ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-160

DETERMINATION OF SOUND POWER LEVELS OF COMPUTER AND BUSINESS EQUIPMENT USING SOUND INTENSITY MEASUREMENTS; SCANNING METHOD IN CONTROLLED ROOMS

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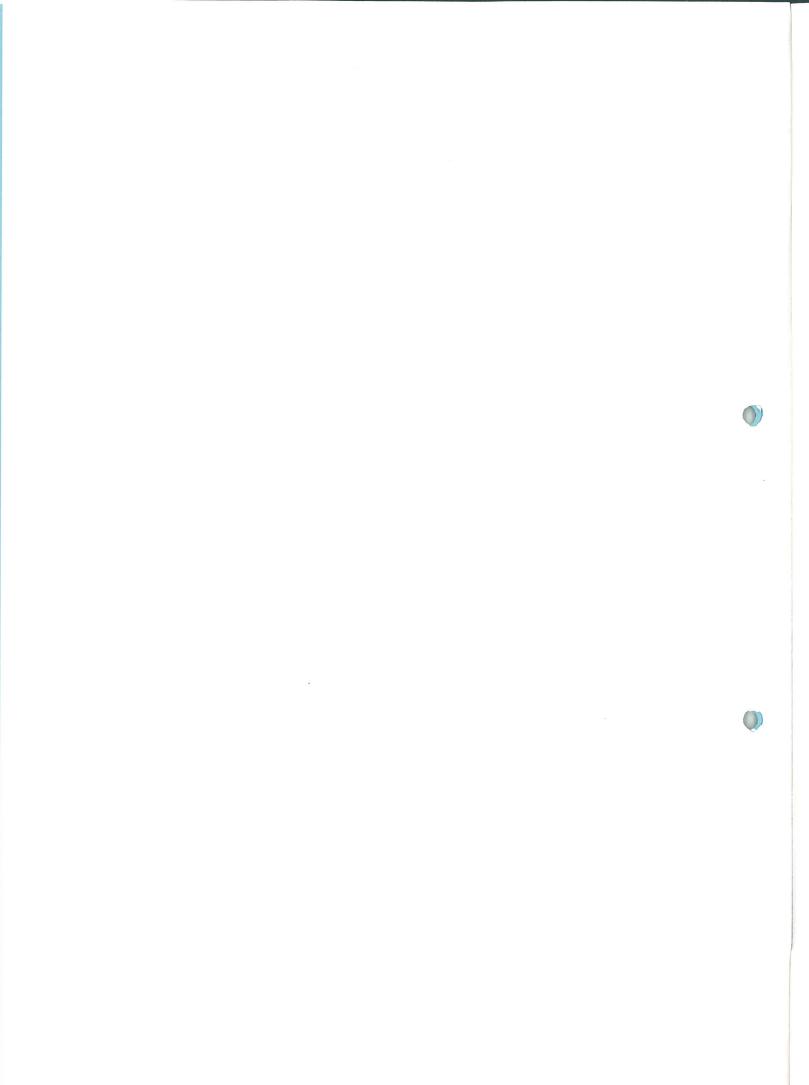
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Brief History

This ECMA Standard specifies methods for the measurement of sound power levels of the airborne noise emitted by computer and business equipment using sound intensity techniques, scanning methods.

The sound power radiated by equipment under test is given by the integral over a surface enclosing the equipment of the normally directed component of sound intensity. The previous standards for the determination of sound power levels of computer and business equipment are based on measurements of sound pressure under specific measurement conditions, mainly as described in ECMA-74 (ISO 7779) which is based on ISO 3741, ISO 3742, ISO 3744 and ISO 3745. This ECMA Standard provides methods for the determination with engineering grade accuracy of sound power levels of computers and business equipment by using scanning techniques to measure sound intensity.

The relationship between sound intensity level and sound pressure level at any point in space depends on the characteristics of the equipment, the characteristic of the measurement environment and the disposition of the measurement positions with respect to the noise source. Therefore the previous standards necessarily specify the source characteristics, the test environment characteristics and qualification procedures, and the measurement methods which are expected to restrict the uncertainty of the sound power level determination to within acceptable limits. However, the previous methods are not applicable when the equipment is to be measured in rooms other than reverberation rooms (ISO 3741 or ISO 3742) or essentially free field over reflecting planes (ISO 3744 or ISO 3745). The purpose of this ECMA Standard is to obtain a practical and sufficiently precise method of sound power determination of computer and business equipment by using sound intensity measurement technique. Thus the sound power level of computer and business equipment can be determined with engineering grade accuracy in rooms other than those required by ECMA-74, clauses 5 and 6.

The scanning method has been selected for use in this ECMA Standard instead of the fixed-point method because of its ease of use in measuring computer and business equipment and its potential for increased accuracy.

Draft Danish Standard DS F 88/146: "Acoustics - Determination of Sound Power levels of Noise Sources using Sound Intensity Measurements. Scanning Method for use in situ" (April 1988) was the basis for this Standard with modifications to insure engineering grade accuracy and to ensure its applicability to the measurement of computer and business equipment. Modifications have been made to the draft Danish standard to ensure compatibility with ECMA-74. Other modifications have been made to insure compatibility with applicable sections of ISO/DIS 9614-1.

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1   Scope

This ECMA Standard specifies a procedure for the determination of sound power levels of computers and business equipment under its normal operating conditions (see ECMA-74), by using sound intensity measurements in rooms other than dedicated acoustical laboratories. The sound intensity distribution is measured on a surface enclosing the equipment under test.

The measurement procedure is based on a scanning technique, i.e. continuously moving the intensity probe across the measurement surface following a pre-defined pattern while the instrument is integrating. The measurements give the total radiated airborne sound power from a noise source.

The basic emission quantity for computer and business equipment is the A-weighted sound power level (sound power levels may also be determined in one-third octave or octave bands). The sound power levels may be used for declaration and comparison purposes (see ECMA-109) for equipment of the same type but from different manufacturers, or of different types. They are not to be considered as installation noise immission levels; however they may be used for installation planning (see ECMA TR/27).

The purpose of this measurement procedure is to obtain sound power levels in "controlled" environments using sound intensity procedures with an engineering grade accuracy that is comparable to that of the methods of clauses 5 and 6 of ECMA-74. The measurements performed using this Standard are made in less restrictive environments than special acoustical rooms; however, if the source is closer to a wall than specified in ECMA-74, the sound power emitted from the source may be different from that emitted in a reverberation room or in an hemi anechoic room, although this difference is not expected to be significant.

For example, this scanning method can be used for checking whether the noise emission values reported in specification sheets according to ISO/IEC 11159 and ISO/IEC 11160 are, indeed, met by installed equipment. The advantage of this method is that this check can be made in ordinary rooms, which reduces the time and cost involved considerably.

This measurement procedure is not intended for the identification of noise sources within the equipment under test.

This standard gives requirements for the acoustical environment, extraneous noise, measurement surface, and scanning technique for the intensity measurement. The procedure for calculating sound power from sound intensity is given. The noise of the equipment under test has to be stationary so that proper time and spatial integration is obtained while scanning over the measurement surface. The measurement of isolated bursts of sound energy is thus not covered by the method, unless the isolated bursts are repeatable and special precautions are utilized during the scanning.

It is recommended that personnel performing sound intensity measurements according to this Standard are trained and experienced in performing acoustical and sound intensity measurements.

2   Conformance

Measurements are in conformance with this Standard if they meet the following requirements:

- The measurement procedure, the installation, and the operating conditions specified by this Standard are fully taken into account.

- The engineering accuracy requirements are met as specified in 8.6.

3   References

ECMA-74	Measurement of Airborne Noise Emitted by Computers and Business Equipment (1987)
ECMA-109	Declared Noise Emission Values of Computer and Business Equipment (1987)
ECMA TR/27	Method for the Prediction of Installation Noise Levels (1985)
ISO 2204 : 1979	Acoustics - Guide to International Standards on the measurement of airborne acoustical noise and evaluation of its effects on human beings
ISO 6926 : 1990	Characterization and calibration of reference sound sources
ISO 7779 : 1988	Acoustics - Measurement of noise emitted from computer and business equipment
ISO 9296 : 1988	Acoustics - Declared noise emission values of computer and business equipment
ISO/DIS 9614-1 : 1989	Acoustics - Determination of sound power levels of noise sources using sound intensity - Measurement at discrete points
ISO/IEC 11159 : 1991	Office equipment - Minimum information to be included in specification sheets - Copying machines
ISO/IEC 11160 : 1991	Office equipment - Minimum information to be included in specification sheets - Printing machines
IEC 942 : 1988	Sound calibrators

4   Definitions

For the purpose of this Standard the definitions in ECMA-74 and the following additional definitions apply.

4.1   Apparent background sound power level

The sound power level measured under the same conditions as used to measure L_{WI} with the equipment under test switched off.

4.2   Background sound pressure level

The total surface sound pressure level measured under the same conditions as used to measure L_{WI} with the equipment under test switched off.

4.3   Extraneous noise

Noise generated and/or reflected from outside the volume enclosed by the measurement surface and the floor.

4.4   Field indicator F

The difference between the time-averaged sound pressure level L_{pT} and the sound intensity level L_{I_n}.

NOTE 1

F can be presented as the difference between frequency band levels or between total levels and is calculated as given in 9.3. The field indicator F is used to evaluate the acoustical field where the intensity measurements are taking place.

NOTE 2

$F = 0$ dB for a propagating plane wave when the intensity is measured in the direction of propagation of the wave at standard conditions.

4.5   Instantaneous sound intensity $I(t)$

The instantaneous rate of flow of sound energy per unit of area oriented normal to the local instantaneous particle velocity. This is a vector quantity which is equal to the product of the instantaneous sound pressure at a point and the associated particle velocity, given by the equation :

$$I(t) = p(t)\, u(t) \quad \text{W/m}^2$$

where :

$p(t)$	is the instantaneous sound pressure at a point, in pascals
$u(t)$	is the instantaneous particle velocity at the same point, in metres per second
t	is time in seconds

4.6   Measurement distance

The shortest distance between the physical surface of the equipment under test and the measurement surface.

4.7   Measurement surface

A predefined surface of area S on which the intensity component normal to the surface is integrated to obtain the radiated sound power through the surface.

4.8   Normal sound intensity I_n

The sound intensity component in the direction normal to a measurement surface defined by unit normal vector n. The signed magnitude of I_n is denoted by I_n and the unsigned magnitude is denoted by $|I_n|$. The unit normal vector n is directed out of the volume enclosed by the measurement surface.

4.9   Normal sound intensity level L_{I_n}

The logarithmic measure of the absolute value of the normal sound intensity $|I|$, given by the equation :

$$L_{I_n} = 10 \lg \frac{|I_n|}{I_0} \quad \text{dB}$$

where I_0 is the reference intensity 10^{-12} W/m^2.

When the sign of I_n is negative, the sound intensity level L is expressed as a negative value noted as (-) xx dB.

4.10 Pressure-residual intensity index

The difference between indicated L_{pT} and L_I when the probe is placed in a sound field in such an orientation that the particle velocity in the direction of the probe measurement axis is 0 (e.g. in an acoustical coupler, or transverse to the direction of propagation of a plane sound wave).

4.11 Sound intensity I

The time-averaged value of $I(t)$ in a stationary sound field, given by the equation :

$$I = \lim_{T \to \infty} \frac{1}{T} \int_{T/2}^{-T/2} I(t) \; dt \quad W/m^2$$

where T is the averaging time (integration time) in seconds.

4.12 Sound power WI

The total time-averaged rate of flow of sound energy generated by a source as determined by this Standard.

In accordance with this ECMA Standard the sound power WI radiated through the measurement surface, S, can be determined by integrating the intensity component normal to S, over S as given by the equation :

$$WI = \int_S I_n \; dS \quad W$$

where : I_n is the magnitude of the sound intensity component normal to the measurement surface;

S is the measurement surface area.

NOTE 3

For measurements according to this Standard, an estimate of the surface integral is found by using the scanning technique described in clause 8.

4.13 Sound power level L_{WI}

The logarithmic measure of the sound power through a measurement surface, given by the equation :

$$L_{WI} = 10 \lg \frac{|WI|}{W_0}$$

where :

WI is the sound power through a measurement surface, in watts;

W_0 is the reference sound power, 10^{-12} W.

When WI is negative, the sound power level L_{WI} is expressed as a negative value noted as (-)xx dB.

NOTE 4

In this ECMA Standard, the sound power is the time-averaged value of the sound power during the measurement interval.

4.14 Stationary noise

A noise is considered stationary in time if its time-averaged properties for the duration of measurement of each surface do not change for the measurement of all surfaces.

4.15 Time-averaged sound pressure level L_{pT} in dB

Ten times the logarithm to the base 10 of the ratio of a time-mean-square value of instantaneous band-limited sound pressure, during a stated time interval, to the square of the standard reference sound pressure. The standard reference sound pressure is 20 µPa.

5 Acoustical environment

5.1 Physical conditions

The test environment shall be such that the principle by which the sound intensity is measured by the particular instrument employed is not invalidated. Reference shall be made to IEC Publications when they become available for guidance in this respect. In addition, the test environment must satisfy the requirements stated in 5.2 of this Standard, and ISO/DIS 9614-1, 4.2 to 4.5. Measurements shall be made in a room having at least partially absorbing walls and ceiling. It is recommended that the area of all room surfaces is at least ten times the surface area of the total measurement surface.

NOTE 5

A room with a low and steady background noise level will improve accuracy.

5.2 Extraneous noise

The extraneous noise shall be stationary (e.g. room ventilators, air conditioning, etc., shall not be switched on or off) during measurements.

When the radiated sound power levels from different sub-assemblies (disks, tapes, etc.) of the equipment are evaluated separately, the extraneous noise needs only to be stationary during measurements on each sub-assembly.

6 Instruments

6.1 General

The measuring instrument shall be capable of measuring A-weighted or frequency band intensity levels in decibels, re 10^{-12} W/m^2. Frequency bands are one-third octave or octave bands. The instrument shall measure the intensity in real time if the noise is impulsive or not steady during the surface measurement duration.

Pressure-residual intensity index shall be higher than 15 dB in the frequency range used.

6.2 Intensity probe

The choice of the probe configuration is dependent upon the frequency range of the dominant noise emissions. Preliminary sound pressure level measurements shall be carried out, at representative positions on the measurement surface, to determine the appropriate probe configuration(s).

The probe shall then be selected in accordance with the manufacturer's specifications. If the sound energy covers a wide frequency range, it may be necessary to use more than one probe configuration.

6.3 Calibration

6.3.1 Sound pressure calibration

Before and after each series of measurements, an acoustical calibrator and, if necessary, a coupler, in accordance with IEC Publication 942, with an accuracy of 0,5 dB shall be applied to the microphone(s) for checking the calibration of the entire measuring system at one or more frequencies over the frequency range of interest. The calibrator shall be checked annually to verify that its output has not changed. In addition, an electrical calibration of the instrumentation system over the entire frequency range shall be performed at intervals of not more than two years.

6.3.2 Intensity measurement check

The intensity probe shall be placed on the measurement surface, oriented normal to the surface, at a position where the noise from the equipment is characteristic for that equipment. The intensity probe should preferably be mounted on a stand to retain the same position while carrying out the measurement check. The intensity shall be measured. The intensity probe shall be rotated by 180° about a normal to its measurement axis in the same position as at the first measurement. The intensity shall be measured again. For the A-weighted or the maximum sound intensity level measured in one-third octave or octave bands, the unsigned difference between the two sound intensity levels shall be less than 0,9 dB for the measuring instrumentation to be acceptable.

6.3.3 Additional field checks

Additional field checks shall be carried out according to the instrument manufacturer's specifications, where recommended.

6.3.4 Pressure-residual intensity index

The pressure-residual intensity index of the instrument used for measurements shall be recorded for each frequency band of measurement before each set of measurements.

6.3.5 Annual sound power calibration

The instrument system shall be calibrated annually by measuring the sound power level of a reference sound source that meets the requirements of ISO 6926. The differences in A-weighted or band sound power levels determined with this Standard and the rated sound power levels shall be less than the values given in table 2 in 8.6.

7 Equipment under test

7.1 General

There is no restriction on the size of the equipment under test. The equipment has to be practically non-absorbing on its external surfaces.

The character of noise radiated by the equipment shall be stationary so that proper time and spatial integration is obtained. The frequency distribution can be broad-band, discrete frequency or narrow-band.

Sufficient samples shall be taken so that series of measurements according to 8.5.3 of L_{I_n} for each measurement surface result in a standard deviation that is less than 50% of the values given in table 2 (see 8.6). If the difference in two measured values of L_{I_n} is less than 1,0 dB, then sufficient samples have been measured. In order to improve the standard deviation, change the direction of the probe pattern and start the measurement at a different position on the pattern.

7.2 Installation of equipment

The equipment under test shall be mounted according to ECMA-74. The equipment shall be mounted so that none of the sides of the measurement surface are parallel to the walls of the room except for equipment mounted on or near a wall (see 6.5.1 of ECMA-74). The floor underneath the equipment under test and the projection of the measurement surface shall be a hard reflecting plane.

7.3 Equipment operation

The equipment under test shall be operated according to 6.5.3 and annex C both of ECMA-74. If an operator is required for the equipment under test the operator shall be present at the same location during all measurements.

8 Measurements of sound intensity levels and sound pressure levels

8.1 General

The intensity probe is moved continuously across the measurement surface using the defined pattern in 8.5.3 while the instrument is integrating, i.e. both time integration and an approximate spatial integration are thus obtained simultaneously. The scanning shall be carried out at a constant speed and with a constant line density to ensure the best estimate of time and spatial integration.

Measurements of the normal sound intensity and sound pressure shall be made in the frequency bands in which the sound power level is to be determined. If the sound pressure is not measured simultaneously with the sound intensity during the scanning, the sound pressure shall be measured separately following the same scanning procedure as for the sound intensity measurement.

The following steps, described in detail below, are used to determine the sound power level of the equipment under test and the field indicator F:

a) evaluate the noise characteristics of the equipment and the extraneous noise (variation in time, frequency content, discrete tones, etc.);

b) choose a measurement surface and related measurement distance for each sub-area;

c) divide the surface into logical and practical sub-areas;

d) scan each sub-area to obtain the sound power through that sub-area;

e) sum the sound power from each sub-area to obtain the total sound power radiated from the equipment;

f) scan each sub-area to obtain the average sound pressure level for that sub-area;

g) determine the spatial average sound pressure level from the sound pressure level measurements for each sub-area according to the equation in 9.3;

h)   calculate the field indicator F to assess the degree of accuracy for the measurement from the procedure in 9.3.

The duration T of the intensity measurement on each measurement sub-area shall be as specified in 5.7.1 of ECMA-74 or as given by the formula

$$T = \frac{800}{B}$$

where B is the filter bandwidth, whichever is greater. If the measurements are overall A-weighted sound intensity, the duration T shall be at least 16 seconds.

8.2 Characteristics of equipment noise and extraneous noise

The requirements with respect to the equipment noise and the extraneous noise are described in clauses 5 and 7.

If the extraneous noise is changing, but is constant at the same level during certain time periods, the measurement surface should be subdivided in accordance with 8.4. The radiated sound power and sound pressure from each main sub-area shall then be measured during periods of constant extraneous noise.

8.3 Measurement surface and related measurement distance

The measurement surface shall totally enclose the equipment under test, excluding reflecting floors and/or walls on which the equipment is mounted. To ease the scanning of the sub-area, the measurement surface shall consist of flat areas, and should follow the main shape of the equipment surface.

With low levels of extraneous noise the measurement surface may be a rectangular parallelepiped and shall have a minimum measurement distance of 0,1 m and a maximum measurement distance of 1,0 m. With high levels of extraneous noise or in cases of doubt about the influence of extraneous noise a measurement distance between 0,1 m and 0,2 m shall be used.

8.4 Surface subdivision

The measurement surface shall be divided into sub-areas if it is impractical to scan the whole measurement surface at one time. Each sub-area shall be indexed and the areas measured.

If it is likely that problems will arise in keeping a constant speed or constant line density during the scanning of an area, the measurement surface shall be divided into smaller sub-areas.

Special attention should be given to strongly radiating areas of the equipment. These areas should be assigned their own sub-areas. Strongly radiating areas can be localized by ear or by a preliminary sound pressure or intensity measurement.

8.5 Measurement procedure

8.5.1 Probe direction

The probe shall always be held normal to the measurement surface while scanning and shall be directed to measure the positive intensity outwards from the equipment under test.

8.5.2 Frequency range

Sound intensity levels integrated over a prescribed area shall be measured in frequency bands. One-third octave or octave bands with centre frequencies within

the range 100 Hz to 8 000 Hz may be used. Alternatively, if a single sound intensity probe configuration covers the frequency range of significant contributions to the A-weighted levels, then A-weighted sound intensity level may be measured directly.

The sound intensity probe used may not cover the whole frequency range from 100 Hz to 8 000 Hz, therefore, the frequency range used to determine the A-weighted sound power level shall be stated.

Contributions from other bands are not significant if the summation of the A-weighted levels from the other bands are more than 10 dB lower than the A-weighted level determined from the overall measurement. If the contributions from the other bands are within 10 dB of the overall A-weighted measurement, octave band or one-third octave band measurements are required.

8.5.3 Scanning pattern

Each sub-area shall be scanned at least twice. The first scan shall use parallel lines turning near each edge with a turning radius equal to one half the distance between the parallel lines, as shown in figure 1, and the second scan using parallel lines perpendicular to those used during the first.

The line density depends on the directivity of the equipment under test, i.e. both on frequency and on size of the equipment. For equipment with high directivity a relatively small distance between the scanning lines shall be used. A maximum distance between the scanning lines equal to the measurement distance is recommended.

Figure 1 - Scanning pattern

Care shall be taken when measuring close to, or in, air flows (for example, near a fan exhaust outlet). The provisions of ISO 9614-1 and the intensity probe manufacturer's instructions for measuring in air flows shall be followed. In the absence of such information, the probe shall not be placed in, or very close to, any airflow exceeding 2 m/s.

8.5.4 Scanning speed

The scanning on each sub-area shall be made with a steady speed between 0,1 m/s and 0,5 m/s.

If the scanning speed and line density are different for different sub-areas, the sound power radiated from each sub-area should be measured separately and summed afterwards in accordance with the formula in 9.2.

The measurements may be interrupted and continued when moving from one sub-area to another or when going around obstacles. Other stops shall be avoided. It is important that each sub-area be scanned with uniform scanning speed and uniform line density to avoid regions within the sub-area causing a greater contribution due to a longer integration time per unit area.

8.5.5 Position of person performing the measurements

The person using the probe shall stand to the side of the probe such that their forearm and the probe handle make a straight line parallel to the measurement surface. This scanning operation keeps the probe head normal to the measurement surface during the whole scanning sequence and minimizes the person's influence on the radiated sound field. Alternatively, a robot may be used to move the probe.

8.5.6 Measurement procedure summary

The requirements of the measurement procedure are summarized in table 1.

Table 1 - Measurement procedure

	Level of extraneous noise	
	High	Low
Measurement distance	0,1 m to 0,2 m	0,1 m to 1,0 m
Distance between scanning lines	equal to, or less than, the measurement distance	
Scanning speed	0,1 m/s to 0,5 m/s	

8.6 Evaluation of measurements and measurement accuracy

The field indicator F shall be calculated in accordance with 9.3.

For this ECMA Standard, the engineering grade of measurement accuracy for the determination of the total sound power level is attained when the field indicator F does not exceed 5 dB. If the F indicator exceeds 5 dB, the accuracy provisions of this ECMA Standard have not been achieved.

NOTE 6

When the field indicator F is between 5 dB and 10 dB a survey grade of measurement accuracy is attained.

Measurements made in conformity with this ECMA Standard tend to result in standard deviations which do not exceed those given in table 2.

Table 2 - Uncertainty in determining sound power levels

Octave band centre frequencies in Hz	One third octave band centre frequencies in Hz	Standard Deviation in dB for $F \leq 5$ dB
125	100 to 160	3,0
250 to 500	200 to 630	2,0
1 000 to 4 000	800 to 5 000	1,5
	6 300 to 8 000	2,5
A-weighted		1,5

The measured sound power level shall be more than 10 dB greater than the apparent background sound power level.

For most computer and business equipment, the A-weighted sound power level will be determined by the levels in the 250 Hz to 4 000 Hz octave bands. The A-weighted sound power level is determined with a standard deviation of approximately 1,5 dB or less if F is less than 5 dB. This accuracy may also be obtained if the results in some frequency bands show large values of the field indicator F but do not contribute significantly to the total level.

9 Determination of radiated sound power levels

9.1 Calculation of radiated sound power levels for sub-areas

The sound power level for the i-th sub-area is calculated from the intensity level by the equation :

$$L_{WI_i} = L_{I_{n_i}} + 10 \lg \frac{S_i}{S_0}$$

where :

L_{WI_i} is the sound power level in decibels for sub-area i;

$L_{I_{n_i}}$ is the normal signed sound intensity level in decibels for sub-area i;

S_i is the area, in square metres, of sub-area i;

S_0 is the reference area, 1 m^2.

The sign of L_{WI} is the same as that of $L_{I_{n_i}}$.

$L_{I_{n_i}}$ and L_{WI_i} are given either as one-third octave band levels or octave band levels or as A-weighted levels.

9.2 Calculation of total sound power level

The sound power from each sub-area is summed to obtain the total sound power radiated from the equipment, given by the equations:

$$L_{WI} = 10 \lg \sum_{i=1}^{N} \frac{WI_i}{W_o}$$

$$WI - \sum_{i-1}^{N} WI_i$$

where :

L_{WI} is the total sound power level, in decibels;

N is the total number of sub-areas;

WI_i is the sound power, in watts, for sub-area i.

The values of WI_i shall be calculated from the equation:

$$\frac{WI_i}{W_0} = 10^{(L_{WI_i}/10)}$$

When the sound power L_{WI_i} is expressed as negative, the value of WI_i will also be negative.

NOTE 7

An example of the summation of sound power levels of five sub-areas of 53, 52, 52, 51 and (-)50 dB is given below:

$$\sum_{i-1}^{N} \frac{WI_i}{W_0} = 10^{53/10} + 10^{52/10} + 10^{52/10} + 10^{51/10} - 10^{50/10} = 5{,}42 \times 10^5$$

$$L_{WI} = 10 \lg (5{,}42 \times 10^5) = 57 \text{ dB}$$

L_{WI} and L_{WI_i} are given as one-third octave or octave band levels or as A-weighted levels. If A-weighted levels are calculated from one third octave or octave band levels the procedure in 5.10.2 of ECMA-74 shall be used.

9.3 Calculation of field indicator, F

The field indicator, F is calculated from the equation :

$$F = L_{pT_S} - L_{WI} + 10 \lg \frac{S}{So} \quad \text{dB}$$

where :

L_{WI} is the total sound power level, in decibels;

S is the area of the measurement surface, in square metres;

So is the reference area, 1 m^2;

L_{pTs} is the total surface time-averaged sound pressure level, in decibels, calculated from the equation :

$$L_{pT} = 10 \lg (1/S) \sum_{i-1}^{N} S_i \, 10^{0,1 L_{pT_i}} \quad \text{dB}$$

where :

L_{pT_i} is the surface time-averaged sound pressure level, in decibels, for sub-area i;

S_i is the area, in square metres, of sub-area i;

S is the total measurement area, in square metres;

N is the total number of sub-areas.

NOTE 8

L_{pT_i} *is either measured simultaneously with the sound intensity during the scanning of sub-area i or measured separately, repeating the scanning procedure used for the intensity measurement.*

The field indicator F is calculated for the frequency bands for which the sound power levels are to be determined.

The sound power levels and sound pressure levels are either A-weighted or frequency band levels.

10 Information to be recorded

The following information, where applicable, shall be recorded for all measurements made in accordance with the requirements of this Standard.

10.1 General

The date, time and place where the measurements were performed, and the name of the person having performed the measurements.

10.2 Equipment under test

i) Description of the equipment under test (including name, model, serial number, principal dimensions and location of sub-assemblies, where applicable).

ii) Operating conditions, including supply frequency and voltage.

iii) Installation conditions.

iv) Location of the equipment in the test environment.

v) Description of each individual mode for which measurements have been performed.

vi) Location and function of any operator required for operation of equipment under test.

10.3 Acoustical environment

i) Description of the test environment, including a sketch showing the location of the equipment, configurations and positions of nearby objects. Dimensions of rooms and material of room surfaces.

ii) Environmental data during the test (air temperature in °C, barometric pressure in kPa and relative humidity in %).

iii) Description of character of noise from sources other than that under test, including variability, occurrence of cycles, tonal quality.

10.4 Instrumentation

i) Equipment used for the measurements, including names, types, serial numbers and manufacturers. Type(s) of probe(s) or probe configurations. If more than one probe configuration is used, the frequency range of each probe used for determining the total sound power shall be reported.

ii) Bandwidth of frequency analyzer.

iii) Method(s) used to calibrate and perform field checks on the instrumentation.

iv)   Date and place of the latest calibration of the intensity measurement device.

10.5   Measurement procedure

i)   Description of each step in the measurement procedure, with reference to this ECMA Standard.

ii)   Description of the operation of the intensity probe during measurement including measurement distance for each sub-area.

iii)   Quantitative description of the measurement surface, including the division in sub-areas with reference to allocated index of each sub-area.

10.6   Acoustical data

i)   Qualitative description or sketch of the measurement surfaces and any sub-areas and their position relative to the equipment including areas S_i.

ii) L_{WI_i} and L_{p_i} for each sub-area, if applicable, for all frequency bands used.

iii)   Tabular or graphic presentation of the calculated value of total sound power level of the equipment in all frequency bands used, together with the field indicator F. Frequency bands that do not fulfil engineering grade accuracy shall be indicated.

iv)   Background sound pressure level and apparent background sound power level shall be reported.

11   Information to be reported

The report shall contain the statement that the sound power levels have been obtained in full conformance with the procedures of this Standard. The report shall state that these sound power levels are given in dB, reference 1 pW.

The report shall contain at least the following information considered to be most characteristic for computer and business equipment :

-   The name(s) and model number(s) of the equipment under test.

-   The A-weighted sound power level, L_{WA} in dB, for the idle mode and operating mode(s), reference 1 pW.

-   The band sound power levels, L_W in dB, for the idle mode and operating mode(s), if required, reference 1 pW.

-   The field indicator F for the A-weighted sound power level.

-   Detailed description of the operating conditions of the equipment under test with reference to annex C of ECMA-74, if applicable.

NOTE 9
For the determination of declared noise emission values, the procedures of ECMA-109 shall be used. According to ECMA-109 the declared A-weighted sound power level, L_{WAd}, of computer and business equipment is expressed in bells using the identity

$1 B = 10 dB$