INTERNATIONAL STANDARD

ISO 10302

First edition
1996-12-15

Acoustics — Method for the measurement of airborne noise emitted by small air-moving devices

Acoustique — Méthode de mesurage du bruit aérien émis par les petits équipements de ventilation

Reference number
ISO 10302:1996(E)

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 10302 was prepared jointly by Techncial Committees ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*, and ISO/TC 117, *Industrial fans*.

Annexes A and B form an integral part of this International Standard. Annexes C and D are for information only.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet: central@isocs.iso.ch
X.400: c=ch; a=400net; p=iso; o=isocs; s=central
Printed in Switzerland

Introduction

This International Standard specifies in detail a laboratory method for determining and reporting the airborne noise emissions of small air-moving devices used primarily for cooling electronic equipment, such as computer and business equipment. To provide compatibility with measurements of noise emitted by such equipment, this International Standard uses the noise emission descriptors and sound power measurement methods of ISO 7779. The descriptor of overall noise emission of the air-moving device under test is the A-weighted sound power level. The one-third-octave-band sound power level is the detailed descriptor of the noise emission. Octave band sound power levels may be provided in addition to the one-third-octave-band sound power levels.

This page intentionally left blank

Acoustics - Method for the measurement of airborne noise emitted by small air-moving devices

1 Scope

1.1 This International Standard specifies a method for measuring the airborne noise emitted by small air-moving devices such as those used for cooling electronic, electrical and mechanical equipment. These air-moving devices include such types as propeller fans, tube-axial fans, vane-axial fans, centrifugal blowers, transverse blowers, cabinet blowers and variations of these types.

This International Standard describes a method and the test apparatus for determining and reporting the airborne noise emitted by small air-moving devices as a function of the airflow and the fan static pressure developed by the air-moving device on the test apparatus. It is intended for use by air-moving device manufacturers, by manufacturers who use air-moving devices for cooling electronic equipment and similar applications, and by testing laboratories on behalf of these manufacturers. Results of measurements made in accordance with this International Standard are expected to be used for engineering information and performance verification, and the method may be cited in purchase specifications and contracts between buyers and sellers. The ultimate purpose of the noise emission measurements is to provide data to assist the designers of electronic, electrical or mechanical equipment which contains one or more air-moving devices.

1.2 This International Standard is applicable to small air-moving devices used for cooling electronic equipment and for similar applications where the total sound power level of the air-moving device is of interest. Experimental data show that this method is useful up to an airflow of 1 m^3/s and up to a fan static pressure of 750 Pa.

This International Standard is suitable for type tests and provides a method for air-moving device manufacturers, equipment manufacturers and testing laboratories to obtain comparable results. The method defined in this International Standard, by reference to ISO 7779, provides for determination of sound power levels in a qualified environment, using either a comparison method in a reverberation room based on ISO 3741 or ISO 3742 or a direct method in essentially free-field conditions over a reflecting plane based on ISO 3744 or ISO 3745. The method specified in this International Standard may be applied to air-moving devices which radiate broad-band noise, narrow-band noise, or noise that contains discrete frequency components.

The method specified in this International Standard permits the determination of noise emission levels for an individual unit under test. If these levels are determined for several units of the same production series, the results may be used to determine a statistical value for the production series using methods described in ISO 7574-4 or in ISO 9296.

CAUTION - Vibration, flow disturbances, insertion loss and other phenomena may alter radiated sound power in the actual application; therefore, the results of measurements made in accordance with this International Standard may differ from the results obtained when air-moving devices are installed in equipment.

NOTE 1 This International Standard does not describe measurement of the structure-borne noise generated by air-moving devices, and it does not cover measurement of the aerodynamic performance of such devices.

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. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 266:-[1)], *Acoustics - Preferred frequencies for measurements*.

ISO 3741:1988, *Acoustics - Determination of sound power levels of noise sources - Precision methods for broad-band sources in reverberation rooms*.

ISO 3742:1988, *Acoustics - Determination of sound power levels of noise sources - Precision methods for discrete-frequency and narrow-band sources in reverberation rooms*.

ISO 3744:1994, *Acoustics - Determination of sound power levels of noise sources using sound pressure - Engineering method in an essentially free field over a reflecting plane*.

ISO 3745:1977, *Acoustics - Determination of sound power levels of noise sources - Precision methods for anechoic and semi-anechoic rooms.*

ISO 7779:1988, *Acoustics - Measurement of airborne noise emitted by computers and business equipment*.

ISO 5801:-[2], *Industrial fans - Performance testing using standardized airways.*

3 Definitions

For the purpose of this International Standard, the following definitions apply:

3.1 sound power level, L_W: Ten times the logarithm to the base 10 of the ratio of a given sound power to the reference sound power. It is expressed in decibels. The reference sound power is 1 pW (= 10^{-12} W).

The frequency weighting or the width of the frequency band used shall be indicated, for example the A-weighted sound power level, octave band sound power level, one-third-octave-band sound power level, etc.

NOTE 2 ISO 9296 requires that the declared values of the A-weighted sound power levels of computer and business equipment be expressed in bels (B), using the identity 1 B = 10 dB. This requirement applies primarily to equipment and functional units thereof which are used in offices and office-like environments and in computer installations, rather than to the constituent components of such equipment. Some manufacturers have also found it convenient to express the A-weighted sound power levels of devices, components and subassemblies, including small air-moving devices, in bels.

3.2 air-moving device: A device for moving air which utilizes a rotating impeller driven by an electric motor with electronic or mechanical command.

NOTES

3 An air-moving device has at least one inlet opening and at least one outlet opening. The openings may or may not have elements for connection to ductwork or to other parts of the airflow path.

4 Tests may be run with a particular frame, motor and rotor, but with different accessories (e.g. finger guards). For the purposes of this International Standard, each such configuration is referred to as an air-moving device.

3.3 fan: An air-moving device.

NOTE 5 Within some industries, including information technology, the unmodified term "fan" means "axial flow air-moving device," and the unmodified term "blower" means "centrifugal device". In this International Standard, the term "fan" is used to mean "air-moving device" and does not necessarily imply axial flow. Modifiers (such as axial, centrifugal or mixed-flow) will be added if it is necessary to distinguish between types. This usage is adopted for consistency with ISO 5801.

3.4 test plenum: A structure onto which the air-moving device under test is mounted for noise emission measurements.

---

[1] To be published (Revision of ISO 266:1975)
[2] To be published

NOTE 6 The plenum provides a flow resistance to the air-moving device, but permits sound from the air-moving device to escape with only minimal attenuation. Thus, the sound power radiated by the air-moving device may be determined from acoustical measurements made outside the test plenum.

3.5 air-moving device performance curve: The presentation of fan static pressure as a function of volume flow rate under standard air conditions and constant operating voltage and frequency in accordance with ISO 5801.

3.6 point of operation: Point on the air-moving device performance curve corresponding to a particular volume flow rate.

NOTE 7 The point of operation is controlled during a test by adjusting the "slider" on the test plenum exit port assembly.

3.7 overall static efficiency of air-moving device: The volume flow rate multiplied by the fan static pressure and divided by the input electrical power. The expression for overall static efficiency, as a percentage is:

$$\eta_{os} = \frac{p_{sF} \times q_V \times 100}{P_0}$$

where

η_{os} is the overall static efficiency, as a percentage;

p_{sF} is the fan static pressure, in pascals;

q_V is the volume flow rate, in cubic metres per second;

P_0 is the motor input power, in watts (true power, not including reactive component), supplied at the terminals of the electric drive motor.

NOTE 8 The air-moving device is defined to include the motor, impeller and frame; therefore, the overall static efficiency includes both the electromechanical efficiency of the motor and the aerodynamic efficiency of the impeller and frame.

3.8 standard air density: Density under standard conditions, 1,201 kg/m^3. For the purposes of this International Standard, standard conditions are 20 °C, 50 % relative humidity, and 1,013 x 10^5 Pa barometric pressure.

3.9 frequency range of interest: The range extending from the 100 Hz one-third-octave band to the 10 kHz one-third-octave band, inclusive. The range and centre frequencies of these one-third-octave bands are specified in ISO 266.

4 Measurement uncertainty

Measurements made in conformance to the method of this International Standard are believed to yield standard deviations of reproducibility that are approximately equal to those given in table 1.

Table 1 - Estimated values of the standard deviation of reproducibility of sound power levels of air-moving devices determined in accordance with this International Standard

Octave-band centre frequency Hz	One-third-octave-band centre frequency Hz	Standard deviation of reproducibility dB
125 250 500 to 4 000 8 000	100 to 160 200 to 315 400 to 6 300 8 000 10 000	4,0 2,5 1,5 2,5 3,0
A-weighted		1,5

The estimated standard deviation of reproducibility in determining A-weighted sound power levels is 1,5 dB.

NOTES

9 These estimates are based on interlaboratory tests of tube-axial and forward-curved centrifugal fans in the capacity range 0,016 m^3/s to 0,456 m^3/s, conducted at ten laboratories following the guidelines provided by ISO 5725.

10 The standard deviations given in table 1 are standard deviations of reproducibility which reflect the cumulative effects of all causes of measurement uncertainty, including variations from laboratory to laboratory, but excluding variations in the sound power level from specimen to specimen. The standard deviation of repeatability for the same specimen and the same laboratory measurement conditions may be considerably smaller than the uncertainties given in table 1.

5 Design and performance requirements for test plenum

5.1 General

The described design is intended to meet the limits for maximum volume flow rate and maximum fan static pressure stated. The design provides an acoustically transparent, adjustable flow resistance to the air-moving device.

The reference design of the plenum is described and shown in 5.1 to 5.6 and figures 1 to 8. Also addressed in these clauses and elsewhere in this International Standard are permitted variations from this design, primarily the option of reducing the linear dimensions of the frame and some dimensions of other parts, while maintaining geometric proportions, in the range from full to half scale. Such a reduction also reduces the maximum linear size of air-moving devices in proportion to the scale, and reduces the permitted volume flow of devices to be tested by the linear scale raised to the third power.

NOTE 11 These variations may better accommodate the use of smaller or quieter fans as well as test chambers with doors too narrow for the reference design plenum.

The mounting panel assembly (comprising adapter plate and flexible panel) may be replaced by a single damped plate with comparable cut-outs (but no adapter plate) of specified material without significantly affecting the airborne sound measurements made in accordance with this International Standard. The specification on the plate stock is a mechanical input impedance of - 50 dB (ref. 1 N · s/m) from 25 Hz to 5 000 Hz when measured in the middle of a plate of dimension 1,0 m^2 with no fan-mounting hole and with the plate freely suspended by two corners. The mobility measurement should be made in accordance with ISO 7626-4[3]. The tolerance on mobility levels is ± 8 dB from 25 to 100 Hz, ± 4 dB from 100 to 200 Hz and ± 2 dB from 200 to 5 000 Hz. These tolerance limits ensure that the plate has sufficient damping to prevent excitation of the frame. Such replacement panels are sometimes used in connection with fan vibration measurements (which are not

[3] ISO 7626-4 "Vibration and shock - Experimental determination of mechanical mobility - Part 4: Measurements of the entire mobility matrix using attached exciters" (to be published)

addressed in this International Standard). Using the same mounting panel for sound and vibration measurements may improve the efficiency of combined tests. If the reference design mounting panel is replaced, on the basis of impedance testing of the plate material, this shall be stated in the test report.

Permitted variations have been shown to yield standard deviations within the range of table 1. The degree to which other deviations from the reference design affect the uncertainty of the determination of sound power levels of air-moving devices is not known.

5.2 Test plenum: Main assembly

The test plenum shall consist of an airtight chamber constructed with a frame covered with an airtight acoustically transparent polyester film, a mounting panel, and an adjustable exit port assembly as shown in figure 1.

NOTE 12 All of the sound that is incident on the film is transmitted without any significant attenuation; i.e. less than 1 dB in the frequency range up to 5 000 Hz, and less than 3 dB up to 12 500 Hz, for a 50 µm thick polyester film.

The plenum shall conform to the following requirements:

a) Plenum size: figure 1 shows the dimensions of the reference or full-scale plenum.

b) Covering: isotropic polyester film of 38 µm nominal thickness. This thickness is independent of the plenum scale. The covering shall be fastened to the frame using an appropriate adhesive system. Batten strips may be used to protect the covering (see figure 2).

c) Frame: nominal size of wood is 5 cm x 5 cm; finished or milled lumber dimension is approximately 3,8 cm^2. Corner gussets are recommended as shown. Frame linear dimensions including the thickness of the wooden members shall be in scale with the plenum size.

d) Frame material: a hardwood such as birch is recommended for strength, stiffness and durability.

e) Vibration isolation: the test plenum support shall provide vibration isolation of the plenum from the floor with a natural frequency for vertical motion below 10 Hz. The intent is to break the vibration-transmission path between the plenum and the floor. Whatever method is chosen, the 0,1 m overall leg height should be maintained (see figures 1 and 3). The 0,1 m leg height shall be in scale with the plenum size.

f) Taps for fan static pressure: the piezometer ring shall be mounted immediately behind the mounting panel. The ring should be sized to match the perimeter of the mounting panel (see figure 4). The perimeter dimensions of the piezometer ring shall be in scale with the plenum size. The tubing diameter and holes do not scale.

5.3 Mounting panel assembly

The mounting panel assembly comprises an aluminium adapter plate, sealed and attached to a rubber sheet which, in turn, is sealed and attached to the test plenum frame (see figure 5).

The opening of the adapter plate shall conform to the recommendations of the manufacturer of the air-moving device. The openings in the clamp frame and rubber panel shall be larger than the opening in the adapter plate to minimize disturbance of the airflow. The length, width and thickness of the aluminum retainer strip and the length and width of the reinforced rubber mounting panel shall be in scale with the plenum size. The other dimensions, including the panel thickness, do not scale.

5.4 Adjustable exit port assembly

The adjustable exit port assembly shall comprise a fixed aperture plate and a slider (movable sliding plate) to provide a continuously variable exit port with area from 0,0 m^2 to 0,2 m^2 (see figures 6 to 8). The exit port maximum area shall be in scale with the square of the linear scale of the plenum.

NOTE 13 The point of operation of the air-moving device is controlled during a test by adjusting the position of the slider on the exit port assembly.

5.5 Insertion loss of test plenum

The one-third-octave-band insertion loss of the test plenum shall not be greater than $^{+3}_{-2}$ dB and is recommended not to be greater than ± 1,5 dB, when determined in accordance with the following procedure.

5.5.1 The sound power levels of a loudspeaker sound power source shall be determined twice: once with the source inside the test plenum, and once with the source outside the plenum but at the same location in the test room. If insertion loss measurements are made in a free-field over a reflecting plane, the hemispherical microphone array should be centred on the sound power source.

5.5.2 Measurement errors can arise if the loudspeaker sound power source is moved relative to reflective surfaces (floor and mounting panel) between the two sound power determinations. Accordingly, install the sound power source on the floor. Remove the mounting panel and rotate the plenum 90° such that the face normally covered by the mounting panel is parallel to the floor and the exit port is on the top surface. The plenum can then be lowered or raised vertically to cover or expose the sound power source without causing movement of the source.

5.5.3 The source shall be mounted to ensure that solid body radiation from the sound power source which is transmitted into the test plenum frame or covering is minimized.

5.5.4 The exit port slider shall be closed during the insertion loss test.

5.6 Instrumentation

The fan static pressure developed inside the test plenum by the air-moving device shall be measured using a piezometer pressure ring (shown in figure 4). This ring has four taps (holes) spaced 90° apart as shown, facing towards the centre of the discharge of the air-moving device (in the plane of the ring). The piezometer ring should be mounted to the wooden frame that supports the mounting panel. A pressure line can be brought out of the box by drilling a small, smooth, burr-free hole through the wooden frame. The fan static pressure should be read on a calibrated manometer or digital pressure meter.

6 Installation

6.1 Installation of test plenum in test room

The test plenum shall be installed as a piece of floor-standing equipment on the floor of a test room which has been qualified for sound power level determinations in accordance with ISO 7779, clauses 5 or 6.

6.2 Direction of airflow

The air-moving device should preferably be tested when discharging into the test plenum. Exceptions to this airflow direction may be made to avoid undesirable flow conditions. For example, centrifugal blowers without scrolls may be tested with the plenum on the inlet.

6.3 Mounting of air-moving device

The air-moving device shall be mounted and sealed to the mounting panel assembly using the means described in 5.3. Additional vibration-isolated supports shall be provided as necessary to maintain the mounting plane parallel with the face of the test plenum.

NOTES

14 The air-moving device should be tested for each of its configurations (see note 4 of 3.2).

15 In some cases, air-moving devices operating at free delivery (plenum exit port completely open) may cause the polyester film panels to flutter, creating unwanted noise. In such cases, steps should be taken to minimize flutter noise. For example, the mounting panel assembly with the air-moving device may be detached from the rest of the plenum, and the latter moved out of the way. The mounting panel assembly should be maintained planar and suspended above the floor of the test room at the same location as described in 6.1.

16 In some cases of high flow rate, air-moving devices may not be able to operate at free delivery with the adjustable exit port completely open, due to the finite opening size. In such cases, the mounting panel assembly with the air-moving device may be detached from the rest of the plenum, and the latter moved out of the way. The mounting panel should be maintained planar and suspended above the floor of the test room at the same location as described in 6.1.

7 Operation of air-moving device

7.1 Input power

7.1.1 Alternating current (AC) air-moving devices

The air-moving device shall be operated at each rated power line frequency, and within ± 1,0 % of either

a) the rated voltage (if any is stated), or

b) the mean voltage of a stated voltage range, e.g., operate at 220 V for a stated range of 210 V to 230 V.

For power having more than two phases, phase-to-phase voltage variations shall not exceed 1 % of the rated voltage.

7.1.2 Direct current (DC) air-moving devices

The air-moving device shall be operated at three voltages which are within ± 1 % of each of the following direct current supply values:

a) rated nominal voltage;

b) rated maximum voltage;

c) rated minimum voltage.

Additional tests may be run at other voltages.

7.2 Points of operation (AC and DC air-moving devices)

The air-moving device shall be tested at three points of operation for each of the required frequencies and voltages given in 7.1. These points of operation correspond to

a) maximum volume flow rate (free delivery);

b) 80 % of maximum volume flow rate;

c) 20 % of maximum volume flow rate.

Additional tests may be run at other points of operation, including the point of maximum overall static efficiency, to establish the sound power level versus volume flow rate curve. Some air-moving devices (e.g. small tube-axial fans) may be unstable when operated near the maximum overall static efficiency point. Tests should not be conducted at unstable points of operation.

Points of operation shall be established as follows.

a) The fan static pressure at the designated percent volume flow rates shall be read from the air-moving device performance curve determined in accordance with ISO 5801 with the same direction of airflow.

b) If the ambient atmospheric density during the noise test differs by more than 1 % from that recorded per ISO 5801, the fan static pressure shall be corrected as follows:

$$p_2 = p_1 \times \frac{\rho_2}{\rho_1}$$