ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-74

MEASUREMENT OF AIRBORNE NOISE EMITTED BY COMPUTERS AND BUSINESS EQUIPMENT

September 1981

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INTRODUCTION

This Standard ECMA-74 specifies methods for the measurement of airborne noise emitted by computer and business equipment. Previously, a wide variety of methods had been applied by individual manufacturers and users to satisfy particular equipment or application needs. These diverse practices have, in many cases, made comparison of noise emission difficult. This Standard makes such comparisons straightforward, and is the basis for designation of the noise emission level of computer and business equipment.

To ensure accuracy, validity and acceptability, this Standard is based on international standards for the determination of the sound power level (ISO 3741, 3742 and 3744) and of the sound pressure level at the operator position(s) (ISO 6081). Also, implementation is simplified by conformance to these international standards.

Two methods for determination of the sound power levels are specified in this Standard in order to avoid undue restriction on existing facilities and experience. The first method is based on reverberant room measurements (ISO 3741, 3742); the second is based on measurements in an essentially free field over a reflecting plane (ISO 3744). Either method may be used in accordance with this Standard. They are comparable in accuracy and yield the same A-weighted sound power level within the tolerance range of this Standard. Thus, uniformity of the resulting value of sound power level is ensured. In many cases free-field conditions over a reflecting plane are realized by semi-anechoic rooms. These rooms may be particularly useful during product design to locate and to improve individual contributing noise sources. Reverberation rooms may be more economical for production control and for obtaining sound power levels for labelling purposes.

The method for measurement of the sound pressure level at the operator or bystander positions (ISO 6081) is described in a separate section, as this level is not considered to be primary labelling information. The measurements can, however, be made at the same time as those made for sound power determination in a free field over a reflecting plane.

For comparison of similar equipment to be possible, the installation conditions and mode of operation must be the same. In Appendix C these parameters are standardized for most categories of equipment. It is intended to extend this Appendix C to other categories in the next edition of this Standard. Other topics for further study include measurement on rack-mounted equipment, either as individual units or as fully equipped racks containing mixed types of equipment.

This Standard has been passed as Standard ECMA-74 by the General Assembly of ECMA on June 18, 1981.

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1. GENERAL

1.1 Scope

This Standard ECMA-74 specifies procedures for measuring and reporting the noise emission of computer and business equipment. It is based on the measurement procedures defined in International Standards ISO 3740, ISO 3741, ISO 3742 and ISO 3744. The basic emission quantity is the A-weighted Sound Power Level which may be used for comparison of equipment of the same type but from different manufacturers, or of different equipment.

The sound power level is supplemented by the A-weighted Sound Pressure Level measured at the operator position(s) or the bystander position(s). This value is not a workers immission rating level, but it may assist in identifying any potential problems that could cause annoyance, activity interference, or hearing damage to operators and bystanders. This Standard is suitable for type tests and provides methods for manufacturers and testing laboratories to obtain comparable results.

1.2 Field of Application

The methods specified in this Standard allow the determination of noise emission levels for the tested individual unit.

The levels obtained serve noise emission labelling and comparison purposes. They are not to be considered as installation noise immission levels, however they may be used for installation planning.

If these levels were determined for several units of the same production series, they can be used to determine a statistical value for that production series.

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.
- For the determination of sound power levels all requirements of either the method of Section II or the method of Section III are complied with as far as they apply and to the exclusion of any other method.
- For the measurement of sound pressure level at the operator or bystander positions all requirements of Section IV are complied with as far as they apply and to the exclusion of any other method.

3. REFERENCES

ISO 266	: Preferred frequencies for measurements
ISO 354	: Measurement of absorption coefficients in a reverberation room
ISO 3740	: Guidelines for the use of basic International Standards and for the preparation of noise test codes
ISO 3741	: Precision methods for broad-band sources in reverberation rooms
ISO 3742	: Precision methods for discrete-frequency and narrow-band sources in reverberation rooms
ISO 3744	: Engineering methods appropriate for free-field conditions over a reflecting plane
ISO 3745	: Precision methods for anechoic and semi-anechoic rooms
ISO 6081	: Noise emitted by machinery and equipment
ISO 6926	: Characterization and calibration of reference sound sources
IEC 225	: Octave, half-octave and third-octave band filters intended for the analysis of sound and vibrations
IEC 651	: Sound level meters

4. DEFINITIONS

For the purpose of this Standard the following definitions apply.

4.1 A-weighted Impulse Sound Pressure Level, LpAI

The A-weighted sound pressure level determined with a sound level meter set for the dynamic characteristic IMPULSE.

NOTE 1:

The A-weighted Impulse Sound Pressure Level L_{pAI} is used only to determine whether the noise emissions are impulsive. It differs from the A-weighted Sound Pressure Level L_{pA} by the additional time-weighting with the dynamic response characteristic IMPULSE. For non-impulsive noises, e.g. those noises with a constant level in the investigated frequency range, L_{pA} and L_{pAI} are the same. With increasing impulsiveness of the noise the difference ($L_{pAI} - L_{pA}$) increases. It may therefore be considered as a measure for the impulsive content of a noise.

4.2 Background Noise

The sound pressure level measured at specified locations when the equipment under test is neither operating nor idling.

4.3 Bystander

An individual who is not the operator of the equipment but whose position lies within the sound field produced by the equipment, either occasionally or continuously.

4.4 Bystander Position

A typical location occupied by a bystander.

4.5 Computer and Business Equipment

Equipment which is primarily used in offices or office-like environments and in computer installations.

4.6 Floor-standing Equipment

A unit that has its own stand and is intended to be installed on the floor.

4.7 Frequency Range of Interest

This range normally extends from the 125 Hz octave band to the 8000 Hz octave band. The 16 kHz octave band shall also be included when a preliminary investigation indicates that it is of importance, or affects the A-weighted sound pressure or sound power levels. Range and centre frequencies of the octave bands are specified in ISO 266.

4.8 Idle Mode

A condition in which the equipment under test, after any necessary warm-up period, is energized but is not operating.

4.9 Measurement Surface

The measurement surface is defined by a rectangular parallelepiped parallel to the Reference Parallelepiped and enclosing it. Any face of this rectangular parallelepiped corresponding to a reflecting plane is coplanar with that reflecting plane. All other faces are located at a distance d from the corresponding face of the Reference Parallelepiped, and the measurement positions are located on these faces. The measurement surface comprises all faces on which measurement positions are located. Its area S is equal to the sum of the areas of these faces, except the face(s) co-planar with the reflecting plane(s).

4.10 Operator

An individual who operates a piece of equipment from a position in the immediate vicinity of the equipment.

4.11 Operator Position

The assigned position of the operator.

4.12 Operating Mode

A condition in which the equipment under test is performing its intended function(s).

4.13 Reference Parallelepiped

The smallest imaginary rectangular parallelepiped that encloses the equipment under test. Any face of this parallelepiped corresponding to a reflecting plane is coplanar with this reflecting plane.

4.14 Reference Sound Source

A device which is intended for use as a stable source of sound, which has a known, calibrated broadband sound power spectrum over the frequency range of interest, and which conforms to ISO 6926.

4.15 Sound Power Level, L_W

Ten times the logarithm to the base 10 of the ratio of a given sound power to the Reference Sound Power. The weighting network (A-weighting) or the width of the frequency band used shall be indicated. The Reference Sound Power is 1 pW. The unit of measurement is dB.

NOTE 2:

In this Standard, the sound power is the rms value of the sound power during the measurement interval.

4.16 Sound Pressure Level, L_p

Twenty times the logarithm to the base 10 of the ratio of the sound pressure to the Reference Sound Pressure. The weighting network (A-weighting) or the width of the frequency band used shall be indicated. The Reference Sound Pressure is 20 uPa. The unit of measurement is dB.

NOTE 3:

In this Standard, the sound pressure is the rms value of the sound pressure during the measurement interval.

4.17 Standard Test Table

A rigid table having a top surface of at least 0,5 m^2 (length of the top plane > 700 mm). A suitable design for the Standard Test Table is shown in Appendix A.

4.18 Surface Sound Pressure Level, $\overline{L_{pf}}$

The sound pressure level averaged over the measurement surface on a mean-square basis and corrected for environmental influences.

4.19 Table-top Equipment

A unit that has a complete enclosure and is intended to be installed or used on a table, desk or separate stand.

4.20 Wall-mounted Equipment

A unit which is normally mounted against a wall and does not have a stand of its own.

SECTION II

PRECISION METHOD FOR DETERMINING SOUND POWER LEVELS OF EQUIPMENT IN REVERBERATION ROOMS

5.1 Field of Application

The procedure defined in this section specifies a direct method and a comparison method for determining the sound power levels produced by computer and business equipment using a reverberation room. It may be applied to equipment which radiates broad-band noise, or narrow-band noise, or noise which contains discrete frequency components or impulsive noise.

The measurements shall be performed in a qualified reverberation room. The volume of the equipment under test should preferably be not greater than 1% of the volume of the reverberation room.

5.2 Measurement Uncertainty

Measurements made in conformity with this method yield standard deviations which are equal to, or less than, those given in Table 1.

TABLE 1 - UNCERTAINTY IN DETERMINING SOUND POWER LEVELS.

Octave band centre frequencies	One-third octave band centre frequencies	Standard deviation
Hz	Hz	dB
125	100 to 160	3,0
250	200 to 315	2,0
500 to 4000	400 to 5000	1,5
8000	6300 to 10000	3,0

NOTE 4:

The standard deviations given in Table 1 reflect the cumulative effects of all causes of measurement uncertainty, including variations from laboratory to laboratory, but excluding variations in the sound power level from equipment to equipment or from test to test which may be caused, for example, by changes in the installation or operating conditions of the equipment. The reproducibility and repeatability of the test results for the same piece of equipment and the same measurement conditions may be considerably better (i.e. smaller standard deviations) than the uncertainties given in Table 1 would indicate.

NOTE 5:

If the method specified in this section is used to compare the sound power levels of similar equipment that are omnidirectional and radiate broad-band noise, the uncertainty in this comparison yields in a standard deviation which is less than that given in Table 1, provided that the measurements are performed in the same environment.

5.3 Test Environments

5.3.1 General

Guidelines for the design of a reverberation room as well as criteria for room absorption and a procedure for room qualification are given in ISO 3741 and ISO 3742.

5.3.2 Test room volume

The minimum test room volume shall be as prescribed in Table 2. If frequencies above 3000 Hz are included in the frequency range of interest, the volume of the test room shall not exceed 300 m^3. The ratio of the maximum dimension of the test room to its minimum dimension shall not exceed 3:1.

TABLE 2 - MINIMUM ROOM VOLUME AS A FUNCTION OF THE LOWEST FREQUENCY BAND OF INTEREST

Lowest frequency band of interest	Minimum room volume in m^3
125 Hz octave or 100 Hz third-octave	200
125 Hz third-octave	150
160 Hz third-octave	100
250 Hz octave or 200 Hz third-octave and higher	70

5.3.3 Background noise

The sound pressure level of the background noise including any noise due to motion of the microphone and/or rotating diffusers shall be at least 6 dB, and preferably more than 10 dB, below the sound pressure level to be measured in each frequency band within the frequency range of interest.

5.3.4 Temperature and relative humidity

The air absorption in the reverberation room varies with temperature and humidity, particularly at frequencies above 1000 Hz. The temperature Θ in ^{o}C and the relative humidity RH in % shall be controlled during the sound pressure level measurements. The product

$$RH \cdot (\Theta + 5)$$

shall not vary by more than ± 10% during the measurements specified in clauses 5.6, 5.7 and 5.8.

5.4 Instrumentation

5.4.1 General

The instrumentation shall be designed to measure the mean sound pressure level in octave and/or one-third octave bands.

This is the level of the mean-square sound pressure averaged over time and space. Alternatively, space averaging may be performed separately by calculating the mean value according to 5.9.

The instrumentation used may perform the required averaging in two different ways.

i) By integrating the squared signal over a fixed time interval. This integration may be performed by either digital or analog means.

ii) By continuous averaging of the squared signal using RC-smoothing with a time constant of at least one second (SLOW meter characteristic). Such continuous averaging provides only an approximation of the true average and it places restrictions on the SETTLING time and observation time (see Note 9).

5.4.2 The microphone and its associated cable

A condenser microphone, or the equivalent in accuracy, stability and frequency response, shall be used. The microphone shall have a flat frequency response for randomly incident sound over the frequency range of interest.

NOTE 6:

This requirement is met by a microphone of a standardized sound level meter complying with the requirements for type 1 of IEC 651 and calibrated for free-field measurements only if it has a linear random response.

The microphone and its associated cable shall be chosen so that their sensitivity does not change by more than 0,5 dB over the temperature range encountered during measurement. If the microphone is moved, care shall be exercized to avoid introducing acoustic or electrical noise (for example, from gears, flexing cables, or sliding contacts) that could interfere with the measurements.

5.4.3 Frequency response of the instrumentation system

The frequency response of the instrumentation shall be flat over the frequency range of interest within the tolerances given in IEC 651 for type 1 instruments.

5.4.4 Filter characteristics

An octave band or one-third octave band filter set meeting the requirements of IEC 225 shall be used. The centre frequencies of the bands shall correspond to those of ISO 266.

5.4.5 Calibration

During each series of measurements, an acoustical calibrator with an accuracy of ± 0,2 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 2 years.

5.5 Installation and Operation of Equipment

5.5.1 Equipment installation

Floor-standing equipment shall be located at least 1,5 m from any wall of the room and no major surfaces shall be parallel to a wall of the reverberation room.

Table-top equipment shall be placed on a reflecting plane, e.g. in the centre of the Standard Test Table or on the floor. A resilient pad may be used only if its use is recommended in the installation specification.

Wall-mounted equipment shall be mounted on a wall of the reverberation room, at least 1,5 m from any other reflecting plane, if not otherwise specified. Alternatively, the equipment may be installed with its mounting surface attached to the floor (if operation allows), at least 1,5 m from any wall of the room.

Hand-held equipment shall be freely suspended in the room, at least 1,5 m from any reflecting room surface.

Appendix C specifies additional installation conditions for most categories of equipment.

NOTE 7:

When the equipment is mounted near one or more reflecting planes, the radiation impedance may differ appreciably from that of free space, and the sound power radiated by the equipment may depend strongly upon its position and orientation. It may be of interest to determine the radiated sound power either for a particular equipment position and orientation, or as the average value for several positions and orientations.

5.5.2 Equipment operation

During the acoustic measurements the equipment shall be operated in a specified manner, typical of normal use. Appendix C specifies such conditions for most categories of equipment.

The noise shall be measured for the idling and the operating modes of the equipment. If several operating modes exist, e.g. reading and punching, the noise of each individual mode shall be determined and reported.

5.6 Determination of Measurement Conditions

When narrow-band noise or discrete frequency components are present in the spectrum, the spatial variations in the sound pressure level exhibit maxima and minima. Therefore, the conditions for the measurement depend greatly on the frequency content of the noise.

5.6.1 Character of noise

The presence of a significant discrete frequency component can often be detected by a simple listening test. If such a component is audible, the measurements described in this clause may be omitted. In this case, either the provisions of the bottom row of Table 3 shall be applied or, alternatively, the reverberation room shall be qualified as described in Annex A of ISO 3742. A conclusion that no significant discrete frequency components are present can be reached only by the following procedure.

For the purposes of this Standard the character of noise of the equipment under test is defined by an estimate of the standard deviation of the sound level variations in the reverberation room. The following procedure shall be used:

Select an array of six fixed microphones (or six microphone positions) spaced at least $1/2\ \lambda_{min}$ apart, where λ_{min} is the wavelength of the sound corresponding to the lowest frequency of the frequency band of interest. Locate the equipment at a single position in the test room.

Obtain the time-averaged sound pressure level L; at each microphone position according to the techniques described in 5.7. Instead of a fixed array, a single microphone may be sequentially positioned at six points equally spaced along a path the length ℓ of which is calculated from equation (II) with $N_m = 6$.

The time-averaged sound pressure level is determined at each point.

For each one-third octave or octave band within the frequency range of interest, calculate the standard deviation from the following equation:

$$s = (n-1)^{-1/2} \left[\sum_{i=1}^{n} (L_i - L_m)^2 \right]^{1/2} \qquad (I)$$

where:

s = the standard deviation of space/time-averaged sound pressure levels in the room, L_i, in dB.

L_m = the arithmetic mean value of the sound pressure levels L_1 to L_6, in dB.

n = 6.

The magnitude of s depends on the properties of the sound field in the test room. These properties are influenced by the characteristics of the room as well as the charac-

teristics of the source (i.e. directivity and spectrum of emitted sound). In theory, a standard deviation of 5,56 dB corresponds to a spectral component of zero bandwidth, i.e. a discrete tone.

The value of s calculated according to equation (I) is used with Tables 3 and 4 to determine the number of microphone positions and the number of source locations.

5.6.2 Number of microphone positions

For broad-band noise the minimum number of microphone positions is $N_m = 3$ (see Table 3, first row). For narrow-band noise and discrete frequency noise the number of microphone positions is determined from Table 4. If a continuous microphone traverse is used, the length of the traverse should be at least

$$l = N_m \frac{\lambda_{min}}{2} \qquad \text{(II)}$$

where:

N_m = the number of microphone positions.

5.6.3 Number of equipment locations

The required number of locations at which the equipment under test is to be placed successively depends on the reverberation time and volume of the room, and on the frequency. For discrete frequency tones, the required number of equipment locations, N_s, should be computed from

$$N_s \geqslant K\left[0{,}79\left(\frac{T}{V}\right)\left(\frac{1000}{f}\right)^2 + \frac{1}{N_m}\right] \qquad \text{(III)}$$

where:

T = the reverberation time of the room, in s

V = the volume of the room in m^3

f = the frequency, in Hz, of the discrete tone or the centre frequency of the band in which a discrete-frequency or narrow-band noise component is found,

K = a constant given in Table 4,

N_m = the number of microphone positions for the narrow-band or discrete frequency tone (see Table 4).

The value of N_s shall be rounded to the nearest higher integer.

The minimum distance between any two equipment locations shall be $r_{min} = 1/2\ \lambda_{min}$. The source positions should not be symmetric with respect to the axes of the test room.

TABLE 3 - PROCEDURES TO BE FOLLOWED IN THE MEASUREMENT OF DISCRETE FREQUENCY COMPONENTS OR NARROW BANDS OF NOISE

Standard deviation s dB	Procedure	Number of microphone positions, N_m (or microphone path length, ℓ)	Number of equipment locations N_s
$s \leqslant 1,5$	Broad-band procedure adequate	$N_m = 3$ or ℓ computed from equation (II) for a continuous path	$N_s = 1$
$1,5 < s \leqslant 3$	Assume that a narrow band of noise is present	N_m determined from Table 4 or ℓ computed from equation (II) for a continuous path	Use half the number of equipment locations computed from equation (III)
$s > 3$	Assume that a discrete tone is present	N_m determined from Table 4 or ℓ computed from equation (II) for a continuous path	Compute N_s from equation (III)

TABLE 4 - NUMBER OF MICROPHONE POSITIONS REQUIRED AND CONSTANT K FOR DETERMINING NUMBER OF EQUIPMENT LOCATIONS

Octave band (and one-third octave band) centre frequencies	Number of microphone positions (N_m) if $1,5 < s \leqslant 3$ dB	Number of microphone positions (N_m) if $s > 3$ dB	Constant K for determining number of equipment locations
125 (100,125,160)	3	6	5
250 (200,250,315)	6	12	10
500 (400,500,630)	12	24	20
1000 (800, 1000, 1250) and up	15	30	25

5.6.4 Microphone arrangement

The microphone traverse or array shall not lie in any plane within 10° of a surface of the reverberation room. No point on the traverse or array shall be closer than $\frac{1}{2}\lambda_{min}$ or 1 m, whichever is smaller, to any room surface.

The minimum distance in m between the nearest microphone position and the equipment under test shall be:

$$d \geqslant 0{,}08\sqrt{V/T} \qquad \text{(IV)}$$

where:

V = the room volume in m^3

T = the reverberation time in s

NOTE 8

It is recommended whenever possible to use twice the minimum distance d.

The repetition rate of the microphone traverse (or the scanning rate for an array of fixed microphones) shall satisfy the following requirements:

i) There shall be a whole number of microphone traverses or array scans during the observation period (see 5.7.1).

ii) If integration over a fixed time interval is used, there shall be a whole number of complete microphone traverses or array scans during the integrating time of the indicating device.

iii) If continuous averaging is used, the traverse or scanning period shall be less than two times the time constant of the indicating device.

5.7 Measurement of Sound Pressure Level

The mean-square value of the sound pressure level along the microphone path (or at the individual microphone positions) shall be measured for each frequency band within the frequency range of interest, and for each defined mode of operation.

The microphone traverse or array shall be the same for each set of readings. The sound diffuser(s) (if any) shall be operated identically for each set of readings. No observers or operators shall be present in the test room during the measurements, unless necessary for operating the equipment under test.

5.7.1 Period of observation

The readings shall be averaged over the following periods of observation:

1) For the frequency bands centred on or below 160 Hz, the period of observation shall be at least 30 s.

2) For the frequency bands centred on or above 200 Hz, the period of observation shall be at least 10 s.

NOTE 9:

If the instrumentation uses continuous time-averaging (RC-smoothing) no observation shall be made after any microphone or filter switching (including transfer of the microphone to a new position) until a SETTLING time of five times the time constant of the instrumentation has elapsed. The observation time shall have at least the same duration as the SETTLING time.

5.7.2 Corrections for background noise

The measured band pressure levels shall be corrected for the influence of background noise according to Table 5. When the sound pressure level of the background noise is less than 6 dB below the band pressure level with either the reference sound source or the equipment operating, the accuracy of the measurements will be reduced and no data shall be reported for that band.

TABLE 5 - CORRECTIONS FOR BACKGROUND NOISE

Difference between sound pressure level measured with equipment or reference sound source operating and background noise alone	Correction to be subtracted from sound pressure level measured with equipment or reference sound source operating to obtain sound pressure level due to equipment alone
dB	dB
<6	measurement invalid
6	1,3
7	1,0
8	0,8
9	0,6
10	0,4
>10	0,0

5.8 Additional Measurements

For the calculation of the sound power level the characteristics of the reverberation room must be considered. The application of the direct method requires the knowledge of the room volume and the reverberation time in each frequency band. When using the comparison method the room characteristics are implicitly measured when measuring the band pressure levels of the reference sound source. This method has the advantage that it is not necessary to measure the reverberation time of the test room.

5.8.1 Measurement of reverberation time

The reverberation time T in s of the reverberation room with the equipment under test present, shall be determined in each octave band or one-third octave band within the frequency range of interest using the procedures described in ISO 354.

5.8.2 Measurement of sound pressure level of reference sound source

The comparison method requires the use of a reference sound source with known sound power levels in frequency bands. The reference sound source shall be operated as described in its calibration chart in the presence of the equipment under test.

The reference sound source shall be mounted on the floor of the reverberation room at least 1,5 m away from any other sound-reflecting surface such as a wall or the equipment being tested. The distance from the microphone traverse or array shall be according to 5.6.4. The number of microphone positions or the equivalent path length shall be the same as defined for the sound pressure level measurements on the equipment to be tested. Generally, one source position for the reference sound source will suffice.

The sound pressure levels in each octave band or one-third octave band within the frequency range of interest shall be measured according to 5.7.

5.9 Calculation of Mean Band Pressure Level

If a continuous path or automatic microphone scanning is used together with analog or digital integration, the measured levels according to 5.7 (corrected according to 5.7.2, if applicable) in each frequency band of interest constitute the mean band pressure levels. If individual microphone positions are used or if the levels fluctuate during the recording period because of a short RC time constant, the averaging shall be performed by using the following equation:

$$L_p = 10 \log \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0,1 L_i} \right] \qquad (V)$$

where:

L_p = the mean band pressure level, in dB. Reference: 20 uPa;

L_i = the band pressure level resulting from i-th measurement, in dB. Reference: 20 uPa;

N = the total number of measurements in the band.

5.10 Calculation of Sound Power Level

The sound power levels in octave and/or one-third octave bands can be determined by two methods. Both require the values of the mean band pressure levels according to 5.9.

5.10.1 Direct method

The sound power level, produced by the equipment in each octave band or one-third octave band within the frequency range of interest shall be calculated from the following equation:

$$L_W = L_p - 10\log\left(\frac{T}{T_o}\right) + 10\log\left(\frac{V}{V_o}\right) + 10\log\left(1 + \frac{S}{8V}\right) - 10\log\left(\frac{B}{B_o}\right) - 14 \qquad \text{(VI)}$$

where:

L_W = the sound power level of the equipment under test, in dB. Reference: 1 pW;

L_p = the mean band pressure level (corrected for background noise) determined according to 5.9, in dB. Reference: 20 uPa;

T = the reverberation time of the room in s;

T_o = 1 s;

V = the volume of the room, in m^3;

V_o = 1 m^3;

λ = the wavelength at the centre frequency of the octave or one-third octave band, in m;

S = the total surface area of the room, in m^2;

B = the barometric pressure, in mbar.

B_o = 1000 mbar.

5.10.2 Comparison method

The sound power level produced by the equipment in each octave or one-third octave within the frequency range of interest is obtained as follows. The band pressure level produced by the reference sound source (corrected for background noise according to 5.7.2) is subtracted from the known sound power level produced by the reference sound source. The difference is added to the band pressure level of the equipment under test (corrected for background noise according to 5.7.2). That is:

$$L_W = L_p + (L_{wr} - L_{pr}) \qquad \text{(VII)}$$

where:

L_W = the band power level of the equipment under test, in dB. Reference: 1 pW;

L_p = the mean band pressure level of the equipment under test, in dB. Reference: 20 uPa;

L_{Wr} = the calibrated band power level of reference sound source, in dB. Reference: 1pW;

L_{pr} = the mean band pressure level of reference sound source in dB. Reference: 20 uPa.

5.10.3 Calculation of A-weighted sound power level

The A-weighted sound power level (L_{WA}) in dB, reference 1 pW, shall be calculated from the following equation:

$$L_{WA} = 10 \log \sum_{J=1}^{Jmax} 10^{0,1\left[(L_W)_J + C_J\right]} \qquad \text{(VIII)}$$

where:

$(L_W)_J$ = the level in the J-th octave or third-octave band.

For computations with octave-band data, J_{max} = 7 and C_J is given in Table 6.

TABLE 6 - COMPUTATION OF C_J FOR J_{MAX} = 7

J	Octave band centre frequency (Hz)	C_J (dB)
1	125	-16,1
2	250	- 8,6
3	500	- 3,2
4	1000	0,0
5	2000	1,2
6	4000	1,0
7	8000	- 1,1

For computations with third-octave band data, J_{max} = 21 and C_J is given in Table 7.

TABLE 7 - COMPUTATION OF C_J FOR $J_{MAX} = 21$

J	One-third octave band centre frequency (Hz)	C_J (dB)
1	100	-19,1
2	125	-16,1
3	160	-13,4
4	200	-10,9
5	250	- 8,6
6	315	- 6,6
7	400	- 4,8
8	500	- 3,2
9	630	- 1,9
10	800	- 0,8
11	1000	0,0
12	1250	0,6
13	1600	1,0
14	2000	1,2
15	2500	1,3
16	3150	1,2
17	4000	1,0
18	5000	0,5
19	6300	- 0,1
20	8000	- 1,1
21	10000	- 2,5

5.11 Information to be Recorded

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

5.11.1 Equipment under test

i) Description of the equipment under test (including principal dimensions).

ii) Operating conditions.

iii) Installation conditions.

iv) Location of equipment in the test room.

v) If the equipment has multiple operating modes, description of each individual mode for which measurements have been performed.

5.11.2 Acoustic environment

i) Dimensions and shape of the test room.

ii) Description of microphone array or path.

iii) Reverberation time in octave or one-third octave bands (direct method only).

iv) Qualification of reverberation room according to Annex A of ISO 3741 or ISO 3742.

v) Air temperature in ^{o}C, relative humidity in % and barometric pressure in mbar.

5.11.3 Instrumentation

i) Equipment used for the measurements, including name, type, serial number and manufacturer.

ii) Bandwidth of frequency analyser.

iii) Frequency response of instrumentation system.

iv) Method used for checking the calibration of the microphones and other system components, the date and place of calibration shall be given.

v) Method used for determining the band mean sound pressure level.

vi) Type and calibration of reference sound source (comparison method only).

5.11.4 Acoustic data

i) Method used for calculating the sound power levels (direct or comparison method).

ii) The correction, in dB, if any, applied in each frequency band for the frequency response of the microphone, frequency response of the filter in the pass-band, background noise, etc.

iii) The sound power levels in dB, Reference 1 pW, in octave and/or one-third octave bands tabulated or plotted to the nearest half dB.

iv) The A-weighted sound power level in dB, Reference 1 pW, rounded to the nearest dB.

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

5.12 Information to be Reported

The report shall contain the statement that the sound power levels have been obtained in full conformance with the direct method or the comparison method of Section II of this Standard. This report shall contain at least following information considered to be most characteristic for computer and business equipment:

- Name(s) and model number(s) of the equipment under test.
- The A-weighted sound power level, L_{WA} in dB. Reference: 1 pW, for the idle mode and the operating mode(s).

- The sound power levels, L_W in dB. Reference: 1 pW, in octave or one-third octave bands, if required.
- Detailed description of operating conditions of the equipment under test with reference to Appendix C, if applicable.

SECTION III

ENGINEERING METHOD FOR DETERMINING SOUND POWER LEVELS OF EQUIPMENT UNDER ESSENTIALLY FREE-FIELD CONDITIONS OVER A REFLECTING PLANE

6.1 Field of Application

The procedure defined in this section specifies a direct method for determining the sound power level produced by computer and business equipment using essentially free-field conditions over a reflecting plane. It may be applied to equipment which radiates broad-band noise, or narrow-band noise, or noise which contains discrete frequency components and impulsive noise.

The measurements shall be performed in a qualified environment.

6.2 Measurement Uncertainty

Measurements made in conformity with this method yield standard deviations which are equal to or less than those given in Table 8.

TABLE 8 - UNCERTAINTY IN DETERMINING SOUND POWER LEVELS

Octave band centre frequencies	One-third octave band centre frequencies	Standard deviation of the mean value
Hz	Hz	dB
125	100 to 160	3,0
250 to 500	200 to 630	2,0
1000 to 4000	800 to 5000	1,5
8000	6300 to 10000	2,5

NOTE 10:

The standard deviations given in Table 8 reflect the cumulative effects of all causes of measurement uncertainty, including variations from laboratory to laboratory, but excluding variations in the sound power level from equipment to equipment or from test to test which may be caused, for example, by changes in the installation or operating conditions of the equipment. The reproducibility and repeatability of the test results for the same piece of equipment and the same measurement conditions may be considerably better (i.e. smaller standard deviations) than the uncertainties given in Table 8 would indicate.

NOTE 11:

If the method specified in this section is used to compare the sound power levels of similar equipment that are omnidirectional and radiate broad-band noise, the uncertainty in this comparison yields in a standard deviation which is less than that given in Table 8, provided that the measurements are performed in the same environment with the same shape of measurement surface.

NOTE 12:

For equipment which emits noise with a relatively flat spectrum in the frequency range of 100 Hz to 10 000 Hz, the A-weighted sound power level is determined with a standard deviation of approximately 2 dB.

6.3 Test Environment

6.3.1 General

The test environment shall provide a free field or preferably a free field over a reflecting plane. Suitable test environments are defined in ISO 3744 and ISO 3745. Those environments include:

i) A semi-anechoic or anechoic room

ii) A flat outdoor area that meets the requirement of clause 6.3.2.

iii) A room in which the contribution of the reverberant field to the sound pressure levels on the measurement surface are small compared with those of the direct field of the equipment.

Conditions described under iii) above are met in very large rooms as well as in smaller rooms with sufficient sound-absorptive materials on their walls and ceiling and a reflecting (hard) floor.

NOTE 13:

A plane (floor, wall) is considered to be reflecting (hard) if its absorption coefficient $\bar{\alpha} \leq 0{,}06$ *over the frequency range of interest (e.g. concrete floor,* $\bar{\alpha} < 0{,}01$*, plastered wall,* $\alpha \approx 0{,}04$*, tiled wall,* $\alpha \approx 0{,}01$*).*

If barometric pressure, temperature and/or relative humidity influence the noise measurement, the following conditions are recommended:

Barometric pressure : 860 mbar to 1060 mbar

Temperature : 20 °C to 30 °C

Relative humidity : 30% to 70%

6.3.2 Adequacy of the test environment

Ideally, the test environment should be free from reflecting objects other than a reflecting plane, so that the equipment radiates into a free-field over a reflecting plane.

Annex A of ISO 3744 describes procedures for determining the magnitude of the environmental corrections (if any) to account for departures of the test environment from the ideal condition. The correction shall not exceed 2 dB.

6.3.3 Background noise

At the microphone positions, the sound pressure levels of the background noise shall be at least 6 dB and prefer-

ably more than 10 dB below the sound pressure level to be measured in each frequency band within the frequency range of interest or the A-weighted sound pressure level.

6.4 Instrumentation

6.4.1 General

The instrumentation shall be designed to measure the mean sound pressure level, A-weighted and in octave and/or one-third octave bands. This is the level of the mean-square sound pressure averaged over time. Surface averaging is usually carried out over a fixed number of microphone positions (Clause 6.6) and by computing the average value according to clause 6.9.1.

The instrumentation used can perform the required time-averaging in two different ways:

i) By integrating the squared signal over a fixed time interval. This integration may be performed by either digital or analog means.

ii) By continuous averaging of the squared signal using RC-smoothing with a time constant of at least one second (SLOW meter characteristic). Such continuous averaging provides only an approximation of the true time average and it places restrictions on the SETTLING time and observation time.

NOTE 14:

Examples of suitable instrumentation systems are given in Annex E of ISO 3744. An example of an instrument employing RC-smoothing is a sound level meter that complies with the requirements for type 1 of IEC 651 with a SLOW meter characteristic.

NOTE 15:

Auxiliary Instrumentation

If level recorders are used, they shall be adjusted according to the manufacturer's instructions so that the response characteristic FAST or SLOW of precision sound level meters of type 1 as defined in IEC 651 are met (e.g. writing speeds of 100 mm/s for 50 mm paper width and 50 dB dynamic range). DC recorders in connection with the DC output of sound level meters shall have a sufficiently short rise time, so that the recording corresponds to the requirements for the meter circuit of precision sound level meters. It is recommended to use DC recorders rather than AC level recorders to avoid misunderstanding in control settings.

6.4.2 The microphone and its associated cable

A condenser microphone, or the equivalent in accuracy, stability and frequency response, shall be used which complies with the requirements for type 1 of IEC 651.

The microphone and its associated cable shall be chosen such that their sensitivity does not change by more than 0,5 dB over the temperature range encountered during mea-

surement. If the microphone is moved, care shall be exercized to avoid introducing acoustical or electrical noise (e.g. noise from wind, gears, flexing cables or sliding contacts) that could interfere with the measurements.

6.4.3 Frequency response of the instrumentation system

The frequency response of the instrumentation system for the angle of incidence specified by the manufacturer shall be flat over the frequency range of interest within the tolerances given in IEC 651 for type 1 instruments.

6.4.4 Weighting network, filter characteristics

An A-weighting network meeting the tolerances of IEC 651 for type 1 instruments and an octave band or one-third octave band filter set meeting the requirements of IEC 225 shall be used. The centre frequencies of the frequency bands shall correspond to those of ISO 266.

6.4.5 Calibration

During each series of measurements, an acoustic calibrator 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 acoustic and an electrical calibration of the instrumentation system over the entire frequency range shall be performed at intervals of not more than 2 years.

6.5 Installation and Operation of Equipment

6.5.1 Equipment installation

The equipment shall be installed according to its intended use. If the normal installation is unknown or if several possibilities exist, the same conditions for a group of similar machines shall be chosen and reported. Such conditions are specified for most categories of equipment in Appendix C and shall be followed when labelling information is to be obtained.

Basically, the equipment is to be installed in a way which allows access to all sides except the reflecting plane(s). The dimensions of the reflecting plane(s) shall exceed the test object by at least the measurement distance. The requirements for reflection are given in Note 13. The plane(s) shall not contribute to the sound radiation due to their own vibrations.

i) Floor-standing equipment shall be installed on the reflecting (hard) floor at a sufficient distance (more than 2 m, if possible, from the walls, if not defined otherwise in Appendix C.

ii) Floor-standing equipment which is to be installed in front of a wall, shall be placed on a hard floor in front of a hard wall. The distance from the wall shall be according to the manufacturer instructions, respectively as defined in Appendix C. If such information is not available the distance shall be 0,1 m.

iii) Table-top equipment shall be placed on a reflecting plane, viz. in the centre of the Standard Test Table or on a hard non-vibrating floor. A resilient pad may be used only if its use is recommended in the installation specification. When using the Standard Test Table, its top surface shall be extended to at least the projection of the measurement surface, by placing additional tables around it, unless otherwise specified in Appendix C. Such additional tables may be of lighter construction than the Standard Test Table provided they satisfy the reflecting requirement of Note 13.

iv) Wall-mounted equipment shall be mounted on a reflecting (hard) wall at least 1,5 m from any other reflecting plane, if not otherwise specified. Alternatively, the equipment may be installed with its mounting surface attached to the reflecting floor (if operation allows) at a sufficient distance from the walls (more than 2 m, if possible).

v) Hand-held equipment shall be freely suspended in the room or mounted on an appropriate device, so that no solid-borne vibrations are transmitted.

6.5.2 Equipment operation

During the acoustic measurements the equipment shall be operated in a specified manner, typical of normal use. Appendix C specifies such conditions for most categories of equipment.

The noise shall be measured for the idling and the operating modes of the equipment. If several operating modes exist, e.g. reading and punching, the noise of each individual mode shall be determined and reported.

6.6 Measurement Surface and Microphone Positions

6.6.1 General

The Reference Parallelepiped just encloses the equipment under test and terminates on the reflecting plane(s). It has a length ℓ_1, width ℓ_2 and a height ℓ_3. Those elements protruding from the equipment under test and which are unlikely to contribute to the noise emission may be disregarded.

For computer and business equipment the preferred measurement surface is the parallelepiped with the surface area S, whose sides are parallel to those of the Reference Parallelepiped at the measurement distance d. The preferred value for d is 1 m, and it shall not be less than 0,25 m. For equipment of the same type, the same measurement distance shall be used.

In some cases, mainly for small equipment, a sphere, hemisphere or a quarter-sphere of radius r may be chosen as the measurement surface, if the condition $r > 2\ d_o$ is met, where d_o is the distance of the corners of the Reference Parallelepiped from the origin of the coordinates.

The coordinates for those measurement surfaces are given in Appendix B.

The microphone positions lie on the measurement surface and are referred to the coordinate system with horizontal axes x and y and the vertical axis z. The x-axis points into the direction of the operator's side of the equipment (if applicable). The position of the origin for the coordinates of the microphone positions is given as follows:

- for floor-standing equipment: on the floor in the centre of the plane of the Reference Parallelepiped which is co-planar with the room floor,
- for table-top equipment: in the table top plane in the centre of the base plane of the Reference Parallelepiped,
- for wall-mounted equipment: in the centre of that plane of the Reference Parallelepiped which is co-planar with the mounting surface,
- for hand-held equipment: in the centre of the Reference Parallelepiped.

The number and location of the microphone positions is defined in 6.6.2 and in Appendix B.

Near air exhausts the microphone position shall be selected in a way that the microphone is not exposed to the airstream.

The microphones shall be oriented in such a way that the angle of sound incidence is the same as that for which the microphone is calibrated. For most practical cases this will be an orientation towards the estimated geometrical centre of the equipment.

NOTE 16:

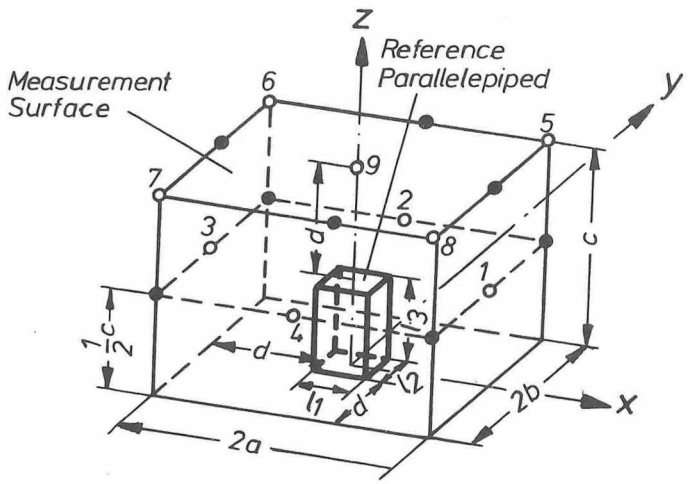
A single microphone which is successively placed at the respective measurement positions may be used for the measurements. Alternatively, several microphones may be placed each at an individual measurement position and may be selected by a suitable switching device.

When testing a series of units which are of the same type and which produce a symmetrical radiation pattern, it is permissible to reduce the number of microphone positions after the first unit has been tested. If tests on the first unit show that the surface sound pressure levels so determined according to the calculation procedures of clause 9 do not deviate by more than 1 dB from those determined from measurements over the entire measurement surface, microphone positions over only a portion of the measurement surface need be used.

6.6.2 Microphone positions on the measurement surface

Arrangement 1 : Measurement surface for floor-standing equipment (Figure 1)

This arrangement may also be applied to equipment which is mounted against a wall. In this case the origin of the coordinates axes is positioned accordingly. For large equipment the number of measurement positions is to be increased if the horizontal distance between adjacent positions exceeds 2 m.



o microphone positions
● additional microphone positions

FIGURE 1 - MEASUREMENT SURFACE WITH 9 MICROPHONE POSITIONS

Position	x	y	z
1	a	0	½ c
2	0	b	½ c
3	-a	0	½ c
4	0	-b	½ c
5	a	b	c
6	-a	b	c
7	-a	-b	c
8	a	-b	c
9	0	0	c

Measurement Surface Area S = 4 (ab+bc+ca)

TABLE 9 - COORDINATES OF MICROPHONE POSITIONS

Arrangement 2 : Measurement surface for floor-standing equipment in front of a wall (Figure 2).

For this arrangement the Reference Parallelepiped extends to the wall.

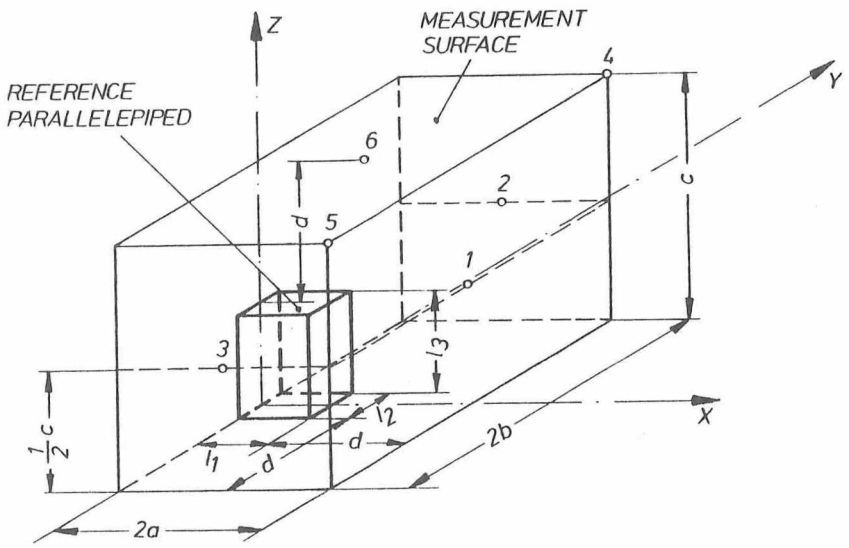


FIGURE 2 - MEASUREMENT SURFACE FOR FLOOR-STANDING EQUIPMENT IN FRONT OF A WALL

TABLE 10 - COORDINATES OF MICROPHONE POSITIONS

Position	x	y	z
1	2 a	0	1/2 c
2	a	b	1/2 c
3	a	-b	1/2 c
4	2 a	b	c
5	2 a	-b	c
6	a	0	c

Measurement Surface Area S = 2 (2ab+2ac+bc)

NOTE 17:

When large equipment is to be measured in small rooms providing free-field conditions over a reflecting plane it might be easier to place the equipment not in the room centre but closer to a corner and to arrange the microphone positions in the free field of the room. The equipment is to be turned around so that noise radiation from the different sides of the machine can be determined sequentially.

NOTE 18:

For comparison of equipment of the same kind and size, e.g. for quality control tests during series production, a reduced number of representative microphone positions may be adequate.

6.6.3 Additional microphone positions on the measurement surface

Sound pressure measurements are required at additional microphone positions if one or more of the following conditions are met:

i) the range of sound pressure values measured at the microphone positions (i.e. the difference in dB between the highest and the lowest sound pressure levels) exceeds the number of measurement points,

ii) any of the dimensions of the Reference Parallelepiped is larger than 2 d,

iii) the equipment radiates noise with a high directivity,

iv) the noise from a large equipment is radiated only from a small portion of the equipment, for example the openings of an otherwise enclosed machine.

If conditions i) or ii) are met additional microphone positions as shown in Fig. 1 shall be used.

If conditions iii) or iv) are met, additional microphone positions on the measurement surface in the region of high noise radiation shall be used.

6.7 Measurement of Sound Pressure Levels

6.7.1 General

Measurements of the A-weighted sound pressure level and octave or one-third octave band pressure levels, if required, shall be made at the microphone positions defined in clause 6.6.

6.7.2 Measurement of the A-weighted sound pressure level, L_{pA} and of the band pressure level

The mean sound pressure level (A-weighted and in frequency bands) shall be measured for the specified mode(s) of operation of the equipment.

The measurement duration shall be adjusted to the operation of the equipment. For machines with continuous oper-

ation (e.g. when idling) a measurement duration of at least 10 s for each measurement position is sufficient. For equipment which performs repetitive operation cycles (e.g. enveloping machines) measurements are required for at least 3 operation cycles. For equipment which performs a sequence of varying operation cycles, the measurement duration shall be over the total sequence.

Equipment with completely different operations which can be performed independently (e.g. reading and punching) shows characteristic noises which are then to be measured separately, considering a sufficient measurement duration. Alternatively, the noise may be recorded with a level recorder during the total working cycle and the characteristic noises are to be determined from this recording.

NOTE 19:

When using a sound level meter, the person reading the meter shall not disturb the sound field at the microphone.

NOTE 20:

When spatial fluctuations occur, due to interferences or standing waves, it is recommended that the microphone be moved by approximately 0,1 d around the measurement position, and the mean value of the sound pressure level be reported.

6.7.3 Corrections for background noise

The measured sound pressure levels shall be corrected for the influence of background noise according to Table 11. When the background sound pressure level is less than 6 dB below the sound pressure level with the equipment operating, the accuracy of the measurements will be reduced and no data shall be reported.

TABLE 11 - CORRECTIONS FOR BACKGROUND NOISE

Difference in dB between sound pressure level measured with equipment operating and background noise along	Correction in dB to be subtracted from sound pressure level measured with equipment operating to obtain sound pressure level due to equipment along
< 6	measurement invalid
6	1,0
7	1,0
8	1,0
9	0,5
10	0,5
>10	0,0

6.8 Corrections for Unwanted Reflections

If necessary, the measured A-weighted sound pressure levels and band pressure levels shall be corrected for the unwanted reflections present in the test environment. The environmental correction, K, accounts for the influence of a non-ideal environment.

Annex A of ISO 3744 gives the detailed procedure to be followed in determining the magnitude of the environmental correction K (in dB). The maximum allowable range for K is 0 to 2 dB. It is to be subtracted from the measured sound pressure levels (equations (X) and (XI)).

NOTE 21:

If the environmental correction varies from microphone position to microphone position within the maximum allowable range, a mean value shall be determined and subtracted from the measured sound pressure level.

6.9 Calculation of Surface Sound Pressure Level

6.9.1 Calculation of sound pressure level averaged over the measurement surface, $\overline{L_{pm}}$

For the A-weighted sound pressure level and the level in each frequency band of interest, a mean value is calculated from the measured sound pressure levels L_{pi} (after corrections for background noise are applied according to 6.7.3, if necessary) by using the following equation:

$$\overline{L_{pm}} = 10 \log \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0,1 L_{pi}} \right] \qquad \text{(IX)}$$

where:

$\overline{L_{pm}}$ = the A-weighted sound pressure level or band pressure level averaged over the measurement surface in dB. Reference: 20 uPa.

L_{pi} = the A-weighted sound pressure level or band pressure level resulting from the i-th measurement in dB. Reference: 20 uPa.

N = the total number of measurements.

6.9.2 Calculation of surface sound pressure level, $\overline{L_{pf}}$

The surface sound pressure levels, $\overline{L_{pf}}$ and $\overline{L_{pAf}}$, are obtained by correcting the values of $\overline{L_{pm}}$ and $\overline{L_{pAm}}$ for reflected sound to approximate the sound pressure level which would be obtained under ideal free-field conditions (respectively free-field conditions over a reflecting plane) by the equations:

$$\overline{L_{pAf}} = \overline{L_{pAm}} - K \qquad (X)$$

$$\overline{L_{pf}} = \overline{L_{pm}} - K \qquad (XI)$$

where:

K = the mean value in dB of the environmental correction over the measurement surface to account for the influence of reflected sound (6.8).

6.10 Calculation of Sound Power Level

The sound power level characterizing the noise emitted by the equipment shall be calculated from the following equations:

$$L_{WA} = \overline{L_{pAf}} + 10 \log \frac{S}{S_o} \qquad (XII)$$

$$L_W = \overline{L_{pf}} + 10 \log \frac{S}{S_o} \qquad (XIII)$$

where:

L_{WA} = the A-weighted or band power level of the equipment in dB. Reference: 1 pW.

L_W = the band power level of the equipment in dB. Reference: 1 pW.

$\overline{L_{pAf}}$ = the A-weighted surface sound pressure determined according to 6.9.2 in dB. Reference: 20 uPa.

$\overline{L_{pf}}$ = the surface band pressure level determined according to 6.9.2 in dB. Reference: 20 uPa.

S = the area of the measurement surface, in m^2.

S_o = 1 m^2

6.11 Information to be Recorded

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

6.11.1 Equipment under test

i) Description of the equipment under test (including principal dimensions).

ii) Operating conditions.

iii) Installation conditions.

iv) Location of equipment in the test environment.

v) If the equipment has multiple operating modes, description of each individual mode for which measurements have been performed.

6.11.2 Acoustic environment

i) Description of the acoustic environment, if indoors, size and acoustic characteristics of the room, including absorption properties of the walls, ceiling and floor.

ii) Acoustic qualification of test environment according to Annex A of ISO 3744.

iii) Air temperature in ^{o}C, barometric pressure in mbar and relative humidity in %.

6.11.3 Instrumentation

i) Equipment used for the measurements, including name, type, serial number and manufacturer.

ii) Bandwidth of frequency analyser.

iii) Frequency response of the instrumentation system.

iv) Method used for checking the calibration of the microphones and other system components; the date and place of calibration shall be given.

v) Method used for determining the mean sound pressure level.

6.11.4 Acoustic Data

i) The shape of the measurement surface, the measurement distance, the location and orientation of microphone positions or paths.

ii) The area S of the measurement surface.

iii) The correction, if any, in dB, applied in each frequency band for the frequency response of the microphone, frequency response of the filter in the passband, etc.

iv) The corrections, if any, for background noise and for unwanted reflections.

v) The A-weighted surface sound pressure level $\overline{L_{pAf}}$, in dB, and the surface band pressure level $\overline{L_{pf}}$. Reference: 20 uPa.

vi) The A-weighted sound power level L_{WA}, in dB, and the band power levels L_W in dB. Reference: 1 pW.

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

6.12 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 Section III 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 the operating mode(s). Reference: 1 pW.

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

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

SECTION IV

METHOD FOR MEASURING SOUND PRESSURE LEVELS AT THE OPERATOR AND BYSTANDER POSITIONS

7.1 Field of Application

This procedure specifies the conditions of measurement of noise at the operator and bystander positions. The procedure may be applied to equipment which radiates broad-band noise, narrow-band noise, or noise which contains discrete frequency components and impulsive noise. The measurements shall be made in a free field over a reflecting plane. The measurements may be performed conveniently together with those made according to Section III.

7.2 Measurement Uncertainty

Measurements made in conformity with this method result in standard deviations which are equal to, or less than, those given in Table 12.

TABLE 12 - UNCERTAINTY IN DETERMINING SOUND PRESSURE LEVELS

Octave band centre frequencies	One-third octave band centre frequencies	Standard deviation of the mean value
Hz	Hz	dB
125	100 to 160	3,0
250 to 500	200 to 630	2,0
1000 to 4000	800 to 5000	1,5
8000	6300 to 10000	2,5

NOTE 22:

Under free field conditions over a reflecting plane, this standard deviation reflects the cumulative effects of all causes of measurement uncertainty, including variations from laboratory to laboratory, but excluding variations in the sound pressure level from equipment to equipment and from test to test which may be caused, for example, by changes in the installation or operating conditions of the equipment.

For an equipment which emits noise with a relatively flat spectrum in the 100 Hz to 10000 Hz frequency range, the A-weighted sound pressure level is determined with a standard deviation of approximately 2 dB.

7.3 Test Environment

7.3.1 General

These measurments shall be made in a free field over a reflecting plane as specified in 6.3.1.

If barometric pressure, temperature and/or relative humidity influence the noise measurement, the conditions recommended in 6.3.1 are also recommended here.

7.3.2 Adequacy of the test environment

The test environment should provide a free field over a reflecting plane as defined in 6.3.1. Any deviations from these conditions may result in an increased sound pressure level and therefore in standard deviations which are greater than those given in Table 12, and shall be reported.

7.3.3 Background noise

The sound pressure level of the background noise shall be at least 6 dB below the corresponding sound pressure level produced by the equipment.

7.4 Instrumentation

Instrumentation shall be designed in accordance with either 5.4 or 6.4 with the following exceptions:

i) There is no requirement for spatial averaging of sound pressure level.

ii) The microphone shall be stationary during the measurement except when standing waves or interference requires otherwise (see Note 25).

iii) The microphone shall have a flat frequency response for directly incident sound over the frequency range of interest.

iv) For noise which is impulsive in character, an impulse precision sound level meter that meets the requirements for type 1 of IEC 651 shall be used.

7.5 Installation and Operation of Equipment

Equipment shall be installed and operated according to the requirements of 6.5 with the following exception:

Table-top equipment shall be installed in the centre of the top plane of a Standard Test Table. Extension tables shall not be placed around the table, unless it has been shown that they do not influence the measurement.

7.6 Microphone Positions

7.6.1 At the operator position

For equipment which is operated from a standing position, the microphone shall be located 1,50 m ± 0,03 m above the floor. For floor-standing equipment which is operated from a seated position, the microphone shall be located 1,20 m ± 0,03 m above the floor. For table-top equipment which is placed on the Standard Test Table the microphone shall be located 0,45 m above the table top plane. The horizontal distance from the Reference Parallelepiped shall be 0,25 m ± 0,03 m unless this distance is not representative of the operator position.

For most categories of equipment additional requirements are specified in Appendix C.

NOTE 23:

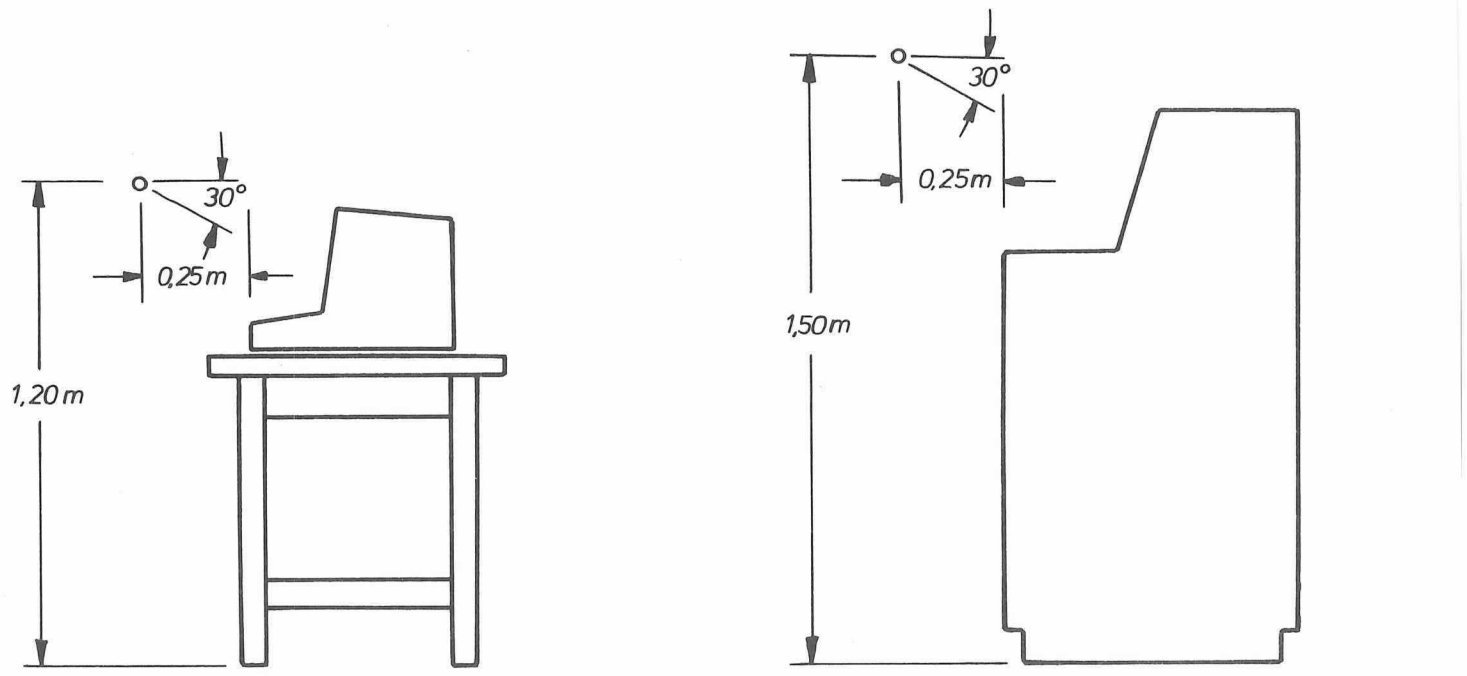
During this measurement the operator should be absent, if possible, or move aside, so that he can still operate the equipment, but not significantly disturb the sound field around the microphone.

7.6.2 At the bystander position(s)

For equipment which does not require operator attention while in the operating mode, an operator position need not be defined. In this case one or more bystander positions shall be selected and defined. The bystander position(s) shall be 1,00 m ± 0,03 m away from the projection of the Reference Parallelepiped on the horizontal plane and 1,50 m ± 0,03 m above the floor. The typical bystander position is the one in front of the equipment.

7.6.3 Microphone orientation

The microphone shall be oriented so that sound incident on it from 30° below horizontal will produce flat frequency response over the frequency range of interest (Fig. 3)



Seated Operator

Standing Operator

FIGURE 3 - EXAMPLES OF THE MICROPHONE POSITIONS FOR STANDING AND SEATED OPERATORS

7.7 Measurement of Sound Pressure Levels

7.7.1 General

Measurements of the A-weighted sound pressure level, or band pressure levels, if required, shall be made at the microphone positions defined in 7.6.

7.7.2 Measurement of the A-weighted sound pressure level L_{pA} or band pressure levels

The mean sound pressure level (A-weighted and in frequency bands) shall be measured for each defined mode of operation of the equipment. The measurement duration shall be as defined in 6.7.2.

NOTE 24:

When using a sound level meter, the person reading the meter shall not disturb the sound field at the microphone.

NOTE 25:

When spatial fluctuations occur, due to interferences or standing waves it is recommended that the microphone be moved by approximately 0,1 m in a vertical plane around the nominal measurement position.

NOTE 26:

For impulsive noise it should be noted that the sound level meter may be overloaded below full meter deflection, especially in switch position SLOW. In such cases an impulse sound level meter conforming to IEC 651 shall be used for the determination of both the sound pressure level and the impulse sound pressure level.

7.7.3 Measurement of the A-weighted impulse sound pressure level, L_{pAI}

Aural examination of the noise emissions of the equipment under test shall be made. If impulsive noise is audible, the A-weighted impulse sound pressure level, L_{pAI}, averaged on a mean-square basis, if necessary, shall be measured at the same microphone positions and for the same mode(s) of operation as used for the measurements in 7.7.1 and 7.7.2. The difference in dB between the A-weighted impulse sound pressure level, L_{pAI}, and the A-weighted sound pressure level, L_{pA}, shall be obtained. The difference (L_{pAI}-L_{pA}) is the impulse parameter, ΔL_I. If $\Delta L_I \geqslant 3$ dB the noise is considered to be impulsive and is to be so reported according to 7.9 v).

NOTE 27:

The measurement of impulse sound pressure levels is performed only to determine whether the noise emissions are impulsive. Other sound pressure level measurements are performed using rms metering (Note 3) regardless of this determination.

NOTE 28:

If the impulse sound level is recorded, using a level recorder, the DC output of the impulse sound level meter shall be used and the time constant of the recorder shall not be greater than 0,25.

7.7.4 Detection of prominent discrete tones

Aural examination of the noise emitted by the equipment under test shall be made. If discrete tones are audible, a one-third octave band analysis shall be made at the microphone positions defined in 7.6. If the sound pressure level of a certain one-third octave band exceeds the levels of either adjacent bands by more than 5 dB, it can be expected that a prominent discrete tone is present in the spectrum. This is to be reported as required in 7.9 v).

7.7.5 Corrections for background noise

The measured sound pressure levels shall be corrected for the influence of background noise according to Table 13. When the background sound pressure level is less than 6 dB below the sound pressure level with the equipment operating, the accuracy of the measurements will be reduced and no data shall be reported.

TABLE 13 - CORRECTIONS FOR BACKGROUND NOISE

Difference in dB between sound pressure level measured with equipment operating and background noise alone	Correction in dB to be subtracted from sound pressure level measured with equipment operating to obtain sound pressure level due to equipment alone
< 6	measurement invalid
6	1,0
7	1,0
8	1,0
9	0,5
10	0,5
>10	0,0

7.7.6 Corrections for unwanted reflections

No corrections are permitted.

7.8 Information to be Recorded

The following information, when applicable, shall be recorded for all sound pressure level measurements at operator or bystander positions.

7.8.1 Equipment under test

i) Description of the equipment under test (including principal dimensions).

ii) Operating conditions.

iii) Installation conditions.

iv) Location of equipment in the test environment.

v) If the equipment has multiple operating modes, description of each individual mode for which measurements have been performed.

7.8.2 Acoustic environment

i) Description of the acoustic environment, if indoors, size and acoustic characteristics of the room including absorption properties of the walls, ceiling and floor.

ii) Acoustic qualification of test environment according to Annex A of ISO 3744.

iii) Air temperature in ^{o}C, barometric pressure in mbar and relative humidity in %.

7.8.3 Instrumentation

i) Equipment used for the measurements, including name, type, serial number and manufacturer.

ii) Bandwidth of frequency analyser.

iii) Frequency response of the instrumentation system.

iv) Method used for checking the calibration of the microphones and other system components; the date and place of calibration shall be given.

v) Method used for measuring the mean value of the sound pressure level and the impulse sound pressure level.

7.8.4 Acoustic data

i) The measurement positions and microphone orientations (preferably including a sketch).

ii) For each measurement position and operating mode, the A-weighted sound pressure level L_{pA} and the impulsive parameter ΔL_I, if it is equal to, or greater than, 3 dB, and the band pressure levels L_p, if required.

iii) For each measurement position and operating mode, the corrections applied for the influence of background noise, if applicable.

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

7.9 Information to be Reported

The report shall contain the statement that the sound pressure levels have been obtained in full conformance with the procedures of Section IV of this Standard. The report shall state that these sound pressure levels are given in dB. Reference: 20 uPa. The report shall contain the following information:

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

ii) If an operator position is defined, the A-weighted sound pressure level, expressed in dB, at the operator position(s) for operating and idle modes, rounded to the nearest decibel.

iii) If one or more bystander positions are defined, the A-weighted sound pressure level, expressed in dB, at such positions for operating and idle modes, rounded to the nearest decibel.

iv) Detailed description of the operating conditions of the equipment under test with reference to Appendix C, if applicable.

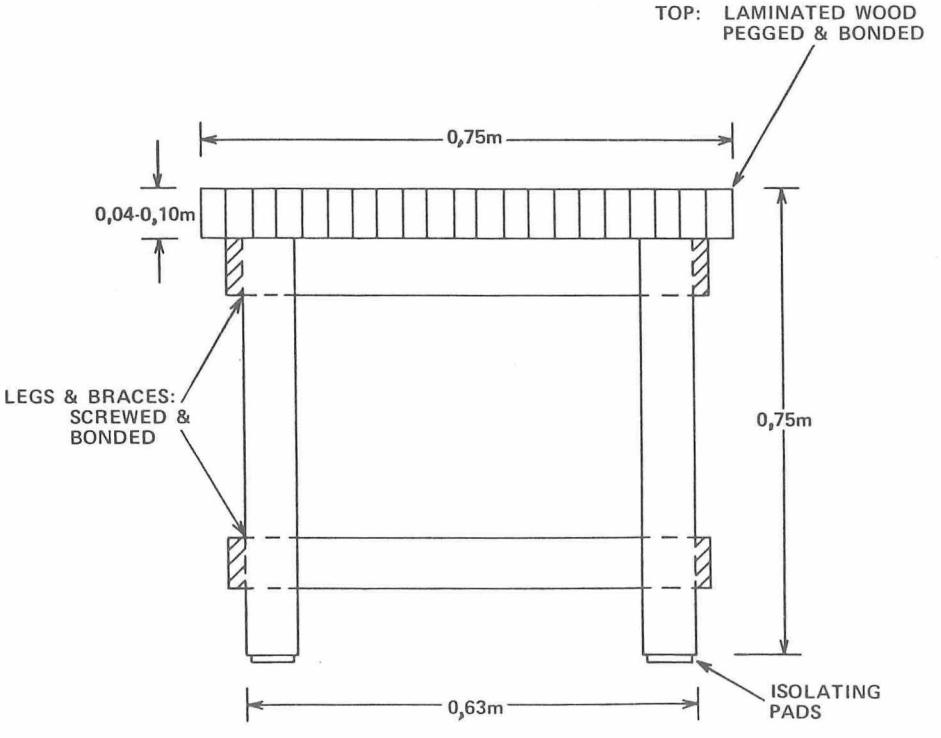
v) One of the following statements as appropriate:

- No impulsive noise, no prominent tones
- Impulsive noise, no prominent tones
- Prominent tones, no impulsive noise
- Impulsive noise and prominent tones

APPENDIX A

STANDARD TEST TABLE

A suitable design for a Standard Test Table is shown below. The table shall be of laminated wood 0,04 m to 0,1 m thick, having a minimum area of 0,5 m^2 and a minimum lateral dimension of 0,7 m.



APPENDIX B

SPECIAL MEASUREMENT SURFACES

In some cases a spherical measurement surface (sphere, hemisphere or quarter sphere) may be used instead of the parallelepiped which is preferred for computers and business equipment. This is mainly recommended for small equipment for which the Reference Parallelepiped is small, e.g. does not exceed 0,4 m in length and width and 0,2 m in height and for which the measuring distance is equal to 1 m. In this case the spherical measurement surface shall have a radius of at least 1 m.

ARRANGEMENT B1: Spherical Measurement Surface
20 Measurement Positions

Position	$\frac{x}{r}$	$\frac{y}{r}$	$\frac{z}{r}$
1	-0,99	0	0,15
2	0,50	-0,86	0,15
3	0,50	0,86	0,15
4	-0,45	0,77	0,45
5	-0,45	-0,77	0,45
6	0,89	0	0,45
7	0,33	0,57	0,75
8	-0,66	0	0,75
9	0,33	-0,57	0,75
10	0	0	1,0
11	0,99	0	-0,15
12	-0,50	0,86	-0,15
13	-0,50	-0,86	-0,15
14	0,45	-0,77	-0,45
15	0,45	0,77	-0,45
16	-0,89	0	-0,45
17	-0,33	-0,57	-0,75
18	0,66	0	-0,75
19	-0,33	0,57	-0,75
20	0	0	-1,0

Measurement Surface Area $S = 4 \pi r^2$

ARRANGEMENT B2 : Hemispherical Measurement Surface

10 Measurement Positions

The measurement positions are those numbered 1 to 10 of arrangement B1.

Measurement Surface Area $S = 2 \pi r^2$

NOTE B1:

For the arrangement of hemispherical measurement surfaces for equipment on a test table, the measurement surface shall terminate on a reflecting plane (see clause 6.1).

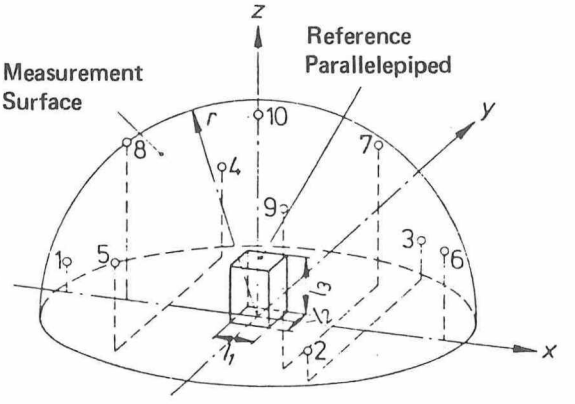


FIGURE B1 : HEMISPHERICAL SURFACE - 10 MEASUREMENT POSITIONS

If the equipment emits prominent tones, strong interference effects may occur if several microphone positions are placed at the same height above the reflecting plane. In such cases the use of a microphone array with the coordinates given below is recommended.

No.	$\frac{x}{r}$	$\frac{y}{r}$	$\frac{z}{r}$
1	0,16	-0,96	0,22
2	0,78	-0,60	0,20
3	0,78	0,55	0,31
4	0,16	0,90	0,41
5	-0,83	0,32	0,45
6	-0,83	-0,40	0,38
7	-0,26	-0,65	0,71
8	0,74	-0,07	0,67
9	-0,26	0,50	0,83
10	0,10	-0,10	0,99

ARRANGEMENT B3 : Quarter-sphere Measurement Surface

5 Measurement Positions

The measurement positions are those numbered 2, 3, 6, 7 and 9 of Arrangement 1.

Measurement Surface Area $S = \pi r^2$

This arrangement should only be used where small equipment is to be placed against two perpendicular reflecting planes.

APPENDIX C

INSTALLATION AND OPERATING CONDITIONS FOR SPECIFIC EQUIPMENT CATEGORIES

This Appendix, which is part of the Standard, specifies installation and operating conditions for most categories of equipment. These conditions shall be satisfied when making measurements according to this Standard.

The specified conditions are considered to be typical for the average end use. Where end use is too difficult to simulate, equivalent conditions are specified with a view to facilitating the operation of the equipment and to enhancing the reliability of the acoustic measurements. For categories of equipment not covered in this Appendix, the actual test conditions shall be described and justified in the test report.

C.1 EQUIPMENT CATEGORY: Typewriters

C.1.1 Description

Equipment with a keyboard for manual information entry. The information is either keyed-in and immediately printed on paper character-by-character (manual typing), or keyed-in and stored for word or line editing with following automatic print-out (interactive operation). Typewriters which are equipped with a full-page storage are considered as typewriters during manual typing and as printers (see C.2) during automatic print-out on a full page.

C.1.2 Installation

Typewriter shall be placed in the centre of the top plane of the Standard Test Table. This position is the preferred one. For measurements according to Section III, the measurement surface terminates on the extended top plane of the Standard Test Table. Extension tables as defined in 6.5.1 iii) shall be used; those tables may, however, be omitted if preliminary tests for a certain typewriter family show, that the resulting surface sound pressure level obtained without extension tables deviates by not more than 1 dB from the level measured with extension tables. Alternatively, the typewriter may be placed on a hard reflecting floor. The used condition shall be reported.

Type font

If the typewriter allows the use of different type fonts or different type elements, a fine line typestyle (e.g. pica, elite) shall be used.

Paper

Single sheet paper of grammage 80 g/m^2 in the format ISO A4 or equivalent. Paper shall be inserted in vertical format at left-hand edge at zero, leading edge of paper sheet shall be approximately 1/3 of paper depth (or 100 mm) apart from the trailing edge (see Figure C1).

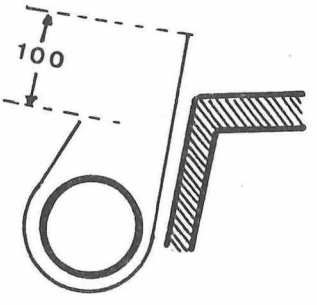


Figure C1. Insertion of single sheet paper

C.1.3 Operation

Idle Mode

Power on and ready for information entry and/or print-out. Paper inserted according to Fig. C1.

Typing Mode

The following settings, when applicable, shall be used:

Impression control

As recommended for single sheet paper (usually "weak").

Multi-copy control

Set for single sheet.

Line spacing

Double line spacing.

Margin

25 mm from the edges.

Paperbail rollers

25 mm in from the edges of the paper; others equally spaced between.

NOTE C1:

The end-of-line indicator (Bell) shall not be included.

The typing mode consists of keying-in the specified characters and the printing on paper.

Character pattern

etnaivetnaivetnaivetnaiv ...

and so on until a full printline of approximately 60 characters is completed.

NOTE C2:

A maximum of two characters may be replaced by other small letters, if there is a need for alteration.

NOTE C3:

Where small letters are not available, capital letters may be used instead; equivalent conditions may be selected for typewriters with special character sets.

Operating speed

- Manual typing: Typing speed shall be 5 characters per second.

NOTE C4:

Keying-in may be performed with a suitable electro-magnetic or pneumatic robot (to simulate manual keystrokes). The noise level due to the operation of the robot alone should be at least 10 dB below the level for printing.

- Interactive operation: Keying-in the specified characters at a rate of 5 char./s until the buffer is filled up; a maximum buffer capacity of one printline shall not be exceeded. Immediate printing of the stored information (max. 1 line) at nominal printing speed is required.

C.1.4 Measurement duration

The mean sound pressure level shall be measured as follows:

- Manual typing: measure during continuous typing over at least 3 full lines.
- Interactive operation: measure during keying-in and printout until at least 3 full lines have been printed.

C.2 EQUIPMENT CATEGORY: Printers

C.2.1 Description

Electronically controlled equipment which prints stored information on paper and is not normally keyboard-operated. The output may be obtained by means of impact printing (e.g. typebar-, train-, chain- or bandprinters, typewheel, type-element or matrix printers) or by non-impact printing (e.g. ink jet, electro-erosion, thermal- or laser printers).

C.2.2 Installation

Floor-standing printers shall be installed on the hard reflecting floor. Printers which are normally placed on a special stand or table shall be installed on such a stand or table on the reflecting floor. Printers which are placed on a normal office table or desk and which take paper from, or stack paper on, the floor, shall, if possible, be placed in the centre of the top plane of the Standard Test Table, using the floor to support the paper. For measurements according to Section III the measurement surface terminates on the reflecting floor.

Table-top printers, which do not use the floor for the paper supply or exit stack, shall be placed in the centre of the top plane of the Standard Test Table. In this case the measurement surface terminates on the extended top plane of the Standard Test Table. Extension tables as defined in 6.5.1 iii) shall be used. Alternatively, the printer may be placed on the hard reflecting floor. The position selected shall be reported.

Type font

If the printer allows the use of different type fonts or different type elements, a type font typical for normal use shall be selected.

Paper

Single sheet paper of grammage 70 g/m^2 to 80 g/m^2; continuous stationery folded or rolled of grammage 50 g/m^2 to 60 g/m^2. The form width shall be typical for the printer; if different widths can be used, the most common one shall be used and described in the report. For special applications (e.g. passbook or cheque processing) the material shall be typical for customer usage and shall be described in the test report. Paper shall have been stored with the material unpacked and exposed to the environmental conditions specified in 6.3.1 for 7 days immediately prior to the test.

C.2.3 Operation

Idle Mode

Paper position

Except for single sheets, paper shall be loaded and fed through for a length of at least 10 times its width.

Print Mode

The following settings, when applicable, shall be used:

Impression control

As recommended for single sheet paper.

Multi-copy control

Set for single sheet.

Line spacing

Double line spacing; skip 20 mm to 30 mm on each side of the paper fold.

Margin

25 mm from the edges (excluding the perforation strip).

Character pattern

The full content of a 40-character test pattern is given below; if the line comprises fewer characters, the left-most ones shall be used.

The characters shall be arranged in groups of five followed by five blank spaces. The format should preferably be shifted from line to line.

J1YY7 2DA90 8S8=2 6AI8Q B31AJ 5FTOE PG1TK X6D-4

NOTE C5:

If some of the specified characters are not available, alternative characters of up to 20% of the characters in one line may be used. If a printer prints both capital and small letters, the first character of each 5-character group, if a letter, shall be a capital letter. For printers which print only numerical information a random set of numbers shall be selected and reported.

The number of characters to be printed in one line depends on the printer itself and is given below.

Maximum line length in characters	Number of characters to be used
< 40	50% of max. line length
40 - 60	20 characters
61 - 110	30 characters
> 110	40 characters

Operating speed

The nominal speed for which the printer is designed shall be used; if several speeds are provided, the one which is typical for the majority of the uses shall be employed and reported. Additional conditions may be defined for special applications.

C.2.4 Measurement duration

The mean sound pressure level shall be measured as follows:

- Single-page form: measure during continuous printing over at least 60% of the page depth. The printing area shall be left-justified and centred vertically. If the printer has an automatic paper feed mechanism, the test shall be extended over three pages.
- Folded stationery: measure during continous printing over at least three pages.
- Rolled stationery: measure during continuous printing over a depth equal to at least the paper width, but for not less than 8 s.
- Passbook: measure during printing the middle pages during a complete operation cycle from insertion to ejection.

C.3 EQUIPMENT CATEGORY: Keyboard

C.3.1 Description

Equipment for manual data entry fixed or connected via a cable to other units, e.g. visual display units, automatic typewriter, etc.

C.3.2 Installation

Keyboards shall be placed in the centre of the top plane of the Standard Test Table. For measurements according to Section III, the measurement surface shall terminate on the extended top plane of the Standard Test Table. Extension tables as defined in 6.5.1 iii) shall not be used.

C.3.3 Operation

i) Operating mode

The keys can be operated manually or preferably by an electromagnetic or pneumatic robot.

The typing speed shall be 5 char./s. The stroke has to be adjusted so that the key just touches its stop.

NOTE C6:

Keying-in may be performed with a suitable electromagnetic or pneumatic robot (to simulate manual keystrokes). The noise level due to the operation of the robot alone should be at least 10 dB below the level of operation. If the keyboard has an acoustic feedback this should be reported.

ii) Test pattern

4 characters plus blank
4 digits plus function key

NOTE C7:

It is possible to generate this pattern with one hand. The selected keys should be placed in the middle of the keyboard and be reported.

C.3.4 Measurement duration

The mean sound pressure level shall be measured in accordance with the relevant clauses of this Standard.

C.4 EQUIPMENT CATEGORY: Teleprinters

C.4.1 Description

Equipment operating as a send/receive machine basically comprising a keyboard, a printing unit, a mechanically or electronic send/receive unit (line control unit) and (integrated or optional) a memory unit (electronic, paper tape punch/reader, magnetic tape, disk or cassette).

Two typical uses are:

i) keyboard operation (when in local or transmission mode): the information is keyed-in by manual typing and immediately printed on paper and/or stored in the memory. In this case the teleprinter is considered to be a typewriter (according to C.1), with interactive operation, if available.

ii) automatic operation (when in local or on-line mode): the machine prints automatically the information received from line network or from the memory unit. In this case the teleprinter is considered to be a printer (according to C.2).

When a teleprinter is fitted with an auxillary unit which produces noise: (paper tape punch/reader, magnetic tape disk or cassette), the machine shall be tested with and without the unit in operation.

In some cases a teleprinter can be available in receive-only configuration (without keyboard). That machine is considered to be a printer (according to C.2).

C.4.2 Installation

For keyboard operation of the teleprinter, see the general installation conditions for typewriters (C.1).

For automatic operation of the teleprinter, see the general installation conditions for printers (C.2).

Paper

If in typical use, multi-part stationery is employed, an additional test with such stationery shall be performed and reported.

C.4.3 Operation

Idle mode

For keyboard operation of the teleprinter, see the operation conditions for typewriters (C.1).

For automatic operation of the teleprinter, see the operation conditions for printers (C.2).

Test pattern

i) Alpha-numeric keyboard

For keyboard operation of alpha-numeric keyboards the test pattern of C.1.3 and Note C.2 apply.

ii) Numeric keyboard

For keyboard operation of numeric keyboards the test pattern shall be any repeated random sequence of four digits followed by a function key stroke.

Operation speed

For keyboard operation of the teleprinter, the operation speed shall be as specified for typewriters.

For automatic operation of the teleprinter, the operation speed shall correspond to a transmission rate of 50 bauds. In addition the teleprinter shall be operated at its highest nominal speed which shall also be reported.

C.4.4 Measurement duration

For keyboard operation of the teleprinter, see the requirements for typewriters (C.1).

For automatic operation of the teleprinter, see the requirements for printers (C.2).

C.5 EQUIPMENT CATEGORY: Duplicator

C.5.1 Description

Equipment which can produce one or more copies from a master. Such equipment can be coupled with a number of additional attachments, in particular with a sorter, with or without automatic stapling, a master loading device and a special paper feeder for continuous stationery or label printing.

C.5.2 Installation

Floor-standing duplicators shall be installed on the hard reflecting floor. Duplicators which are normally placed on a special stand or table shall be installed on such a stand or table on the reflecting floor. Duplicators which are placed on a normal office table or desk and which take paper from, or stack paper on, the floor, shall, if possible, be placed in the centre of the top plane of the Standard Test Table, using the floor to support the paper. For all of these installation conditions the measurement surface terminates on the reflecting floor.

Table-top duplicators, which do not use the floor for the paper supply or exit stack, shall be placed in the centre of the top plane of the Standard Test Table. In this case the measurement surface terminates on the extended top plane of the Standard Test Table. Extension tables as defined in 6.5.1 iii) shall be used. Alternatively, the duplicator may be placed on the hard reflecting floor. The position selected shall be reported.

The same installation conditions shall be followed when the duplicator is coupled with one or more attachments.

C.5.3 Paper

Single sheet paper of grammage 70 g/m^2 to 80 g/m^2; continuous folded or rolled stationery. For special applications (e.g. label printing) the material shall be typical for customer usage and shall be described in the test report. Paper shall have been stored with the material unpacked and exposed to the climatic conditions specified in 6.3.1 for 7 days immediately prior to the test.

C.5.4 Operation

Idle mode

Suitable paper supply shall be loaded.

Print mode

The nominal speed for which the duplicator has been designed shall be used; if several speeds are provided, the one which is typical for the majority of the uses shall be employed.

Additional conditions may be defined for special applications.

Single copy printing

An operation cycle shall comprise printing of one single copy. Where needed for measurement, consecutive operation cycles shall be performed.

Duplication

An operation cycle shall comprise continuous printing of copies of the same master.

Attachments

Attachments are used generally only in duplication mode.

i) Sorter

The number of copies shall be set to the 60% capacity of the sorter. An operation cycle shall comprise consecutive duplication of two masters and sorting of the copies.

ii) Automatic stapling

If the sorter has an automatic stapling device attached to it, an operation cycle shall comprise in addition to the operation cycle of C.5.4 i), stapling of the sorted sets of copies.

iii) Automatic master loading

An operation cycle shall comprise continuous automatic loading of masters and printing one copy of each master.

iv) Duplication on continuous stationery

An operation cycle shall comprise duplication of one master on 10 pages for folded stationery or 2 m for rolled stationery.

v) Combined attachments

If several of the described attachments are used simultaneously, an operation cycle shall comprise all operations needed for performing the operation cycle of each attachment.

C.5.5 Measurement duration

For each set-up the mean sound pressure level shall be measured in accordance with the relevant clauses of this Standard.

C.6 EQUIPMENT CATEGORY: Card Readers - Card Punches

C.6.1 Description

Equipment of this category may perform a single function, such as reading the information from, or punching it into, a punched card. The two functions may also be combined in one machine which allows to use both functions in one process or to use them separately. The number of cards processed per unit time depends for readers mainly on the nominal processing speed; for punches it may be significantly influenced by the total number of columns to be punched per card.

NOTE C8:

For equipment which performs similar functions such as card duplicating machines, card verifiers, card or document sorters and collators, code interpreters (with printing features), paper tape readers and punches, the following Installation and Operating Conditions may also be applied.

C.6.2 Installation

The equipment shall be installed in accordance with the relevant clauses of this Standard.

C.6.3 Operation

Idle mode

Power on and ready for reading or punching cards.

Reading/Punching mode

Random alpha-numeric information shall be read from, or punched into, each card; approximately 40% of the maximum available number of columns (usually 80) shall contain information. The character pattern shall be arranged in groups of five characters followed by five blank spaces:

J1YY7 2DA90 8S8=2 6AI8Q B31AJ 5FTOE PG1TK X6D-4

C.6.4 Measurement duration

The mean sound pressure level shall be measured in accordance with the relevant clauses of this Standard, subject to the following additional requirement: process a random card deck of at least 10 cards; the minimum measurement time is 8 seconds.

C.7 EQUIPMENT CATEGORY: Magnetic Tape Storage Units

C.7.1 Description

Equipment for data storage employing magnetic tape wound on reels or within a cassette or a cartridge. A unit may contain one or more separately operable tape drives.

C.7.2 Installation

Installation shall be in accordance with the relevant clauses of this Standard.

C.7.3 Operation

Idle mode

Tape loaded, power on, unit ready to receive and respond to control line commands to any drive. In multiple drive units, all drives shall be loaded and ready.

Operating modes

The following modes shall be used where applicable. In multiple drive units only one drive shall be in operating mode. All other drives shall be in idle mode.

i) Read/Write mode

Start, read or write, stop - with capstan (or equivalent) operation commanded as follows:

The capstan on-time and the capstan off-time are equal and arbitrarily set at the time to pass 25 mm of tape at the rated tape speed, given by:

$$\left(\frac{25 \text{ mm}}{\text{rated tape speed in m/s}}\right) \text{ ms}$$

rounded-off to the nearest whole millisecond.

ii) Streaming mode

Forward run while writing.

C.7.4 Measurement duration

The mean sound pressure level shall be measured in accordance with the relevant clauses of this Standard, subject to the following additional requirements.

Operating modes

i) Discrete Records Forward

Measure during the prescribed time or during at least 20 consecutive start/stop operations, whichever is longer.

ii) Streaming mode

Measure during the prescribed time under steady state conditions.

C.8 EQUIPMENT CATEGORY: Magnetic Disk Storage Units

C.8.1 Description

Equipment for data storage employing one or more rotating magnetic disks. Disks may be removable or non-removable. A unit may contain one or more separately operable disk drives.

C.8.2 Installation

Installation shall be in accordance with the relevant clauses of this Standard.

C.8.3 Operation

Idle mode

Disk(s) loaded, power on, unit ready to receive and respond to control line commands to any drive. In multiple drive units all drives shall be loaded and ready.

Operating modes

Read/Write mode

Consecutive seeks on a single drive to random cylinders (tracks). In multiple drive units, other drives shall be in Idle mode.

C.8.4 Measurement duration

The mean sound pressure level shall be measured in accordance with the relevant clauses of this Standard (e.g. duration up to 30 s for Section II), subject to the following additional requirements.

Idle mode

Measure for at least 8 s.

Operating mode

Read/Write mode

Measure for at least 8 s and during at least 20 seeks.

C.9 EQUIPMENT CATEGORY: Electronic Units

C.9.1 Description

Equipment such as processors, electronic memories and controllers, containing only electronic circuits, power supplies but no moving mechanical parts except those associated with cooling.

C.9.2 Installation

Installation shall be in accordance with the relevant clauses of this Standard.

C.9.3 Operation

Operating mode

Steady state operation with normal load on all elements.

C.9.4 Measurement duration

The mean sound pressure level shall be measured in accordance with the relevant clauses of this Standard.