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Acoustics — Measurement of airborne noise emitted and structure-borne vibration induced by small air-moving devices —

Part 1: Airborne noise measurement

Acoustique — Mesurage du bruit aérien émis et des vibrations de structure induites par les petits équipements de ventilation —

Partie 1: Mesurage du bruit aérien

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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.

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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 10302-1 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This first edition of ISO 10302-1 cancels and replaces ISO 10302:1996.

ISO 10302 consists of the following parts, under the general title *Acoustics — Measurement of airborne noise emitted and structure-borne vibration induced by small air-moving devices*:

— *Part 1: Airborne noise measurement*

— *Part 2: Structure-borne vibration measurements*

Introduction

This part of ISO 10302 specifies in detail methods for determining and reporting the airborne noise emissions of small air-moving devices (AMDs) used primarily for cooling electronic equipment, such as that for information technology and telecommunications.

To provide compatibility with measurements of acoustical noise emitted by such equipment, this part of ISO 10302 uses the noise emission descriptors and sound power measurement methods of ISO 7779. The descriptor of overall airborne noise emission of the AMD 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.

Acoustics — Measurement of airborne noise emitted and structure-borne vibration induced by small air-moving devices —

Part 1: Airborne noise measurement

1 Scope

This part of ISO 10302 specifies methods for measuring the airborne noise emitted by small air-moving devices (AMDs), such as those used for cooling electronic, electrical, and mechanical equipment where the sound power level of the AMD is of interest.

Examples of these AMDs include propeller fans, tube-axial fans, vane-axial fans, centrifugal fans, motorized impellers, and their variations.

This part of ISO 10302 describes the test apparatus and methods for determining the airborne noise emitted by small AMDs as a function of the volume flow rate and the fan static pressure developed by the AMD on the test apparatus. It is intended for use by AMD manufacturers, by manufacturers who use AMDs for cooling electronic equipment and similar applications, and by testing laboratories. It provides a method for AMD manufacturers, equipment manufacturers and testing laboratories to obtain comparable results. Results of measurements made in accordance with this part of ISO 10302 are expected to be used for engineering information and performance verification, and the methods can be cited in purchase specifications and contracts between buyers and sellers. The ultimate purpose of the measurements is to provide data to assist the designers of electronic, electrical or mechanical equipment which contains one or more AMDs.

Based on experimental data, a method is given for calculating the maximum volume flow rate of the scaled plenum up to which this part of ISO 10302 is applicable.

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 3741, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for reverberation test rooms*

ISO 3744, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane*

ISO 3745, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for anechoic test rooms and hemi-anechoic test rooms*[1)]

1) To be published. (Revision of ISO 3745:2003.)

ISO 5801:2007, *Industrial fans — Performance testing using standardized airways*

ISO 7779:2010, *Acoustics — Measurement of airborne noise emitted by information technology and telecommunications equipment*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ANSI/ASA S2.32, *Methods for the experimental determination of mechanical mobility — Part 2: Measurements using single-point translational excitation*

JBMS 72:2003, *Acoustics — Method for the measurement of airborne noise emitted by micro-fans*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7779 and the following apply.

3.1 General definitions

3.1.1
air-moving device
AMD
fan
device for moving air which utilizes a rotating impeller driven by an electric motor with electronic or mechanical command

NOTE 1 An air-moving device has at least one inlet opening and at least one outlet opening. The openings can have elements for connection to ductwork or to other parts of the airflow path.

NOTE 2 Tests can be run with a particular frame, motor, and rotor, but with different accessories (e.g. finger guards). For the purposes of this part of ISO 10302, each such configuration is referred to as an air-moving device.

NOTE 3 Within some industries, including information technology, the unmodified term “fan” means “axial flow air-moving device”, and the unmodified term “blower” means “centrifugal air-moving device”. In this part of ISO 10302, 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) are added as necessary to distinguish between types.

3.1.2
micro-fan
air-moving device which has a maximum volume flow rate less than or equal to 0,015 m^3/s

NOTE 1 Micro-fans are a subset of fans under test according to this part of ISO 10302.

NOTE 2 ISO 5801:2007, 22.4.2, Table 4 limits the range of applicability to Reynolds numbers of 12 000 or higher. This Reynolds number corresponds to the lower limit of volume flow rate of approximately 0,01 m^3/s. Since lower volume fans are of interest for many cooling applications, the methodology of JBMS-72:2003, Annex A is used to measure the p-q curve of a micro-fan.

3.2 Acoustical definitions

3.2.1
sound power level

L_W

ten times the logarithm to the base 10 of the ratio of the sound power, P, to a reference value, P_0, expressed in decibels

$$L_W = 10 \lg \frac{P}{P_0} \text{ dB} \tag{1}$$

where the reference value, P_0, is 1 pW

NOTE If a specific frequency weighting as specified in IEC 61672-1[6] and/or specific frequency bands are applied, this should be indicated by appropriate subscripts; e.g. L_{WA} denotes the A-weighted sound power level.

3.2.2
frequency range of interest

range extending from the 100 Hz one-third-octave band to the 10 kHz one-third-octave band

NOTE 1 The centre frequencies of these one-third-octave bands are defined in ISO 266[1].

NOTE 2 For small, low-noise fans to be measured (i.e. micro-fans), depending on the size of applicable plenum, the radius of the test hemisphere may be reduced to less than 1 m, but not less than 0,5 m (see 8.2.1). However, a radius less than 1 m could itself impose limits on the frequency range over which tests are performed. For details, reference is made to ISO 7779:2010, B.1.

3.2.3
insertion loss of test plenum

ΔL

sound power level difference due to the presence of test plenum, defined as follows:

$$\Delta L = L_{W,\text{out}} - L_{W,\text{in}} \tag{2}$$

where

$L_{W,\text{out}}$ is the sound power level of a sound source determined when installed outside the test plenum;

$L_{W,\text{in}}$ is the sound power level of a sound source determined when installed inside the test plenum

NOTE The insertion loss of the test plenum is expressed in decibels.

3.3 Aerodynamic definitions

3.3.1
test plenum

structure on to which the air-moving device under test is mounted for acoustical noise emission measurements

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

3.3.2
air-moving device aerodynamic performance curve
"p-q curve"
presentation of fan static pressure as a function of volume flow rate under standard air conditions and constant operating voltage and frequency

NOTE 1 For the purpose of this part of ISO 10302, a qualifier, "aerodynamic", before "performance curve" is inserted to distinguish from acoustical noise emission characteristics against volume flow rate.

NOTE 2 The presentation is derived in accordance with ISO 5801 or Annex A, which complement each other. The method for small air-moving devices of volume flow rate up to 0,015 m^3/s is specified in Annex A.

NOTE 3 For convenience, in this part of ISO 10302, the term "p-q curve" is used.

3.3.3
point of operation
point on the air-moving device aerodynamic performance curve corresponding to a particular volume flow rate

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

3.3.4
overall static efficiency of air-moving device
$\eta_{o,s}$
volume flow rate multiplied by the fan static pressure and divided by the input electrical power

NOTE 1 The overall static efficiency, $\eta_{o,s}$, expressed as a percentage, is given by

$$\eta_{o,s} = \frac{p_{s,f}\, q_V}{P_{input}} \times 100 \tag{3}$$

where

$p_{s,f}$ is the fan static pressure, in pascals;

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

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

NOTE 2 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.

3.3.5
standard air density
density under standard air conditions

NOTE The value is 1,20 kg/m^3.

3.3.6
standard air conditions (for aerodynamic performance measurement)
specified meteorological conditions

NOTE For the purposes of this part of ISO 10302, the conditions are: 20 °C temperature; 50 % relative humidity; and $1{,}013 \times 10^5$ Pa ambient pressure.

4 Limitations of measurement

Experimental data show that this method is useful up to the maximum volume flow rate, $q_{V,\max}$, as a function of nominal air volume, V, of the plenum used and up to a fan static pressure of 750 Pa.

$$q_{V,\max} = \frac{q_{V,0}}{V_0} V \tag{4}$$

where

$q_{V,\max}$ is the maximum volume flow rate of the scaled plenum, in cubic metres per second;

$q_{V,0}$ is the maximum volume flow rate of the full-size plenum, in cubic metres per second, $q_{V,0} = 1\ \text{m}^3/\text{s}$;

V_0 is the nominal air volume of the full-size plenum defined in Clause 6, in cubic metres, $V_0 = 1{,}3\ \text{m}^3$;

V is the nominal air volume of the scaled plenum, in cubic metres.

NOTE 1 The value of the interior air volume of a full-size plenum of $1{,}3\ \text{m}^3$ is rounded up from $1{,}296\ \text{m}^3 = 1{,}2\ \text{m (width)} \times 1{,}2\ \text{m (depth)} \times 0{,}9\ \text{m (height)}$.

NOTE 2 It is noted that the “nominal air volume” means approximate air volume calculated from the outer dimensions of the plenum. For instance, in case of 1/4 sized plenum, the nominal air volume of the plenum, excluding the leg height, becomes $V = blh = 0{,}3\ \text{m} \times 0{,}3\ \text{m} \times 0{,}225\ \text{m} = 0{,}020\ 25\ \text{m}^3$, where b is width, l is depth, and h is height.

For the purposes of this part of ISO 10302, it is recommended that the smallest plenum possible be applied, provided that the maximum volume flow rate of the fan is within the limit of Equation (4).

The method defined in this part of ISO 10302, by reference to ISO 7779, provides for determination of sound power levels in a qualified environment, using either a comparison method in a reverberation test room based on ISO 3741, 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 part of ISO 10302 may be applied to air-moving devices (AMDs) which radiate: a) broad-band noise; b) narrow-band noise; or c) noise that contains discrete frequency components.

The method specified in this part of ISO 10302 permits the determination of acoustical 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.

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 part of ISO 10302 may differ from the results obtained when AMDs are installed in equipment.

NOTE 3 This part of ISO 10302 does not describe measurement of the structure-borne noise generated by AMDs.

5 Design and performance requirements for test plenum

5.1 General

The design specified is intended to meet the limits stated for maximum volume flow rate and maximum fan static pressure. The design provides an acoustically transparent, adjustable flow resistance to the AMD.

NOTE 1 See 5.5 for requirements for confirming acoustical transparency in accordance with this part of ISO 10302.

The reference design of the plenum is specified in 5.2 to 5.6 and shown in Figures 1 to 8. Also addressed in these subclauses and elsewhere in this part of ISO 10302 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 quarter scale. Such a reduction reduces the maximum permitted volume flow rate of AMDs to be tested in direct proportion to the reduction in volume of the plenum [see Equation (4)], i.e. by the linear scale raised to the third power.

NOTE 2 These variations can better accommodate the use of smaller or quieter fans as well as test chambers with doors too narrow for the reference design plenum.

Permitted variations have been shown to yield standard deviations of reproducibility 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 AMDs is not known.

5.2 Test plenum: main assembly

5.2.1 General: 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.

The plenum shall conform to the requirements specified in 5.2.2 to 5.2.7.

5.2.2 Plenum size: Figure 1 shows the dimensions of the full-size plenum.

5.2.3 Covering: Isotropic polyester film of nominal thickness 25 µm to 50 µm. Batten strips may be used to protect the covering (see Figures 1 and 2).

5.2.4 Frame: Suitable material with nominal size of 50 mm × 50 mm that provides structural integrity for the plenum. Corner gussets are recommended for wood framing and may be needed for other materials (see Figure 3). Frame linear dimensions including the thickness of the framing members shall be in scale with the plenum size.

5.2.5 Frame material: Experience has shown that either a hardwood, such as birch, or aluminium tubing provides sufficient strength, stiffness and durability and complies with the acoustical performance requirements outlined in 5.5.

5.2.6 Vibration isolation: The test plenum feet or support should provide vibration isolation of the plenum from the floor, for any size of plenum. The intent is to break the vibration-transmission path between the plenum and the floor. Whichever method is chosen, the 0,1 m overall leg height should be maintained for the full-size plenum (see Figures 1 and 3). The 0,1 m leg height shall be in scale with the plenum size.

5.2.7 Taps for fan static pressure: The pressure 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 pressure ring shall be in scale with the plenum size. The tubing diameter and taps do not scale, but remain constant.

5.3 Mounting panel assembly

The mounting panel assembly shall comprise some kind of adapter plate sealed and attached to a reinforced rubber sheet which, in turn, is sealed and attached to the test plenum frame through the use of aluminium retaining strips (see Figures 1, 4, and 5). The adapter plate is used to mount the fan securely to the rubber panel. It may take the form of that shown in Figure 5, which is well suited to axial-flow fans, or some other form more suitable to the particular air-moving device under test. The adapter plate should not cause any disturbance to the air flow and should not cause any additional sound radiation other than that from the air-moving device itself.

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.

The specification on the plate stock is mobility level (reference: 1 m/N s) of –45 dB 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 level measurement shall be made in accordance with ANSI/ASA S2.32.

The tolerance on mobility levels is ±8 dB from 25 Hz to 100 Hz, ±4 dB from 100 Hz to 200 Hz and ±2 dB from 200 Hz 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 addressed in ISO 10302-2). 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.

The opening of the adapter plate shall conform to the recommendations of the AMD manufacturer. 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 aluminium retainer strip as well as 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 of area from 0,0 m^2 to 0,2 m^2 for the full-size plenum (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 The point of operation of the AMD is controlled during a test by adjusting the position of the slider on the exit port assembly.

5.5 Insertion loss of test plenum

For the purpose of this part of ISO 10302, adequacy of the test plenum is evaluated by means of insertion loss of the test plenum (3.2.3).

The one-third-octave-band insertion loss of the test plenum shall be not greater than (0^{+3}_{-2}) dB and is recommended to be not greater than (0 ± 1,5) dB, when determined in accordance with the procedure specified in steps a) to c).

a) The sound power levels of a sound source (e.g. a loudspeaker) 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.

b) Measurement uncertainties 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 by 90° so 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.

c) 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.

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

5.6 Instrumentation for static pressure measurement

The fan static pressure developed inside the test plenum by the AMD shall be measured using a pressure ring (shown in Figure 4). This pressure ring has four taps spaced 90° apart as shown, facing towards the centre of the discharge of the AMD (in the plane of the ring). The pressure ring should be mounted on the 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 frame. The fan static pressure should be read on a calibrated pressure meter.