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
ISO 10302-2:2011(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 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

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

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):

$$q_{V,\mathrm{max}} = \frac{q_{V,0}}{V_0} V \tag{2}$$

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

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

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 frame1).

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):

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

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):

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

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

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:

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

10.4.2 Background acceleration level measurement

Before each measurement series and at least once a day, the background one-third-octave band acceleration level shall be measured and recorded as part of the test record. If the person conducting the measurements suspects that the data are influenced by background vibrations that may have changed since the background measurement, the background measurement should be repeated immediately. The background measurement shall be made in accordance with the procedures specified in this part of ISO 10302, except that the AMD shall be removed from the damped panel or switched off. Background measurements shall be made at all the specified accelerometer locations and energy averaged, i.e. this measurement should be the same as an operational test, but with the AMD off or removed from the damped panel. The duration of the background measurement should also comply with 10.9.

10.5 Corrections for background acceleration levels

When the background acceleration level is more than 10 dB below the measured level (including background) in every one-third-octave band, no corrections are required.

When the background one-third-octave band acceleration level is between 3 dB and 10 dB below the measured level (including background), the measured level at each point and in each frequency band shall be corrected for the influence of the background level using Equation (6):

$$L_{a,\text{corr}\,i,j} = L_{a_{i,j}} - K_{1_{i,j}} \qquad (6)$$

where

$L_{a,\,\text{corr}_{i,j}}$ is the background-corrected acceleration level, in decibels;

$K_{1_{i,j}}$ is the background acceleration correction, in decibels.

The value of $K_{1_{i,j}}$ is calculated from Equation (7):

$$K_{1a_{i,j}} = -10 \lg\left(1 - 10^{-0{,}1\Delta L_{a_{i,j}}}\right) \text{dB} \qquad (7)$$

where

$$\Delta L_{a_{i,j}} = L_{a,\text{m}_{i,j}} - L_{a,\text{b}_{i,j}}$$

in which

$L_{a,\text{m}_{i,j}}$ is the measured acceleration level in the jth one-third-octave band, at the ith accelerometer location, in decibels, including the contribution of the background acceleration, in decibels;

$L_{a,\text{b}_{i,j}}$ is the measured background acceleration level in the jth one-third-octave band, at the ith accelerometer location, in decibels.

All background-corrected data shall be marked as being corrected. If data are corrected in one or more bands and these corrected data are used to determine the overall level, then the overall level shall be marked as background corrected if the effect on the overall level is more than 0,5 dB.

When the one-third-octave band background acceleration level is less than 3 dB below the measured one-third-octave band level (including the contribution of background), no corrections are allowed. The overall level is determined from the band levels, whether corrected or not.

If the overall background acceleration level is less than 3 dB below the measured overall level (including background noise), no corrections are permitted. However, the overall level may be reported as an upper bound to the AMD acceleration level. This report shall state that the background acceleration level requirements of this part of ISO 10302 have not been satisfied for that measurement.

10.6 Accelerometer mounting

The accelerometer shall be rigidly attached (screwed or glued) or shall be attached to the damped panel using beeswax. For the procedures, refer to ISO 5348. The recommendations of the accelerometer manufacturer for such mounting shall be carried out so that frequency response meets the requirements of 9.2.

If the manufacturer's recommendations are not available, the following method shall be followed.

a) Ensure that the mounting surface is as smooth as possible. Also ensure that the accelerometer base and the mounting point on the damped panel are free of dirt and grease.

b) Pinch or scrape off a small quantity of beeswax and roll between the fingers to soften it.

c) Smear the wax on the damped panel at the mounting location, covering an area somewhat larger than that of the accelerometer base. The wax layer should be just thick enough to fill any voids between the two surfaces.

d) Slide the accelerometer on to the wax. Secure the accelerometer to the surface by applying pressure while turning slightly. It is essential that the wax layer be as thin as possible.

Care shall be taken to ensure that the accelerometer system is suitably grounded and that a “ground loop” does not introduce extraneous noise into the measurement. Cable attachment and routing shall comply with 10.7.

10.7 Accelerometer cable

Incorrect vibration measurements can be caused by poor mounting and routing of the cable connecting the accelerometer to the rest of the measurement system. Care shall be taken to follow the recommendations of the manufacturer concerning the accelerometer cable. In addition, the following general recommendations should be observed.

a) The cable should not be sharply bent or twisted.

b) The cable should be taped, or otherwise attached, to the damped panel so as to avoid relative movement to the extent practicable. The cable should be routed to leave the damped panel along its fixed edge.

c) The cable should be routed to avoid sources of high electromagnetic fields.

NOTE If it is not possible to avoid high electromagnetic fields, the accelerometer system can be of a type recommended for use under the existing conditions.

10.8 Accelerometer locations

A measurement shall be taken from an accelerometer mounted to the damped panel immediately adjacent to each AMD attachment point.

If the AMD is attached at more than six points, a smaller number of accelerometer locations than the AMD mounting points may be used. In such a case, there shall not be less than four measurement locations, and they shall be chosen adjacent to attachment points distributed as evenly as possible through the array of attachment points. The number of accelerometer locations and the attachment points selected shall be clearly described in the report.

For each location, the centre of the accelerometer shall be positioned at a point on the line through the attachment point and the centre of the AMD discharge (or inlet) opening, the point being 10 mm ± 2 mm outward from the outer edge of the AMD.

When an AMD design permits a choice of different attachment points, the report shall clearly identify which attachment option was tested.

CAUTION — It should be recognized that different attachments may produce different results.

10.9 Data acquisition time

The duration of the acceleration measurement shall be at least 16 s at each mounting point.

11 Test report

11.1 Information to be recorded

Results shall be reported over the frequency range of interest (see Clause 4) as both overall acceleration levels and unweighted one-third-octave band acceleration levels, at a stated voltage or speed and point of operation.

The following data shall be recorded:

a) AMD data:

    1) manufacturer model,

    2) type of AMD (e.g. tube-axial fan),

    3) impeller diameter,

    4) number of blades,

    5) rotational frequency to the nearest 5 min^{-1},

    6) part/serial number,

    7) name plate date,

    8) date of manufacture,

    9) part description,

    10) input voltage (and frequency if alternating current),

    11) measured AMD principal dimensions,

    12) fan static pressure;

b) accelerometer locations;

c) temperature;

d) relative humidity;

e) air density;

f) ambient pressure;

g) test set-up description;

h) air flow rate and static pressure;

i) whether the inlet or outlet of the AMD is mounted to the damped panel, method of mounting including number of points and locations;

j) a statement of whether the test plenum was being pressurized or evacuated;

k) special mounting hardware and accelerometer mountings, if used;

l) transducer, test plenum size and analysis equipment types and model numbers, serial numbers;

m) average and individual acceleration levels in each one-third-octave band;

n) the overall unweighted acceleration level and one-third-octave band levels, at least tabulated to one decimal place and, optionally, graphically presented for each AMD tested;

o) date of test;

p) laboratory location;

q) name of operator.

11.2 Information to be reported

The following information shall be reported:

NOTE Data should be presented using forms similar to those given in Annex A and/or Annex C.

a) a statement that the AMD has been tested in conformity with this part of ISO 10302;

b) manufacturer, product name (if any), manufacturer's part number, serial number (if any), dimensions (length, width, depth, hub diameter, impeller diameter), all other name plate data, and a complete description of the AMD under test;

c) the AMD aerodynamic performance curve, or reference points of operation used;

d) the average overall acceleration level (reference: 1 μm/s^2), $\langle L_a \rangle$, in decibels to the nearest 0,1 dB (preferred) 0,5 dB (required), for each point of operation;

e) the average band acceleration level (reference: 1 μm/s^2), $\langle L_{a,\, i} \rangle$, in decibels to the nearest 0,1 dB (preferred) 0,5 dB (required), in one-third-octave bands for each point of operation;

f) detailed description of operating conditions of the AMD under test as recorded in 11.1 (voltage, frequency, fan static pressure, volume flow rate, input power, and rotational frequency);

g) information on temperature in degrees Celsius, on humidity as a percentage, on ambient pressure in kilopascals, and any other information that may be pertinent to the particular AMD under test;

h) the expanded measurement uncertainty.

Annex A
(informative)

Suggested data format for presentation

Air-moving device (AMD) structure-borne vibration test report

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The data presented in this report have been determined in accordance with ISO 10302-2, *Acoustics — Measurement of airborne noise emitted and structure-borne vibration induced by small air-moving devices — Part 2: Structure-borne vibration measurements*.

Manufacturer:____

Model: ____

Type of AMD: ____

Impeller diameter: ________________ Number of impeller blades: ________ Speed: ________

Part/serial number: ____________________ Name plate data: ____________________

Date of manufacture: ____

Part description: ____

Line voltage and frequency: ____

AMD mounted on strut or non-strut side: ____

Plenum box size: ____

Accelerometer locations: ____

Test conditions for plenum pressure adjustment:

- Temperatures ____________________
- Relative humidity ____________________
- Air density ____________________
- Ambient pressure ____________________

AMD structure-borne vibration test report

(*continued*)

1. Name of operator ____

2. AMD mounting

   2.1 inlet mounted ________________________ , or outlet mounted ________________________

   2.2 method of mounting ____

   2.3 number and location of mounting points ____

3. Test plenum pressurized __________________ , or evacuated ______________________________

4. Instrumentation

   4.1 vibration transducer type, manufacturer, model, serial number ______________________________

   4.2 analysis instrumentation ____

AMD structure-borne vibration test report

(*continued*)

Test conditions (see ISO 5801[21] and JBMS-72-1[22])				Overall average acceleration level
Operating condition	**Volume flow rate**	**Static pressure**	**Rotational frequency**	$\langle L_a \rangle$
	m^3/s	Pa	min^{-1}	dB (re 1 μm/s^2)
Adjustable exit port (slider) of the plenum completely open				
80 % maximum flow rate				
20 % maximum flow rate				
Others (if specified)				

Name of individual performing measurements:

Organization: ____________________

Date: ____________________

Document number: ____________________

Other referenced documents: ____________________

AMD structure-borne vibration test report

(*continued*)

Input power

W

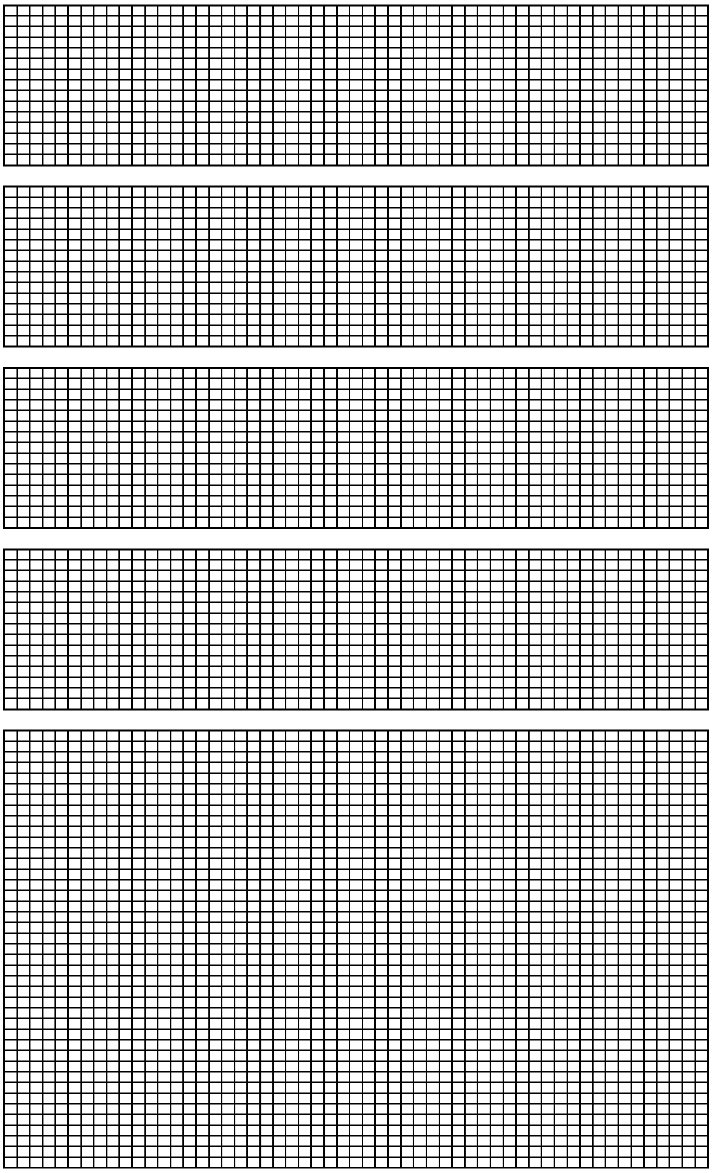
A-weighted sound level, L_{WA}
dB (re 1 pW)

Overall acceleration level, L_a
dB (re 1 µm/s^2)

Rotational frequency
min^{-1}

Fan static pressure

Pa



Volume flow rate in standard air condition (m^3/s)

Model: ______________________ Part/serial number: ______________________

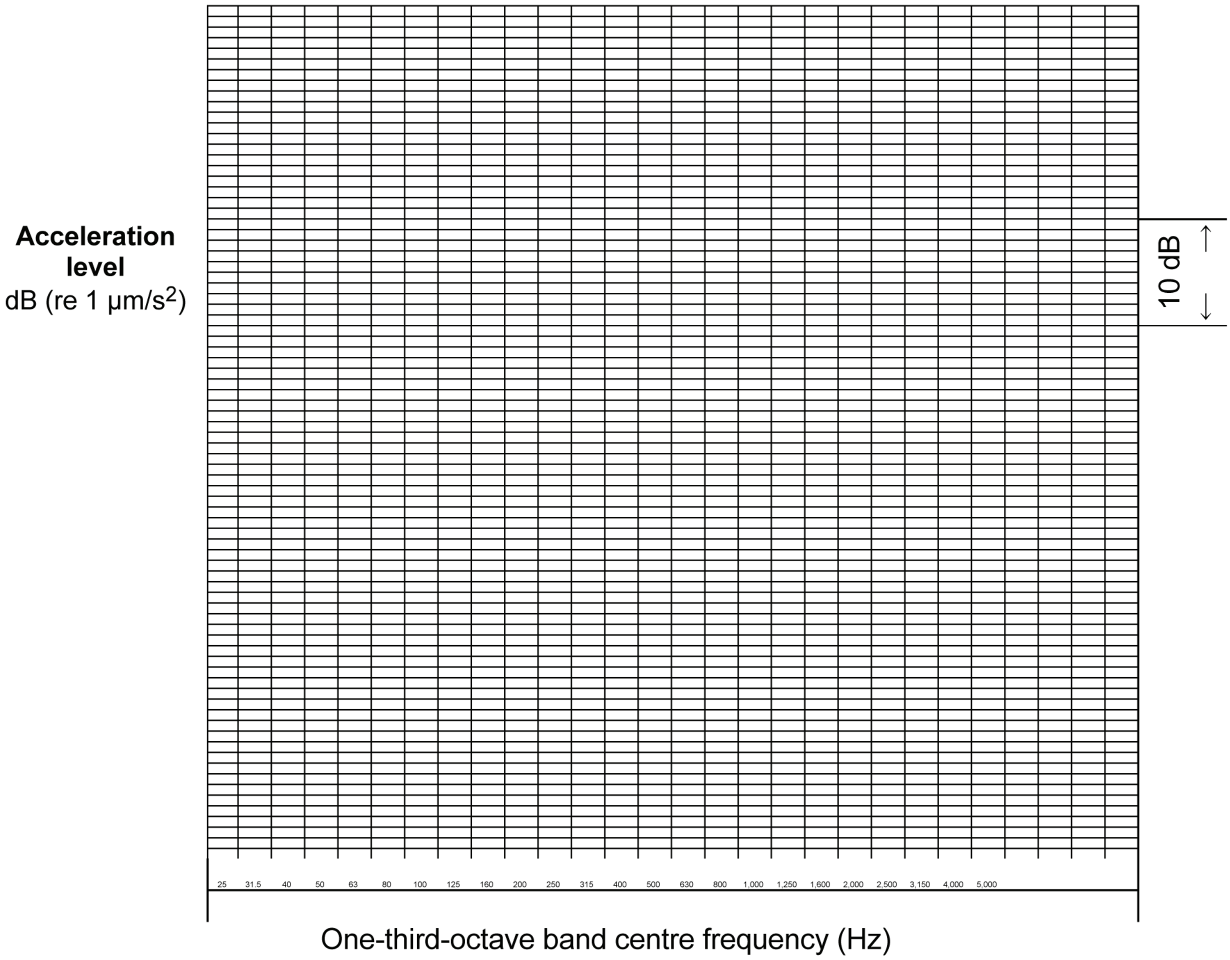
Test voltage: ______________________ Power line frequency (if applicable): ______________________

Date: ______________________ Other information: ______________________

AMD structure-borne vibration test report

(*continued*)

Air-moving device one-third-octave band acceleration level spectra



Model: ______________________________ Part/serial number: ______________________________

Test voltage: ______________________________ Power line frequency: ______________________________

Date: ______________________________ Other information: ______________________________

Annex B
(informative)

Recommended voltages for testing AMDs that operate with variable speeds

B.1 Background of measurement

Unlike airborne noise from AMDs, which increases monotonically with rotational frequency, structure-borne vibration levels sometimes behave erratically as a function of rotational frequency. This is because the fan responds as a flexible dynamic structure to variations in the forcing frequencies associated with the motor commutation and the bearings. This phenomenon is evident for AMDs with lightly damped resonances where increases of 10 dB or more can occur in a small speed range, but even for AMDs without strong resonances, variations of 3 dB to 5 dB are common.

B.2 Recommended procedure

For the slider setting associated with 80 % of free delivery air flow, or for free delivery if the AMD is not being tested under static pressure loadings, vibratory acceleration level measurements should be made on the damped panel at one attachment point of the AMD as the voltage is swept slowly or incremented in small steps. Incremental steps, if used, should be less than or equal to either 0,05 V or 1 % of the voltage range of interest, whichever is larger. The duration of the resonance search measurement at each voltage step should be at least 8 s. If a continuously swept voltage is used, the total duration of the sweep should be greater than or equal to the time required for the incremental step approach.

Record the overall unweighted acceleration level at each voltage for the incremental step approach, or plot as a function of voltage if the continuous voltage sweep approach is used. The acceleration levels at these sweep voltages, incremental or continuous, are to be compared with the acceleration level at the maximum fixed voltage required in 8.1, and the result of this comparison used to decide further action.

a) If the sweep levels nowhere exceed the levels at the maximum fixed voltage by 1,5 dB, then no further action is required.

b) Otherwise, if the sweep acceleration levels anywhere exceed the acceleration levels by at least 1,5 dB at the maximum fixed voltage of 8.1, then the voltage at which the maximum acceleration level occurs should be noted, and a full measurement (16 s duration; see 10.9) and report according to this part of ISO 10302, including all mounting positions, should be made at this voltage. If measurements are being made at other static pressure loadings, the same procedure should be followed at these points.

Annex C
(informative)

Sample specification of AMD structure-borne vibratory acceleration levels

C.1 Recommended specification format

This AMD shall not have an overall acceleration level greater than ___ dB (reference: 1 μm/s^2) when tested in accordance with ISO 10302-2, *Acoustics — Measurement of airborne noise emitted and structure-borne vibration induced by small air-moving devices — Part 2: Structure-borne vibration measurements,* operating at ___ V a.c./d.c., ___ Hz at an operating point corresponding to a fan static pressure of ___ Pa and a volume flow rate of ___ m^3/s.

C.2 Optional specification format

This AMD shall not have an overall acceleration level greater than ___ dB (reference: 1 μm/s^2) when tested in accordance with ISO 10302-2, *Acoustics — Measurement of airborne noise emitted and structure-borne vibration induced by small air-moving devices — Part 2: Structure-borne vibration measurements,* operating at ___ V a.c./d.c., ___ Hz and against any flow resistance between one corresponding to a fan static pressure of ___ Pa and a volume flow rate of ___ m^3/s and one corresponding to a fan static pressure of ___ Pa and a volume flow rate of ___ m^3/s.

C.3 Determination of specification values

Specification values for the above formats shall be determined by analysing data from AMDs tested in accordance with ISO 10302-2.

The specifications described in C.1 and C.2 refer to the acceleration levels and aerodynamic performance of a single AMD. Additional information may be required to describe allowable variations in a batch of AMDs.

Annex D
(informative)

Guidance on the development of information on measurement uncertainty

D.1 General

The data of standard deviation of reproducibility given in Table 1 for provisional use in test reports are incomplete, not taking into account any potential uncertainty contribution due to the measurement method itself selected for the purpose of the interlaboratory comparison from which the values in the table were derived. Moreover, it cannot usually be assured in such a comparison that all influence parameters were representatively covered by the participating laboratories. Finally, the results of interlaboratory comparisons do not provide any analysis of the relevant components of uncertainty and their magnitudes, and thus do not enable a laboratory to identify the major contributions to uncertainty and to improve corresponding measurement conditions in order to reduce the overall uncertainty, if requested.

The accepted format for the expression of uncertainties associated with measurement results is that given in ISO/IEC Guide 98-3. This format requests that a functional relationship (model function) be established between the measurand, which in the context of this part of ISO 10302 is the frequency-dependent vibratory acceleration level induced by an AMD, and several input quantities describing effects that may influence the measurement result. Each of these input quantities is characterized by its estimate, its probability distribution and its standard uncertainty. The existing knowledge on these input quantities is to be compiled in an uncertainty budget from which the combined standard uncertainty and the deviation of reproducibility of the measurement result can be derived.

Scientifically verified data necessary to establish a generally valid uncertainty budget for each measurement performed in accordance with this part of ISO 10302 were not available at the time of publication. However, an indication of the relevant sources of uncertainty and their characteristics are given, mostly based on empirical knowledge. The general approach to the determination of uncertainties conforming to ISO/IEC Guide 98-3 is illustrated. It allows an approximate determination of uncertainties under special assumptions.

The evaluation of measurement uncertainty is the final responsibility of each laboratory performing a measurement. Even if the requirements of this part of ISO 10302 are fully met, the uncertainty of results from different laboratories may differ depending on the specific measurement conditions. This annex should therefore only be regarded as a guide.

NOTE Interlaboratory comparisons in accordance with ISO 5725[2] constitute a very useful tool to check uncertainty evaluations in accordance with ISO/IEC Guide 98-3. However, for reasons given above, they cannot fully replace such evaluations.

D.2 Model function

This part of ISO 10302 permits the measurement of the vibratory acceleration level induced by an AMD. The following uncertainty evaluation is compatible with the corresponding format of ISO 10302-1.

The energy average vibratory acceleration level of an AMD, $\langle L_a \rangle$, determined in accordance with this part of ISO 10302, is a function of a number of parameters as defined by Equation (D.1):

$$\langle L_a \rangle = \left(L_{a_i} + K_{1_{i,j}} + \delta_{\text{pick}} + \delta_{\text{mount}} + \delta_{\text{oc}} \right) \quad \text{(D.1)}$$

where

L_{a_i} is the overall unweighted vibratory acceleration level at the ith accelerometer location, with the AMD under test in operation, in accordance with Equation (3), in decibels;

$K_{1_{i,j}}$ is the background acceleration correction in accordance with Equation (7), in decibels;

δ_{pick} is an input quantity to allow for any uncertainty in the acceleration measuring instrumentation, in decibels;

δ_{mount} is an input quantity to allow for any variability in the mounting conditions of the AMD under test, in decibels;

δ_{oc} is an input quantity to allow for any deviation in the operating conditions of the AMD under test from nominal conditions, in decibels.

NOTE 1 The input quantities in Equation (D.1) to allow for uncertainties are those thought to be applicable at the state of knowledge current when this part of ISO 10302 was published, but further research could reveal that there are others.

A probability distribution (normal, rectangular, Student-t, etc.) is associated with each of these input quantities. Its expectation value (mean value) is the best estimate for the value of the input quantity and its standard deviation is a measure of the dispersion of values. The uncertainty in the estimate of an input quantity is termed its standard uncertainty. It is a function of the standard deviation, probability distribution and number of degrees of freedom.

NOTE 2 Unless stated otherwise in D.3, a normal distribution of values associated with each of the input quantities is assumed.

D.3 Input quantities and their contributions to measurement uncertainty

D.3.1 General

The contributions of the various input quantities to the overall measurement uncertainty depend on their associated standard uncertainties and their sensitivity coefficients. The sensitivity coefficients are a measure of how the values of the vibratory acceleration level are affected by changes in the values of the respective input quantities. Mathematically, these coefficients are equal to the partial derivatives of the function $\langle L_a \rangle$ [Equation (D.1)] with respect to the relevant input quantities. The contributions to the overall uncertainty are then given by the products of standard uncertainties, u_i, and sensitivity coefficients, c_i.

NOTE For simplification in the context of this part of ISO 10302, potential correlation between any of the input quantities is neglected at the time of publication, though further research could reveal that correlation between any of the input quantities has a significant influence on the measurement uncertainty thus evaluated.

D.3.2 Overall unweighted vibratory acceleration level, L_{a_i}

The overall unweighted vibratory acceleration level of the AMD under test at the ith accelerometer location is usually determined only once. This result is considered to be a suitable estimate of the quantity. Its standard uncertainty, indicating the repeatability of this value, has to be determined separately by a number of (at least six) successive measurements carried out at a single accelerometer location under identical conditions (i.e. same measurement procedure, same observer, same measuring instrument, same location, but with the measuring instrument removed and installed again between trials). The standard deviation, s, of the values of these measurements may be taken as the standard uncertainty of L_{a_i}.

The sensitivity coefficient is the partial derivative of $\langle L_a \rangle$ [Equation (D.1)], with respect to L_{a_i} and is given, after substitution for $K_{1_{i,j}}$ in accordance with its definition [see Equation (7)], by

$$c_{L_{a_i}} = 1 + 1/\left(10^{0,1\Delta L_{a_i}} - 1\right) \tag{D.2}$$

NOTE For extremely low vibratory acceleration level AMDs, background acceleration can adversely lead to a large sensitivity coefficient and can considerably increase the uncertainty contribution.

Measurement repeatability may be strongly influenced by the averaging time. If chosen appropriately, the short term repeatability is typically small and less than 0,1 dB, so that the contribution to the overall measurement uncertainty amounts to 0,1 dB.

D.3.3 Background acceleration correction, $K_{1_{i,j}}$

An estimate of $K_{1_{i,j}}$ is derived from measurements of the measured acceleration level of the AMD under test and of background acceleration in accordance with its definition. The standard uncertainty of the background acceleration correction may be obtained from the standard deviation, s, of the results of repeated measurements (at least six) of the background level difference, ΔL_a, at a single acceleration location.

Since the relationship between $\langle L_a \rangle$ and L_{a_i} is already covered in D.3.2, the sensitivity coefficient of the background acceleration correction is obtained as the partial derivative of $\langle L_a \rangle$ with respect to the background acceleration level, $L_{a,\mathrm{b}\,i,j}$, and is given by

$$c_{K_{1_{i,j}}} = 1/\left(10^{0,1\Delta L_a} - 1\right) \tag{D.3}$$

The contribution of the background acceleration correction to the overall measurement uncertainty is not generally quantifiable. Especially for low vibration sources under test, the effect might not be negligible and needs to be examined carefully.

D.3.4 Acceleration measuring instrumentation, δ_{pick}

The estimate of δ_{pick} is 0 dB and the corresponding sensitivity coefficient is 1. The standard uncertainty, u, due to performance deviations of the measuring instrumentation from nominal performance depends on the instrumentation in accordance with ISO 16063-11 or ISO 16063-21, as applicable. For a well-calibrated instrument at medium frequencies, and for a broadband and approximately stationary vibration character, u_{pick} may be assumed to be typically 0,5 dB.

NOTE The value 0,5 dB is preliminary and subject to change.

D.3.5 Mounting conditions, δ_{mount}

The estimate of δ_{mount} is 0 dB and the corresponding sensitivity coefficient is 1. Mounting conditions are specified in Clause 7. They include the design and performance for the test plenum including the requirements on the instrumentation for static pressure and the installation of the test plenum in the test room. The uncertainty due to any variability in these mounting conditions, u_{mount}, may further depend on the characteristics of the AMD under test. A generally valid figure for its magnitude can therefore not be given. It is recommended that a number of acceleration measurements be performed on different AMDs under different mounting conditions within the tolerances specified in Clauses 6 and 7 under otherwise identical conditions. The standard deviation of the results may then be taken as a suitable estimate of u_{mount}.

D.3.6 Operating conditions, δ_{oc}

The estimate of δ_{oc} is 0 dB and the corresponding sensitivity coefficient is 1. Operating conditions are specified in Clause 8 for different points of operation. They may affect different AMDs in different ways. Due to the variability of conditions within these specifications, a generally valid figure for the standard uncertainty due to different operating conditions cannot be given. It is recommended that a number of acceleration measurements under different operating conditions be performed within the tolerances given in Clause 8 under otherwise identical conditions. The standard deviation of the results of these measurement may be taken as a suitable estimate of the standard uncertainty, u_{oc}. Multiple changes in operating conditions may be randomly assigned between tests.

D.4 Uncertainty budget

All available information on the various input quantities as indicated in D.3 should be compiled in an uncertainty budget allowing an easy overview of the most significant uncertainty contributions. Such a budget allows a decision on which of the various input quantities might finally be neglected and which need more thorough consideration. A skeleton of an uncertainty budget with some generally valid entries is given in Table D.1 as an example.

Table D.1 — Example of an uncertainty budget for determination of vibratory acceleration levels

Quantity	***Estimate*** *dB*	***Standard uncertainty*** u *dB*	***Probability distribution***	***Sensitivity coefficient*** c	***Uncertainty contribution*** $u\,c$ *dB*
L_{a_i}	L_{a_i}	$u_{L_{a_i}}$	*Normal*	$c_{L_{a_i}} = 1 + 1/\left(10^{0{,}1\Delta L_{a_i}} - 1\right)$	$u_{L_{a_i}}\; c_{L_{a_i}}$
$K_{1_{i,j}}$	$K_{1_{i,j}}$	$u_{K_{1_{i,j}}}$	*Normal*	$c_{K_{1_{i,j}}} = 1/\left(10^{0{,}1\Delta L_a} - 1\right)$	$u_{K_{1_{i,j}}}\; c_{K_{1_{i,j}}}$
δ_{pick}	*0*	u_{pick}	*Normal*	*1*	u_{pick}
δ_{mount}	*0*	u_{mount}	*Normal*	*1*	u_{mount}
δ_{oc}	*0*	u_{oc}	*Normal*	*1*	u_{oc}

D.5 Combined standard uncertainty and expanded uncertainty

From the individual contributions as described in D.3 and as compiled in an uncertainty budget in D.4, the combined standard uncertainty, $u_{\langle L_a \rangle}$, can be calculated using Equation (D.4):

$$u_{\langle L_a \rangle} = \sqrt{\sum_i \left(u_i \cdot c_i\right)^2} \tag{D.4}$$

ISO/IEC Guide 98-3 requires an expanded measurement uncertainty, U, to be specified so that the interval $[\langle L_a \rangle - U, \langle L_a \rangle + U]$ covers, for example, 95 % of the values that might reasonably be attributed to $\langle L_a \rangle$. To that purpose, a coverage factor, k, is used such that

$$U_{\langle L_a \rangle} = k \cdot u_{\langle L_a \rangle} \tag{D.5}$$

The expanded uncertainty depends on the degree of confidence that is desired. For a normal distribution of measured values, there is 95 % confidence that the true value lies within the range $[\langle L_a \rangle - U]$ to $[\langle L_a \rangle + U]$. This corresponds to a coverage factor of $k = 2$.

If the purpose of determining the vibratory acceleration level is to compare the result with a limit value, it might be more appropriate to apply the coverage factor for a one-sided normal distribution. In that case, the coverage factor $k = 1{,}6$ corresponds to a 95 % confidence level.

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