INTERNATIONAL STANDARD

ISO 10302-2

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

Part 2:
Structure-borne vibration measurements

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

Partie 2: Mesurage des vibrations de structure

Reference number
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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 10302-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This first edition of ISO 10302-2, together with 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 measurement*

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

Part 2: Structure-borne vibration measurements

1 Scope

This part of ISO 10302 covers vibration levels from small air-moving devices (AMDs) with mounting footprints of less than 0,48 m × 0,90 m for the full-size test plenum defined in ISO 10302-1 and less than 0,18 m × 0,3 m for the half-size plenum.

It covers all types of AMDs which can be mounted on, and are self-supported at, the discharge or inlet plane of a test plenum box as specified in ISO 10302-1.

The procedures defined in this part of ISO 10302 specify methods for determining the vibration levels that a small AMD would induce in an average structure used in information technology and telecommunications equipment. The methods specified in this part of ISO 10302 allow the determination of induced vibration levels for the individual AMD that is tested. These data can be used to determine the statistical values of vibration levels for a production series if levels are measured for several units of that series.

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 266, *Acoustics — Preferred frequencies*

ISO 5348, *Mechanical vibration and shock — Mechanical mounting of accelerometers*

ISO 10302-1:2011, *Acoustics — Measurement of airborne noise emitted and structure-borne vibration induced by small air-moving devices — Part 1: Airborne noise measurement*

ISO 16063-11, *Methods for the calibration of vibration and shock transducers — Part 11: Primary vibration calibration by laser interferometry*

ISO 16063-21, *Methods for the calibration of vibration and shock transducers — Part 21: Vibration calibration by comparison to a reference transducer*

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10302-1 and the following apply.

3.1
vibratory acceleration level
L_a
ten times the logarithm to the base 10 of the ratio of the square of the root-mean-square acceleration, a, to the square of a reference value, a_0, expressed in decibels

$$L_a = 10 \lg \left(\frac{a^2}{a_0^2} \right) \text{dB} \tag{1}$$

where the reference value, a_0, is 1 μm/s^2

NOTE 1 The width of the frequency band is stated; for example, overall for all bands in the frequency range of interest or one-third-octave band.

NOTE 2 Some other standards use other reference values.

NOTE 3 In this part of ISO 10302, “vibratory acceleration level” is frequently referred to simply as “acceleration level”.

3.2
frequency range of interest
one-third-octave bands with centre frequencies specified in ISO 266, from 25 Hz to 5 kHz inclusive

3.3
information technology and telecommunications equipment
ITT equipment
equipment for information processing, and components thereof, used in homes, offices, server installations, telecommunications installations or similar environments

[ISO 7779:2010[3], 3.1.3]

NOTE ISO 10302 is intended to support the designers of ITT equipment.

4 Descriptors

The primary descriptor for vibration levels induced by an AMD is the energy average of the overall unweighted (non-frequency-weighted) vibratory acceleration level at the measurement locations for the frequency range of interest (3.2). This frequency range covers most of the frequency range covered by ISO 10302-1 for air-borne noise from AMDs, and adds the one-third-octave bands centred at 25 Hz to 80 Hz.

The detailed descriptors are the unweighted one-third-octave band acceleration levels. Although the measurement apparatus and the procedures of this part of ISO 10302 can also be used in conjunction with narrow-band frequency analysis instrumentation to investigate specifics in more detail, such narrow-band analysis is not specified here.

NOTE Acceleration measurements are convenient because non-intrusive lightweight accelerometers are readily available and simple to use. The overall unweighted acceleration level is chosen because it is a simple measure that correlates well with the A-weighted structure-borne noise level radiated by a structure (see References [7], [11]). The A-weighted structure-borne noise level radiated from a vibrating structure is determined from the average acceleration level of the structure by: a) converting from acceleration to velocity; b) correcting for the radiation efficiency of the structure; c) applying an A-weighting. To the first order, these three calculations cancel each other as a function of frequency, except for a constant. This leaves the overall unweighted acceleration level as a simple measure of the fan-induced A-weighted structure-borne noise.

5 Measurement uncertainty

The uncertainty of results obtained from measurements in accordance with this part of ISO 10302 shall be evaluated, preferably in compliance with ISO/IEC Guide 98-3. If reported, the expanded uncertainty together with the corresponding coverage probability as defined in ISO/IEC Guide 98-3 shall be given. Guidance on the determination of the expanded uncertainty is given in Annex D.

If, in a laboratory performing measurements in accordance with this part of ISO 10302, current knowledge is still insufficient to fully apply ISO/IEC Guide 98-3, the values of the standard deviation of reproducibility, σ_{R0} given in Table 1, multiplied by a coverage factor of 2 to get an estimate of the expanded uncertainty for a coverage probability of 95 %, are recommended for provisional use in test reports.

Table 1 — Estimated values of the standard deviation of reproducibility of vibratory acceleration levels of air-moving devices determined in accordance with this part of ISO 10302

One-third-octave band centre frequency Hz	Standard deviation of reproducibility σ_{R0} dB	Standard deviation of repeatability σ_{r0} dB
25	5,0	2,0
31 to 63	5,0	1,0
80 to 160	3,0	1,0
200 to 5 000	2,0	1,0
	Overall	
25 to 5 000	1,0	0,5

NOTE 1 These estimates are based on interlaboratory tests of five AMDs (three tube-axial fans and two forward-curved blowers) in the capacity range of 0,001 6 m^3/s to 0,137 m^3/s, conducted at two laboratories using three either half- or full-sized plenums by five different operators following the guidelines of ISO 5725[2] (see References [7], [11]).

NOTE 2 The standard deviations of reproducibility reflect the cumulative effects of all causes of measurement uncertainty, including variations from laboratory to laboratory, but excluding variations in the acceleration level from specimen to specimen. The standard deviation of repeatability for the same specimen and the same laboratory measurement conditions is considerably smaller than the standard deviation of reproducibility.

NOTE 3 The values apply to AMDs that are not damaged and are operating in a stable manner, under the test conditions defined in this part of ISO 10302.

6 Design and performance requirements for test fixture

6.1 Basic design

6.1.1 General

The basic design of the test plenum shall be as specified in ISO 10302-1, except that the mounting panel specified in ISO 10302-1 shall be replaced by the damped panel specified in 6.2.

6.1.2 Flow rate

The flow rate of the fan mounted on the plenum box under test conditions should be no greater than the value calculated according to Equation (2):

$$q_{V,\max} = \frac{q_{V,0}}{V_0} V \qquad (2)$$

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, i.e. $q_{V,0} = 1\ \mathrm{m}^3/\mathrm{s}$;

V_0 is the nominal air volume of the full-size plenum defined in ISO 10302-1, in cubic metres, i.e. $V_0 = 1{,}3\ \mathrm{m}^3$;

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

6.1.3 Static pressure

The static pressure of the AMD operating on the plenum should be no greater than 750 Pa.

6.1.4 Air/pressure distribution

All relative geometries (such as locations and proportions of the mounting panel or the exit port) shall be the same as those of the full-size plenum of ISO 10302-1.

6.2 Damped panel

The specification on the plate stock is a mechanical mobility level (reference: 1 m/N s) of −45 dB from 25 Hz to 5 000 Hz when measured in the middle of a panel of dimensions 1,0 m^2 with no fan-mounting hole and with the panel freely suspended by two corners. The mobility level measurement should be made in accordance with ANSI/ASA S2.32[17]. The tolerance on the 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 panel has sufficient damping to prevent excitation of the frame[1)].

6.3 Mounting area

This part of ISO 10302 covers vibration levels from small AMDs with a maximum mounting footprint of up to 0,48 m × 0,90 m for the full-size plenum. For all sizes of plenum, the distances from the edges of the AMD maximum mounting footprint to the edges of the damped panel are constant: 0,06 m from the top and bottom and 0,15 m from the sides. (Thus for a half-sized plenum, this part of ISO 10302 covers AMDs with a maximum mounting footprint of up to 0,18 m × 0,30 m.)

7 Installation

7.1 Orientation of the AMD

The discharge side of the AMD shall be mounted on the damped panel if this is an available mounting option. If other mounting options are used, they shall be reported.

7.2 Mounting of the AMD

The AMD shall be mounted on a damped panel meeting the specifications of 6.2. Unless special mounting attachment devices are being evaluated, the AMD shall be attached to the damped panel with through-screws, as specified by the AMD manufacturer. The screws shall be tightened to the torque specified by the AMD manufacturer. In the absence of manufacturers' specifications, M3.5 (UNC 6-32) through-screws are recommended, tightened to 0,34 m. In the case of multiple in-line mounting holes being provided in the AMD housing, only the holes against or nearest the damped panel assembly shall be used.

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1) An example of a suitable supplier of material for the damped plate is Soundcoat. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this supplier. Equivalent materials from another supplier may be used if they can be shown to meet the requirements of 6.2.

7.3 Damped panel opening

The plenum opening for air to exit or enter the AMD shall be as specified by the manufacturer. In the absence of manufacturers' specifications, the opening shall be at least as large as the corresponding discharge or inlet of the AMD, smooth and free of burrs. The AMD shall be mounted on the damped panel assembly directly and without any seals or gasketing.

8 Operation of AMDs

8.1 Input power

8.1.1 Alternating current AMDs

Unless otherwise specified, the AMD shall be operated at each rated power line frequency and within ±1 % of either:

a) the rated AMD voltage (if any is stated); or

b) the mean voltage of the stated range.

For power having more than two phases, the phase-to-phase voltage variation shall not exceed 1 % of the rated voltage. The voltage condition used shall be recorded.

8.1.2 Direct current AMDs

The AMD shall be operated within ±1 % of each of the following supply voltages:

a) rated nominal voltage;

b) rated maximum voltage;

c) rated minimum voltage.

Additionally recommended, but not required, voltages are given in Annex B if the fan operates with variable speeds. In this case, the voltage condition used shall be recorded.

8.2 Points of operation

Unless otherwise specified, the AMD shall be tested at three points of operation for each of the required frequencies and voltages given in 8.1. These points of operation correspond to:

a) the adjustable exit port (slider) completely open;

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 vibratory acceleration level versus volume flow rate curve. Some AMDs (e.g. small tube-axial fans) may be unstable when operated near the maximum static efficiency point. Tests should not be conducted at unstable points of operation.

Points of operation shall be determined in accordance with ISO 10302-1:2011, 7.2.

9 Instrumentation

9.1 Plenum pressure measurements

The AMD static pressure shall be measured in accordance with ISO 10302-1.

9.2 Accelerometer and accelerometer system

Structure-borne vibration shall be measured with an accelerometer and suitable signal conditioning equipment ("accelerometer system"). The accelerometer system shall have a frequency response flat within ±1,0 dB in the frequency range 20 Hz to 6 300 Hz inclusive, when mounted in accordance with ISO 5348 and calibrated using one or more of the methods specified in ISO 16063-11 or ISO 16063-21 as applicable, and including the effects of all signal conditioning equipment and connecting cables.

The accelerometer shall be of a type which is suitable for measurements of translational acceleration in a well-defined direction and is usually a piezoelectric accelerometer. The mass of the transducer, i.e. that portion of the accelerometer system which is to be attached to the structure, should not exceed 3 g. Care shall be taken to ensure that environmental conditions such as strong electric or magnetic fields, temperature or temperature transients, and mounting technique do not have an adverse effect on the accelerometer system used for the measurements.

An alternative sensor is permissible, but shall be at least equal in performance to a piezoelectric accelerometer.

NOTE 1 The mass of the accelerometer should be selected appropriately for the size of the AMD.

Accelerometer cables shall be selected to minimize extraneous signals due to triboelectric effect, noise, and other environmental sensitivity.

NOTE 2 The in-service frequency response of an accelerometer system at high frequencies depends upon the quality of the mounting. To allow for typical field-quality mounting using beeswax, the accelerometer should have a manufacturer-specified beeswax-mounted resonance frequency of at least 25 kHz, or a useful frequency range to at least 8 kHz (so called 10 % accuracy limit).

9.3 Signal conditioners

The accelerometer system in 9.2 shall include suitable signal conditioning equipment. Typically, such equipment may consist of one or more of the following: charge amplifier, voltage amplifier, power supply, high-pass and low-pass filters.

9.4 Analyser

The analyser shall be capable of determining the root-mean-square acceleration level in one-third-octave bands in the frequency range of interest. When combined with the accelerometer system, the complete system including the analyser shall have a frequency response flat within ±2,0 dB in the frequency range of interest.

The one-third-octave band filters shall meet the requirements of IEC 61260, class 1.

The nominal centre frequency of the one-third-octave bands shall be the preferred frequencies specified in ISO 266.

9.5 Basic calibration

A basic calibration of the accelerometer, the vibration calibrator used for operational calibration and all instruments in the chain is recommended once a year and required once every 2 years. The accelerometer and the vibration calibrator shall be calibrated by a procedure that is in accordance with ISO 16063-11 or ISO 16063-21, as applicable, and traceable to a national measurement standard. The remaining instrumentation chain shall be calibrated in accordance with the manufacturer's instructions.

10 Measurement procedure

10.1 Preparation

Proceed as follows:

a) record the name, model number, serial number, dimensions, name plate data, date code, and complete description of AMD under test;

b) obtain the AMD aerodynamic performance curve in accordance with ISO 10302-1;

c) measure the ambient temperature, relative humidity, and ambient pressure;

d) zero the manometer for test plenum;

e) calibrate the accelerometer and measurement instrument chain in accordance with 9.5;

f) measure the background acceleration level in accordance with 10.4.2;

g) see 10.4.1 on how to derive averages.

10.2 Operational test for AMD

Proceed as follows:

a) mount the AMD on the test plenum in accordance with Clause 7;

b) warm up the AMD until the temperature of the windings is stable, typically 15 min;

c) adjust the voltage in accordance with 8.1;

d) adjust the slider to obtain the desired point of operation following the instructions in 8.2;

e) measure the acceleration level at each accelerometer location for the time period specified in 10.9;

f) record data in accordance with Clause 11;

g) repeat steps c) to f) for additional points of operation as required.

10.3 Operational calibration

Operational calibration checks shall be performed at the beginning and end of each series of measurements and at least once a day, and the results shall be kept as part of the test report. For this calibration, the chain of instruments shall be the same as that used for the vibratory acceleration level measurements of AMDs. In particular, transducers shall be conditioned in accordance with the manufacturer's specification.

The accelerometer shall be calibrated by vibration calibrator or similar means according to the manufacturer's instructions. This calibration need be performed at only one frequency within the frequency range of interest, preferably at an amplitude greater than or equal to the measured values for the AMDs under test.

The amplitude of the signal that results from placing the accelerometer on the vibration calibrator shall be read out on the meter or analyser that is used for the AMD measurements. The amplitude as read at the output may be adjusted by gain switches, potentiometers or data acquisition software so the final read-out agrees within 0,5 dB of the manufacturer's specified amplitude for the vibration calibrator.

10.4 Measurement

10.4.1 Operational measurement and data averaging

The acceleration level measurement shall consist of a one-third-octave band measurement at each of the accelerometer locations specified in 10.8, at each of the voltages specified in 8.1, for each of the points of operation specified in 8.2, and for the duration specified in 10.9. Measurement results shall be rounded to the nearest 0,1 dB.

NOTE 1 As well as conventional contact-type accelerometers, measurement techniques using non-contact means, such as laser vibrometers, are also available at the time of publication.

For each voltage and static pressure loading, the overall unweighted acceleration level at each accelerometer location, L_{a_i}, shall be computed from the one-third-octave band acceleration levels at that location using Equation (3):

$$L_{a_i} = 10 \lg \left(\sum_j 10^{0,1 L_{a_{i,j}}} \right) \text{dB} \tag{3}$$

where

L_{a_i} is the overall unweighted acceleration level at the ith accelerometer location;

$L_{a_{i,j}}$ is the jth one-third-octave band acceleration level at the ith accelerometer location;

j is the one-third-octave band, from 25 Hz to 5 000 Hz.

For each voltage and static pressure loading, the energy average of the overall and one-third-octave band acceleration levels shall be computed using Equations (4) and (5):

$$\langle L_a \rangle = 10 \lg \frac{1}{N} \sum_{i=1}^{N} 10^{0,1 L_{a_i}} \text{ dB} \tag{4}$$

$$\langle L_{a_j} \rangle = 10 \lg \frac{1}{N} \sum_{i=1}^{N} 10^{0,1 L_{a_{i,j}}} \text{ dB} \tag{5}$$

where N is the total number of accelerometer locations.

The energy average acceleration level in Equations (4) and (5) are the values that are reported in accordance with Clause 11.

NOTE 2 As an example, if the measured overall acceleration levels, L_{a_i} at four locations are 93,2 dB, 96,9 dB, 103,1 dB, and 97,9 dB, the energy average of the overall acceleration level is given by:

$$\langle L_a \rangle = 10 \lg \left[\frac{1}{4} \left(10^{9,32} + 10^{9,69} + 10^{10,31} + 10^{9,79} \right) \right] \text{dB} = 99,2 \text{ dB}$$

