas if it were brought to rest via an isentropic process given by the following equation:

$$p_{sg} = p \left(1 + \frac{\kappa - 1}{2} Ma^2\right)^{\frac{\kappa}{\kappa - 1}}$$

NOTE 1 Ma is the Mach number at this point (see 3.23).

NOTE 2 This pressure is normally expressed in pascals.

NOTE 3 For Mach numbers less than 0,122 obtained for standard air with duct velocities less than 40 m/s, the stagnation pressure is virtually the same as the total pressure.

3.21
Mach factor
f_{Mx}
correction factor applied to the dynamic pressure at a point, given by the expression

$$f_{Mx} = \frac{p_{sg} - p}{p_d}$$

NOTE The Mach factor may be calculated by:

$$f_{Mx} = 1 + \frac{Ma^2}{4} + \frac{(2 - \kappa)\, Ma^4}{24} + \frac{(2 - \kappa)(3 - 2\kappa)\, Ma^6}{192} + \ldots$$

3.22
dynamic pressure at a point
p_d
pressure calculated from the velocity and the density ρ of the air at the point given by the following equation:

$$p_d = \rho \frac{v^2}{2}$$

NOTE This pressure is normally expressed in pascals.