Standard ECMA-275
June 1998

ECMA

Standardizing Information and Communication Systems

Measurement of structure-borne vibration induced by small air moving devices (AMDs)

Phone: +41 22 849.60.00 - **Fax:** +41 22 849.60.01 - **URL:** http://www.ecma.ch - **Internet:** helpdesk@ecma.ch

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Brief History

This Standard contains the recommended methods for testing, determining, and reporting the vibration levels induced by small air moving devices (AMDs) that are found in cooling equipment used for information technology and telecommunications.

The vibration levels are a function of operation speed and pressure loading. Previously, a variety of methods have been used by AMD manufacturers, information technology and telecommunications equipment manufacturers, consultants, and others to satisfy various needs. These diverse practices have, in many cases, made comparison of AMD vibration difficult. The practice recommended in this Standard provides a common basis for such comparisons that is consistent with current measurement standards.

The use of this Standard is encouraged to promote uniformity in the measurement and reporting of the vibration levels induced by AMDs for use in information technology and telecommunications equipment.

The practice specified in this Standard is intended for use by AMD manufacturers, information technology and telecommunications equipment manufacturers, and testing laboratories. Results of measurements conducted in accordance with this practice are expected to be useful for engineering design, performance verification, comparisons among competing AMD designs, and evaluation of vibration isolation devices for small AMDs. This Standard may also be cited in purchase specifications and in contracts between suppliers and users.

The basis for this Standard is from the Institute of Noise Control Engineering Recommended practice 1-96 (see annex D)

This ECMA Standard has been adopted by the ECMA General Assembly of June 1998.

Table of contents

1 Scope

This Standard covers vibration levels from small air moving devices (AMDs) with mounting footprints of less than 0,48 m x 0,90 m for the full size test plenum and less than 0.18 m x 0,3 m for the half size.

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. Some guidance is given for non-self-supporting AMDs.

2 Field of application

The procedures defined in this Standard specify methods for determining the vibration levels that a small AMD would induce in an average structure used in information technology and telecommunications equipment. Although the procedures cited here may be used to acquire data in different frequency bandwidths, standard bandwidths are recommended so that comparisons between data from various tests or laboratories yield comparable results.

The methods specified in this Standard allow the determination of induced vibration levels for the individual AMD that is tested. These data may be used to determine the statistical values of vibration levels for a production series if levels are measured for several units of that series.

3 References

3.1 International Standards

ISO 266:1997, "*Acoustics – Preferred frequencies for measurements*"

ISO 1683:1983, "*Acoustics – Preferred reference quantities for acoustic levels*"

ISO 5347:1993, "*Methods for the calibration of vibration and shock pick-ups" Parts 1-19*

ISO 5347:1997, "*Methods for the calibration of vibration and shock pick-ups" Parts 20-22*

ISO 5725:1994, "*Precision of Test Methods – Determination of repeatability and reproducibility by Interlaboratory tests*"

ISO 5801:1997 "*Industrial fans – Performance testing using standardized airways*"

ISO 7626:1986, "*Vibration and shock – Experimental determination of mechanical mobility – Part 1: Basic definition and transducers*"

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

ISO 9611:1996 "*Acoustics: Characterization of sources of structure-borne sound with respect to sound radiation from connected structures – Measurement of velocity at the contact points of machinery when resiliently mounted*"

ISO 10302:1996, "*Acoustics - Method for the measurement of airborne noise emitted by small air-moving devices*"

IEC 61260:1995, "*Electroacoustics – Octave-band and fractional-octave-band filters"*

4 Definitions

4.1 Air moving device (AMD)

A device for moving air utilizing a rotating impeller driven by an electric, electronic, or mechanical motor. An air moving device has at least one inlet opening and at least one outlet opening. The openings may or may not have elements for connection of ductwork or other parts of the air flow path. An air moving device may have various accessories which may affect performance, vibration and noise emissions; therefore, it is necessary to establish which accessories are to be considered a part of the air moving device for testing purposes.

A constant speed AMD, either AC or DC powered, does not include a control function which varies the speed of rotation in response to a control input. A variable speed AMD, either AC or DC powered, includes a control function which, in the course of normal operation, is designed to vary the speed of rotation, either in fixed steps or continuously over some range of speeds, in response to a control input.

4.2 Vibratory acceleration level, L_a

Twenty times the logarithm to the base 10 of the ratio of the RMS acceleration to a reference of 1,0 µm/s^2 as specified in ISO 1683. The width of the frequency band shall be stated; for example, overall for all bands in the frequency range of interest, or one-third octave band, etc.

NOTE

Other standards may use another reference acceleration.

4.3 Test plenum

A structure onto which an AMD under test is mounted for vibration level measurements.

NOTE

The plenum provides a flow resistance to the AMD, but permits sound from the AMD to escape with only minimal attenuation. Thus, in addition to the vibration level measurements made in accordance with this Standard, this plenum box can also be used for determination of sound power in accordance with ISO 10302.

4.4 AMD performance curve

The presentation of static pressure as a function of volumetric flow rate at standard air conditions and constant operating voltage and frequency in accordance with ISO 5801.

4.5 Point of operation

The point on the AMD performance curve corresponding to a particular volumetric flow rate and static pressure.

NOTE

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

4.6 Standard air density

Under standard conditions (20 °C, 50% relative humidity, and 1,013 × 10^5 Pa barometric pressure), air density is 1,201 kg/m^3.

4.7 Frequency range of interest

The range extending from the 25 Hz one-third octave band to the 5 kHz one-third octave band, inclusive. The range and centre frequencies of these one-third octave bands are specified in ISO 266.

5 Descriptors

The primary descriptor for vibration levels induced by an AMD is the energy average of the overall unweighted vibratory acceleration level at the measurement locations (frequently referred to simply as the *acceleration level*) for the frequency range of interest. The frequency range of interest extends from the 25 Hz one-third-octave band to the 5 kHz one-third-octave band inclusive. The range and centre frequencies of these one-third-octave bands are specified in ISO 266. This frequency range covers most of the frequency range covered by ISO 10302 for air-borne noise from AMDs, and adds the one-third octave bands centered 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 standard 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 nonintrusive 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. 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 and then, c) applying an A-weighting correction. 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.

6 Measurement uncertainty

The estimated values of the standard deviation of reproducibility and repeatibility of vibrator-acceleration levels of air-moving devices determined according to this Standard are given in the following table.

One-third octave band centre frequency Hz	Standard deviation of reproducibility dB	Standard deviation of repeatibility dB
25	5,0	2,0
31 to 63	5,0	1,0
80 to 160	3,0	1,0
200 to 5000	2,0	1,0
Overall		
25 to 5000	1,0	0,5

The estimated standard deviation of reproducibility in determining the overall unweighted acceleration level for the frequency range from 22,3 Hz to 5,7 kHz is less than 1 dB, and the standard deviation of reproducibility repeatability is less than 0,5 dB.

NOTES

These estimates are based on interlaboratory tests of five air-moving devices (three tubeaxial fans and two forward-curved blowers) in the capacity range of 0,0016 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.

The standard deviations of reproducibility given above reflect the cumulative effects of all causes of measurement uncertainty, excluding variations in the acceleration level from specimen to specimen. The standard deviation of repeatibility for the same specimen and the same laboratory conditions represent the "random error" associated with the practice specified in this Standard.

The values given above apply to air-moving devices that are not damaged and are operating in a stable manner, under the test conditions defined in this Standard.

7 Design and performance requirements for test fixture

7.1 Basic design

The basic design of the test plenum shall be as specified in ISO 10302 except the mounting panel assembly as specified in 5.3 of ISO 10302 shall be replaced by the damped plate specified in 7.2 of this ECMA Standard.

7.1.1 Flow rate limitations

The maximum flow rate permitted of any given size of plenum box is determined from the flow rate of the standard full size plenum box according to the following equation:

$$R = \frac{V}{1,3} \mathrm{x} 0,456 \qquad (1)$$

where

R is the maximum permitted flow rate in m^3/sec

V is the volume of any given size plenum in m^3

7.1.2 Pressure limitation

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

7.1.3 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 standard plenum of ISO 10302.

7.2 Damped plate

The specification on the plate stock is a mechanical mobility of –45 dB (ref 1 m/Ns) from 25 Hz to 5000 Hz when measured in the middle of the plate of dimension 1,0 m^2 with no fan-mounting hole and with the plate freely suspended by two corners. The mobility measurement should be made in accordance with ISO 7626-4. The tolerance on the mobility levels is ± 8 dB from 25 Hz to 100 Hz, ± 4 dB from 100 Hz to200 Hz, and ± 2 dB from 200 Hz to 5000 Hz. These tolerance limits ensure that the plate has sufficient damping to prevent excitation of the frame.

7.3 Mounting area

This Standard covers vibration levels from small AMDs with a maximum mounting footprint of up to 0,48 m x 0,90 m for the full size plenum. For all sizes 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 document covers AMDs with a maximum mounting footprint of up to 0,18 m x 0,30 m).

8 Installation

8.1 Orientation of the AMD

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

8.2 Mounting of the AMD

The AMD shall be mounted on a damped plate meeting the specifications of 7.2. Unless special mounting attachment devices are being evaluated, the AMD shall be attached to the test plate 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 Nm. In the case of multiple in-line mounting holes being provided in the AMD housing, only the holes against or nearest to the mounting plate assembly shall be used.

8.3 Mounting plate 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 to the damped plate assembly directly and without any seals or gasketing.

9 Operation of air moving devices

9.1 Input power

9.1.1 Alternating Current AMDs

Unless otherwise specified, the AMD shall be operated at each rated power line frequency and within ± 1,0% 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.

9.1.2 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

Additional recommended, but not required, voltages are given in annex A if the fan will operate with variable speeds.

9.2 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 9.1. These points of operation correspond to

a) maximum volume flow rate (free delivery);
b) % of maximum volume flow rate;
c) 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 acceleration level versus volume flow rate curve. Some AMDs (e.g., small tube-axial fans) may be unstable when operated near the maximum overall static efficiency point. Tests should not be conducted at unstable points of operation.

Points of operation shall be determined according to ISO 10302, section 7.2.

10 Instrumentation

10.1 Plenum pressure measurements

The AMD static pressure shall be measured in accordance with ISO 10302. 10.2 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 within the frequency range of 20 Hz to 6300 Hz inclusive, when mounted in accordance with this test method and measured using one or more of the methods specified in ISO 5347, 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 usually will be a piezoelectric accelerometer. The mass of the transducer, i.e., that portion of the accelerometer system which is to be attached to the structure, shall not exceed 3 grams. 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.

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

NOTE

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 (10% accuracy limit).

10.3 Signal conditioners

The transducer system in 10.2 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.

10.4 Analyzer

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

The one-third octave band filters shall meet the requirements of IEC 61260 for xx, yy, 1, or better.

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

11 Measurement procedure

11.1 Preparation

a) Record the name, model number, serial number, dimensions, nameplate data, date code, and complete description of AMD under test..

b) Obtain the AMD performance curve in accordance with ISO 5801.

c) Measure the ambient temperature, relative humidity, and barometric pressure.

d) Zero the manometer for test plenum.

e) Calibrate the accelerometer and measurement instrument chain in accordance with 11.3.

f) Measure the background acceleration level in accordance with 11.4.

g) See 11.4.1 on how to derive averages.

11.2 Operational test for AMD

a) Mount the AMD on test plenum in accordance with clause 8.

b) Warm-up the AMD until the temperature of the windings is stable, typically 15 minutes.

c) Adjust the voltage in accordance with 9.1.

d) Adjust the slider to obtain desired point of operation following the instructions in 9.2.

e) Measure the acceleration level at each mounting point for the time period specified in 11.9.

f) Record data in accordance with clause 12.

g) Repeat the above steps c through f for additional points of operation as required.

11.3 Calibration

11.3.1 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 vibration level measurements of AMDs. In particular, transducers shall be conditioned in accordance with the manufacturer's specification.

The accelerometer shall be fastened to a suitable vibration shaker equipped with a reference accelerometer calibrated by or referenced to an absolute calibration in compliance with ISO 5347. This calibration need be performed at only one frequency within the frequency range of interest, preferably at an amplitude equal to or greater than the measured values for the AMDs under test.

The amplitude of the signal that results from placing the accelerometer on the shaker shall be read out on the meter or analyzer that will be 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 shaker.

11.3.2 Basic calibration

A basic calibration of the accelerometer, the shaker used for operational calibration and all instruments in the chain is recommended once a year and required once every two years. The accelerometer and the shaker shall be calibrated by a procedure in compliance with ISO 5347, and traceable to a national standards laboratory. The remaining instrumentation chain shall be calibrated in accordance with the manufacturer's recommendations traceable to a national standards laboratory.

11.4 Measurement

11.4.1 Operational measurement and data averaging

The acceleration level measurement shall consist of a 1/3rd octave band acceleration level measurement at each of the transducer mounting locations specified in 11.8, at each of the voltages specified in 9.1, for each of the operating points specified in 10.1, and for the duration specified in 11.9. Measurements shall be in decibels, rounded to the nearest 0,1.

For each voltage and pressure loading, the overall unweighted vibratory acceleration level at each measurement location L_{ai} shall be computed from the one-third octave band acceleration levels at that location from the following equation:

$$L_{ai} = 10\lg\Sigma 10^{L_{aij}/10} \qquad (2)$$

where L_{ai} is the overall unweighted vibratory acceleration level at the *i*th measurement location
L_{aij} is the jth one-third octave band acceleration level at the *i*th measurement location
j = the one-third octave band, from 25 Hz to 5000 Hz.

For each voltage and pressure loading, the energy average of the overall and one-third octave band acceleration levels shall be computed in accordance with the following equations:

$$\langle L_a \rangle = 10\lg\frac{1}{N}\sum_{i=1}^{N} 10^{\frac{L_{ai}}{10}} \qquad (3)$$

$$\langle L_a \rangle = 10\lg\frac{1}{N}\sum_{i=1}^{N} 10^{\frac{L_{aij}}{10}} \qquad (4)$$

where N is the total number of measurement locations.

The energy average acceleration level in equations (3) and (4) are the values that are reported in accordance with clause 12.

NOTE

As an example, if the measured overall vibration levels L_{ai} at four locations are 93, 97, 103, and 98, the energy average of the overall acceleration level is given by:

$$\langle L_a \rangle = 10\lg[(1/4)\,(10^{9,3}+10^{9,7}+10^{10,3}+10^{9,8})] = 99,2$$

11.4.2 Background measurement

Before each measurement series and at least once a day, the background 1/3rd 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 is 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 Standard except the AMD shall be removed from the damped plate or switched off. Background measurements shall be made at all the specified mounting locations and energy averaged — that is this measurement should be the same as an operational test but with the AMD off. The duration of the background measurement should also comply with 11.9

11.5 Corrections for background acceleration levels

When the background acceleration level is more than 10 dB below the measured level (including background) in every 1/3rd octave band, no corrections are required.

When the background 1/3rd octave band acceleration level is between 3 and 10 dB below the measured level (including background) the measured level at each point and in each frequency band may be corrected for the influence of the background level by the following equation:

$$L_{acorr} = 10\lg\left(10^{\frac{L_{am}}{10}} - 10^{\frac{L_{ab}}{10}}\right)$$

where:

L_{acorr} is the corrected acceleration level (dB)

L_{am} the measured acceleration level, including the background acceleration level (dB)

L_{ab} is the measured background acceleration level (dB)

All 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 corrected if the effect on the overall level is more than 0,5 dB.

When the background acceleration level is less than 3 dB below the measured level (including background) no corrections are allowed, but the measured 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 Standard have not been satisfied for that measurement.

11.6 Accelerometer mounting

The accelerometer shall be rigidly attached (screwed or glued), or shall be attached to the damped plate using beeswax. The recommendations of the accelerometer manufacturer for such mounting shall be carried out so that frequency response meets the requirements of section 10.2.

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

1. Ensure that the mounting surface is as smooth as possible. Also ensure that the accelerometer base and the mounting point on the plate are free of dirt and grease.
2. Pinch or scrape off a small quantity of wax and roll between the fingers to soften it.
3. Smear the wax on the damped plate 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.
4. Slide the accelerometer onto 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 11.7.

NOTE

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:

1. *The cable should not be sharply bent or twisted.*
2. *The cable should be taped, or otherwise attached, to the damped plate so as to avoid relative movement to the extent practicable. The cable should be routed to leave the damped plate along its fixed edge.*
3. *The cable should be routed to avoid sources of high electromagnetic fields.*

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

11.8 Accelerometer locations

A measurement shall be taken from an accelerometer mounted to the damped plate 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 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 center of the accelerometer shall be positioned at a point on the line through the attachment point and the center 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 attachment may produce different results.

11.9 Data acquisition time

The duration of the acceleration measurement shall be at least 16 s at each mounting point, with a minimum of 30 s total acquisition time for all positions.

12 Test report

12.1 Data to be recorded

Results shall be reported over the frequency range of interest (clause 5) as (1) overall acceleration levels and (2) unweighted one-third octave band acceleration levels, at a stated voltage or speed and point of operation.

Included in the report shall be:

- AMD Data *[Check with 10302*]
  - manufacturer model and part number
  - type (e.g. tubeaxial fan)
  - impeller diameter
  - number of blades
  - rotational speed in revolutions per minute (RPM) to nearest 5 RPM
  - part/serial number
  - nameplate date
  - date of manufacture
  - part description
  - input line voltage and frequency if alternating current
  - measured AMD principal dimensions
  - fan static pressure
- accelerometer locations
- dry bulb and wet bulb temperatures
- relative humidity
- air density
- barometric pressure
- test set-up description
- air flow and static pressure
- date of test
- laboratory location
- name of operator
- whether the inlet or outlet of the AMD is mounted to the damped plate, method of mounting including number of points and locations
- whether the test plenum was being pressurized or evacuated
- special mounting hardware and accelerometer mountings shall be described, and
- transducer, test plenum size and analysis equipment types and model numbers, serial numbers, shall be recorded.
- Average and individual acceleration levels in each 1/3rd octave band

The overall unweighted acceleration level and one-third octave band levels shall be at least tabulated to one decimal place, and optionally, graphically presented for each AMD tested.

12.2 Information to be reported

Data should be presented using forms similar to those given in annex A.

a) A statement that the air-moving device has been tested in conformance with this Standard.

b) Manufacturer, product name (if any), manufacturer’s part number, serial number (if any), dimensions (length, width, depth, hub diameter, impeller diameter), all other nameplate data, and a complete description of the air-moving device under test.

c) The air-moving device performance curve, or the reference points of operation used.

d) The average overall acceleration level $<L_a>$ in decibels (reference: 10 μm/s^2) to the nearest 1,0 dB for each point of operation.

e) The average acceleration level $<L_a>$ in decibels (reference: 10 μm/s^2) to the nearest 1,0 dB in one-third octave bands for each point of operation.

f) Detailed description of operating conditions of the air-moving device under test as recorded in 12.1 (voltage, frequency, fan static pressure, volume flow rate, input power, and rotational speed).

g) Information on temperature in degrees Celsius, on humidity as a percentage, on barometric pressure in kilopascals, and any other information that may be pertinent to the particular air-moving device under test.

Annex A

Suggested data format for presentation

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

Page 1 of __

The data presented in this report have been determined in accordance with Standard ECMA-275, "Measurement of structure-borne vibration induced by small air moving devices (AMDs)."

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:

- Dry and wet bulb temperatures_______________
- Relative humidity___________________________
- Air density_________________________________
- Barometric pressure_________________________

Air Moving Device (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, mfgr., model. serial number ______________________________

   4.2 analysis instrumentation ______________________________

Air Moving Device (AMD) structure-borne vibration test report
(continued)

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Test Condition (see ISO 5801 ANSI/ASHRAE 51)				Overall Average Acceleration Level
Operating condition	Volumetric flow m^3/s	Static pressure Pa	Rotational speed rpm	$<L_a>$ (re 1,0 $\mu m/s^2$) dB
Maximum flow 80% Maximum flow 20% Maximum flow Others (specified)				

Name of individual performing measurements:

Organization: ____

Date: ____

Document number: ______________________________________

Other referenced documents: ______________________________

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

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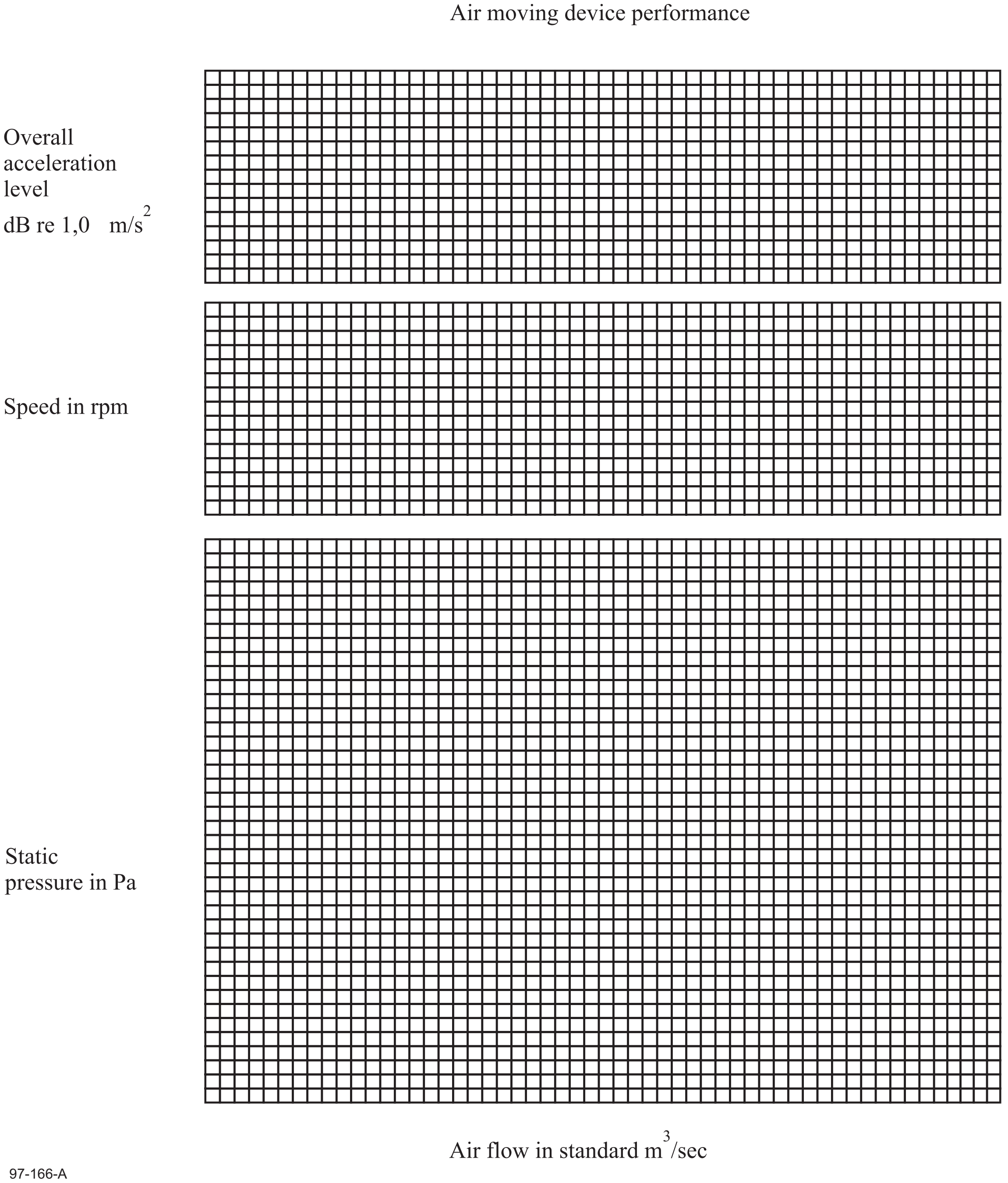

Model: ______________________________ Part/Serial number: _________________________

Test voltage: _________________________ Power line frequency (if applicable):____________

Date: _______________________________ Other information:__________________________

Air Moving Device structure-borne vibration test report

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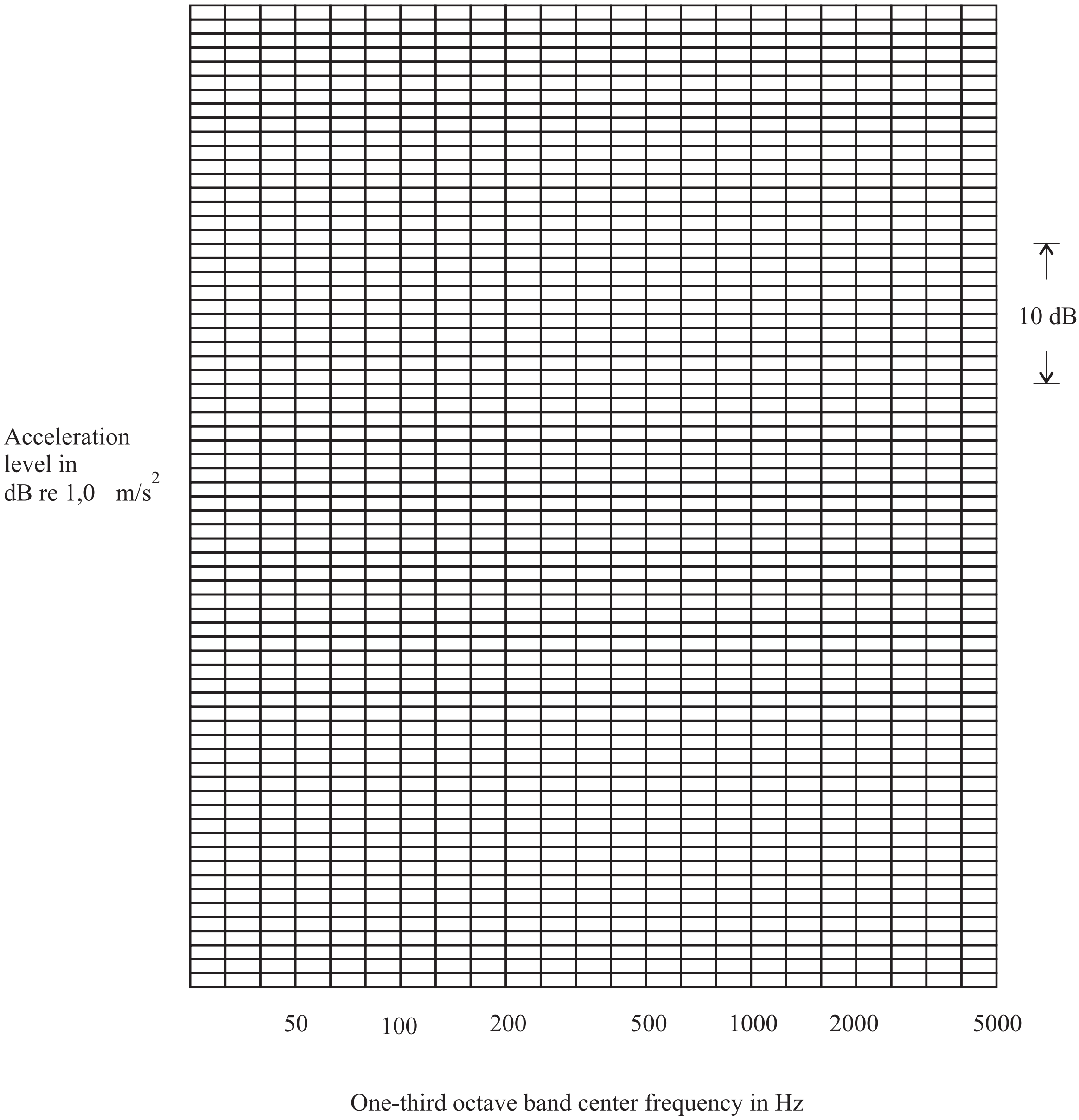
Air moving device

one-third octave band acceleration level spectra



97-0167-A

Model: ____________________________________ Part/Serial number __________________________

Test voltage: _______________________________ Power line frequency:_______________________

Date: _____________________________________ Other information: __________________________

Annex B

(informative)

Recommended voltages for testing AMDs that will operate with variable speeds

B.1 Background

Unlike airborne noise from AMDs, which increases monotonically with rotation speed, structure-borne vibration levels sometimes behave erratically as a function of rotation rate. 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 resonance’s where increases of 10 dB or more can occur in a small speed range, but even for AMDs without strong resonance’s, variations of 3 to 5 dB are common.

B.2 Recommended Procedure

For the slider setting associated with 80% of free delivery airflow, or for free delivery if the AMD is not being tested under static pressure loadings, vibratory acceleration level measurements shall be made on the damped plate 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 (a) 0,1 V or (b) 1% of the voltage range of interest, whichever is larger. The duration of the measurement at each voltage step should be at least 8 s. If a continuously swept voltage is used, then the total duration of the sweep should be equal to or larger than the time required for the incremental step approach.

The overall unweighted vibratory acceleration level shall be recorded at each voltage for the incremental step approach, or it shall be plotted as a function of voltage if the continuous voltage sweep approach is used. The vibratory acceleration levels at these sweep voltages -- incremental or continuous -- are to be compared with the vibratory acceleration level at the maximum fixed voltage required in 9.1, 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 9.1, then voltage at which the maximum acceleration level occurs shall be noted, and a full measurement and report according to this Standard, including all mounting positions, should be made at this voltage. If measurements are being made at other static pressure loading, the same procedure shall be followed at these points.

Annex C

(informative)

Sample specification of AMD structure-borne vibration levels

C.1 Recommended specification format

This air moving device shall not have an overall acceleration level greater than __ dB re 1,0 µm/s^2 when tested in accordance with ECMA Standard-275, "Measurement of structure-borne vibration induced by small Air Moving Devices (AMDs)," operating at ___ V a.c./d.c., ___ Hz at an operating point corresponding to a fan static pressure of ____ Pa and a volumetric flow rate of _____ m^3/s.

C.2 Optional specification format

This air moving device shall not have an overall acceleration level greater than __ dB re 10 µm/s^2 when tested in accordance with ECMA Standard-275, "Measurement of structure-borne vibration induced by small Air Moving Devices (AMDs)," 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 volumetric flow rate of ____ m^3/s and one corresponding to a fan static pressure of ____ Pa and a volumetric flow rate of ____ m^3/s.

C.3 Determination of specification values

Specification values for the above formats shall be determined by analyzing data from AMDs tested according to this Standard.

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

Annex D

(informative)

Bibliography of papers related to this methodology

"Measurement of Structureborne Vibration Induced by Small Air Moving Devices" Institute of Noise Control Engineering Recommended Practice, 1997.

Hellweg, R. D., Pei, H .S., and Wittig, L. E., "Precision of a New Method to Measure Fan Structureborne Vibration", INTER NOISE 96, p 191, 1996.

Wittig, L.E., "Fan Vibration Measurements on the INCE Plenum Box – Apparatus Size Limitations", NOISE CON 91, p 617, 1991.

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Pei, H.S. and Wittig, L., " Structureborne Noise from Small fans – Summary of the Work by the INCE TG/CBE Fan Vibration Subcommittee", NOISE CON 90, p. 31, 1990.

Potter, A., "Structure-borne Noise and Fan Back Pressure", NOISE CON 90, p. 37, 1990.

Wittig, L. E. and Hsieh, H., "A Test Fixture for Measuring Small Fan Vibration Levels", NOISE CON 90, p. 49, 1990.

Koch, J. and Poldino, M., "Vibration Testing of Small Air Moving Devices", NOISE CON 90, p. 61, 1990.

Lotz, R., "Precision of a New International Standard for Measurement of Fan Noise – ISO 10302", NOISE CON 91, p. 119, 1991.

Wittig, L. E. and Hellweg, R. D., "Statistical Analysis of Noise Level Measurements Made on Variations of the ISO 10302 Fan Plenum Box", INTER NOISE 92, p. 461, 1992.

Other Standards

MIL-STD-740-2(SH), "Military Standard: Structure-borne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment"

MIL-B-23071C, "Military Specification: Blowers, Miniature, for Cooling Electronic Equipment"

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