ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-74

MEASUREMENT OF AIRBORNE NOISE EMITTED BY COMPUTERS AND BUSINESS EQUIPMENT

2nd Edition – December 1987

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BRIEF HISTORY

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 and of the sound pressure level at the operator position(s). 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 and 3745). 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 noise emission declaration 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 noise emission declaration 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 many categories of equipment.

The first edition of this Standard was issued in September 1981. It was contributed to ISO TC43 and formed the base for ISO 7779. The differences between the first and second edition are indicated in Appendix F.

Accepted as 2nd edition of Standard ECMA-74 by the General Assembly of 10th December 1987.

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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, ISO 3744 and ISO 3745. 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 positions. This level is not a workers emmission rating level, but it may assist in identifying any potential problems that could cause annoyance, activity interference, or hearing damage to operators and bystanders.

1.2 Field of Application

This Standard is suitable for type tests and provides methods for manufacturers and testing laboratories to obtain comparable results.

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

The levels obtained may serve noise emission declaration and comparison purposes (see Standard ECMA-109). They are not to be considered as installation noise emmission levels, however they may be used for installation planning (see ECMA TR/27).

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

ECMA-108 : Measurement of High Frequency Noise Emitted by Computer and Business Equipment

ECMA-109 : Declared Noise Emission Values of Computer and Business Equipment

ECMA TR/27 : Method for the Prediction of Installation Noise Levels

ISO 266 : Preferred frequencies for measurements

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, L_{pAI} in dB

The A-weighted sound pressure level determined with a sound level meter set for the I-time weighting characteristic (IMPULSE).

4.2 Background Noise

The noise 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 measurement position at a typical location occupied by a bystander.

4.5 Computer and Business Equipment

Equipment, and components thereof, which is primarily used in computer installations, offices or similar environments.

4.6 Floor-standing Equipment

A functional unit which 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.

NOTE 1

If the 16 kHz octave band is included in the measurements, the procedures of this Standard may yield measurement uncertainties greater than those stipulated herein.

NOTE 2

For equipment which emits sound only in the 16 kHz octave band, use the procedure specified in Standard ECMA-108.

4.8 Functional Unit

An entity of physical equipment, which has been allocated an identification number, capable of accomplishing a specified information processing task. A functional unit may be supported by a frame or frames and may be self-enclosed or designed to be attached to another device.

4.9 Idle Mode

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

4.10 Measurement Surface

A hypothetical surface of area S enveloping the equipment being tested on which the measuring points are located.

4.11 Operator

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

4.12 Operator Position

A measurement position at the assigned position of the operator.

4.13 Operating Mode(s)

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

4.14 Rack-mounted Equipment

One or more sub-assemblies installed in one or more end-use enclosures.

4.15 Reference Box

A hypothetical reference surface which is the smallest rectangular parallelepiped that encloses the equipment being tested and terminates on the reflecting plane.

4.16 Reference Sound Source

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

4.17 Sound Power Level, L_W in dB

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.

NOTE 3

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

4.18 Sound Pressure Level, L_p in dB

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.

NOTE 4

In this Standard the sound pressure is the time-averaged value of the sound pressure during the measurement interval.

4.19 Standard Test Table

A rigid table used for installation of table top equipment during acoustical tests. The requirements for the Standard Test Table are given in Appendix A.

4.20 Sub-assembly

A functional unit intended to be installed in another unit or assembled with other units in a single enclosure. The unit may or may not have its own enclosure and identification number.

4.21 Surface Sound Pressure Level, $\overline{L}_{pf}$ in dB

The sound pressure level averaged over the measurement surface and corrected for environmental influences.

4.22 Table-top Equipment

A functional unit which is intended to be installed or used on a table, desk or separate stand.

4.23 Wall-mounted Equipment

A functional unit which is normally mounted against or in a wall and may not have a stand of its own.

SECTION II

METHODS FOR DETERMINING SOUND POWER LEVELS OF EQUIPMENT IN REVERBERATION ROOMS

5.1 Field of Application

The procedure defined in this section specifies 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 Hz	One-third octave band centre frequencies Hz	Standard deviation 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 5

For most computer and business equipment, the A-weighted sound power level will be determined by the levels in the 250 Hz to 4000 Hz octave bands. The A-weighted sound power level is determined with a standard deviation of approximately 1,5 dB. A larger standard deviation may result when the levels in other bands determine the A-weighted level.

NOTE 6

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 7

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 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 Level

The sound pressure level of the background noise including any noise due to the motion of the microphone and/or rotating diffusers shall be at least 6 dB, and preferably more than 15 dB, below the sound pressure level measured, when the equipment under test is operating, 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 °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 5.6, 5.7 and 5.8.

For those units the sound pressure of which varies with temperature, the test temperature shall be 23 °C ± 2 °C.

The conditions within the reverberation room should be:

- Barometric pressure : 86 kPa to 106 kPa
- Temperature : 15 °C to 30 °C
- Relative humidity : 40% to 70%

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.

The mean sound pressure level is the level of the squared sound pressure averaged over time and space. Alternatively, space averaging may be performed separately by calculating the space/time average 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. Digital integration is the preferred method.

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.

NOTE 8

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.

5.4.2 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 9

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 exercised to avoid introducing acoustical 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

Before and after each series of measurements, an acoustical 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 electrical calibration of the instrumentation system over the entire frequency range shall be performed at intervals of not more than two years.

The reference sound source shall be checked annually to verify that its output sound power level has not changed.

5.5 Installation and Operation of Equipment

5.5.1 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. Installation conditions for many different categories of equipment are specified in Appendix C; these shall be followed when declared noise emission values are to be determined.

i) 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.

If the equipment being tested consists of several enclosures in an installation or is too large for testing purposes, the enclosures may be measured separately. In such circumstances, additional covers may be required for the enclosures during the acoustical evaluation. These additional covers shall be acoustically comparable with the other covers on the equipment. If a unit is mechanically or acoustically coupled to another unit so that the noise levels of one are significantly influenced by the other, the equipment being tested shall, where practicable, include all units coupled together in this way.

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 in accordance with the manufacturer's instructions. If such information is not available, the distance shall be 0,1 m.

iii) Table-top equipment shall be placed on the floor, at least 1,5 m from any wall of the room. A resilient pad may be used only if its use is recommended in the installation specification.

iv) Table-top equipment, such as printers which typically

are used 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.

v) Rack-mounted equipment shall be tested as floor-standing or table-top equipment, as appropriate. Rack-mounted equipment which does not include, but requires the use of, air-moving equipment (i.e. cooling-fan assemblies) when in operation shall be tested with such equipment, as supplied or recommended by the manufacturer. Rack-mounted equipment with more than one end-use enclosures may be tested and reported either as individual functional units or as a complete system.

vi) Wall-mounted equipment shall be mounted on a wall of the reverberation room at least 1,5 m from any other reflecting surface, unless otherwise specified. Alternatively, if operation allows and noise emissions are not affected by orientation, the equipment may be laid on its side and installed with its mounting surface attached to the floor at least 1,5 m from any wall of the room.

vii) If the equipment is usually installed by being mounted in or through a wall or other structure, a representative structure shall be used for mounting during the measurements.

viii) Hand-held equipment shall be supported 0,1 m above the reflecting plane by vibration-isolating elements. The supports shall not interfere with the propagation of airborne sound.

ix) A sub-assembly shall be supported 0,25 m above the reflecting plane by vibration-isolating elements. The supports shall not interfere with the propagation of airborne sound.

NOTE 10

When the equipment is mounted near one or more reflecting planes, 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 one particular equipment position and orientation or from the average value for several positions and orientations.

NOTE 11

Care shall be taken to ensure that any electrical conduits, piping, air ducts or other auxiliary equipment connected to the equipment being tested do not radiate significant amounts of sound energy into the test room. If practicable, all auxiliary equipment necessary for the operation of the equipment shall be located outside the test room and the test room shall be cleared of all objects which may interfere with the measurements.

5.5.2 Input Voltage and Frequency

The equipment shall be operated within 5% of either

- the rated voltage, or
- the average voltage of a stated voltage range (e.g. oper-

ating at 120 V for a stated range from 110 V to 130 V), at the rated power line frequency.

Phase-to-phase voltage variations shall not exceed 5%.

5.5.3 Equipment Operation

During the acoustical measurements the equipment shall be operated in a manner typical of normal use. Appendix C specifies such conditions for many different categories of equipment. For categories of equipment not covered by Appendix C, the test conditions used shall be described and reported.

The noise shall be measured with the equipment in both the idling and the operating modes. If several operating modes exist, e.g. reading and punching, the noise of each individual mode shall be determined and recorded. For equipment which in normal functional operation has several operating modes, the mode producing the highest A-weighted sound power level shall be determined, unless otherwise specified in Appendix C.

In the case of rack-mounted equipment in which the operation of several functional units is possible, the unit producing the highest A-weighted sound power level shall be operated together with those other units required for its operation. All other units shall be in the idle mode.

Some equipment does not operate continuously because of its mechanical design or its mode of operation under program control. Long periods may occur during which the equipment is idling. The operating mode measurements should not include these idling periods. If it is not possible to operate the equipment continuously during the acoustical evaluation, the time interval during which measurements have to be made shall be described in the test report.

Some equipment has operational cycles that are too short to allow reliable determination of the noise emissions. In such cases a typical cycle shall be repeated several times.

If the equipment being tested produces attention signals, such as tones or bells, such intermittent sound shall not be included in an operating mode. During the acoustical evaluation in the operating mode(s), such attention signals shall be inoperative.

The equipment shall be operated for a sufficient period of time before proceeding with the acoustical test to allow the temperature to stabilize.

5.6 Microphone and Source Positions

The major cause of uncertainty in determining sound power level in a reverberation room is the spatial irregularity of the sound field. The extent of this irregularity and, hence, the effort required to determine the average sound pressure level accurately is greater for discrete-frequency sound than for broad-band sound.

A conclusion that no significant discrete-frequency components or narrow bands of noise are present in the sound emitted by the source can only be reached by following the procedure de-

scribed in 5.6.1. It is strongly recommended that the room be qualified in accordance with ISO 3742 because the number of microphone and equipment positions calculated in accordance with the following procedure is usually large.

5.6.1 Identification of Discrete-Frequency Components and Narrow Bands 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 Section 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 $\frac{1}{2}\ \lambda_m$ apart, where λ_m 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 for N = 6:

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

where:

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

L_i = the time-averaged sound pressure level at each microphone position, in dB.

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

N = the number of microphone positions.

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 characteristics 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

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

5.6.3 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 $\frac{1}{2}\lambda_m$ or 1 m, whichever is smaller, to any room surface. No point on the traverse or array shall be closer than $\frac{1}{4}\lambda_m$ or 0,5 m, whichever is smaller, to the path of a moving diffuser.

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

$$d \geqslant 0{,}8 \cdot 10^{\left(\frac{L_{Wr} - L_{pr}}{20}\right)} \qquad \text{(III)}$$

where:

L_{Wr} = the known sound power level, in dB, of the reference source

L_{pr} = the space/time-averaged sound pressure level, in dB, produced in the room by the reference source.

NOTE 12

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

NOTE 13

The microphone traverse or array should avoid areas of air discharge, if any, or sound beaming from the equipment being tested.

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 twice the time constant of the indicating device.

5.6.4 Number of Equipment Locations

The required number of locations at which the equipment under test is to be placed successively depends on the room absorption and on the frequency. When discrete frequency tones are present, the required number of equipment locations, N_s, shall be computed from

$$N_s \geqslant k\left[0{,}032 \cdot 10^{0{,}1(L_{pr} - L_{Wr})} \cdot \left(\frac{1000}{f}\right)^2 + \frac{1}{N_m}\right] \qquad \text{(IV)}$$

where:

L_{Wr} = the known sound power level, in dB, of the reference source

L_{pr} = the space/time-averaged sound pressure level, in dB, produced in the room by the reference source.

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 $\frac{1}{2}\ \lambda_m$. The source positions should not be symmetrical 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	Minimum number of microphone positions, N_m (or microphone path length, l)	Number of equipment location 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 (IV)
$s > 3$	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 (I

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	Minimum number of microphone positions (N_m) if $1,5 < s \leqslant 3$ dB	Minimum 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 above	15	30	25

5.7 Measurement of Sound Pressure Level

The space/time-averaged 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 Measurement Duration

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

- For the frequency bands centred on or below 160 Hz, the period of observation shall be at least 30 s.
- For the frequency bands centred on or above 200 Hz, the period of observation shall be at least 10 s.

For equipment which performs repetitive operation cycles (e.g. enveloping machines), the measurement duration shall include at least three operation cycles. For equipment which performs a sequence of varying operation cycles, the measurement duration shall include the total sequence (See Note 8).

Appendix C specifies additional requirements for many types of equipment.

5.7.2 Corrections for Background Noise

When the level of the background noise is at least 15 dB below the sound pressure level at each measurement point and in each frequency band, no correction for background noise is required.

When the level of the background noise is less than 15 dB below but is more than 6 dB below the sound pressure level at each measurement point and in each frequency band, the measured sound pressure levels shall be corrected for the influence of background noise using the equation:

$$B = L_c - 10 \log (10^{0,1L_c} - 10^{0,1L_b}) \qquad (V)$$

where:

B = the correction, in dB, to be subtracted from the sound pressure level measured with the sound source operating to obtain the sound pressure level due to the sound source alone;

L_c = the measured sound pressure level, in dB, with the sound source operating;

L_b = the level of background noise alone, in dB.

When the level of the background noise is less than 6 dB below the sound pressure level at each measurement point and in each frequency band, the accuracy of the measurements is reduced and no corrections shall be applied for that band. The results may, however, be reported and may be useful in determining an upper limit to the sound power level of the equipment being tested. If such data are reported, it shall be clearly stated that the background noise requirements of this Standard have not been satisfied for that frequency band.

5.8 Measurement of the Sound Pressure Level of the Reference Sound Source

For the purpose of calculating the sound power level of the equipment, this Standard uses the comparison method of ISO 3741. This method has the advantage that it is not necessary to measure the reverberation time of the test room. The comparison method requires the use of a reference sound source with characteristics and calibration in accordance with ISO 6926. The reference sound source shall be operated, as described in its calibration chart, in the presence of the equipment being tested, and the operator, if required to operate the equipment.

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 source to the microphone traverse or array shall be in accordance with 5.6.3. The number of microphone positions or the equivalent path length shall be the same as specified for the sound pressure level measurements on the equipment. 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 in accordance with 5.7.

5.9 Calculation of Space/Time-Averaged 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 space/time-averaged 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:

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

where:

L_p = the space/time-averaged 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

5.10.1 Calculation of Band Sound Power Levels

The sound power level produced by the equipment in each octave or one-third octave band within the frequency range of interest is obtained as follows. The band sound 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 sound 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 sound power level of the equipment under test, in dB. Reference: 1 pW;

L_p = the space/time-averaged band sound pressure level of the equipment under test, in dB. Reference: 20 uPa;

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

L_{pr} = the space/time-averaged band sound pressure level of reference sound source, in dB. Reference: 20 uPa.

5.10.2 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:

$$L_{WA} = 10 \log \sum_{j=1}^{j_{max}} 10^{0,1\left[(L_W)_j + C_j\right]} \qquad \text{(VIII)}$$

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 5.

TABLE 5 - 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 6.

TABLE 6 - 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

j	One-third octave band centre frequency (Hz)	C_j (dB)
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 name, model, serial number, principal dimensions and location of sub-assemblies, where applicable).

ii) Operating conditions, including supply frequency and voltage.

iii) Installation conditions.

iv) Location of equipment in the test room.

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

vi) Location and function of an operator, if present.

5.11.2 Acoustical Environment

i) Dimensions and shape of the test room.

ii) Description of microphone array or path.

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

iv) Air temperature in °C, relative humidity in % and barometric pressure in kPa.

v) Description of diffusers or rotating vanes, if any.

5.11.3 Instrumentation

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

ii) Bandwidth of the 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 band space/time-averaged sound pressure level.

vi) Type and calibration of the reference sound source.

vii) Location and orientation of the microphone traverse or

array.

5.11.4 Acoustical Data

i) Method used for calculating the sound power levels.

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 value of the difference (L_{Wr} - L_{pr}), in dB as a function of frequency.

vi) 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 Section II of this Standard. This report shall contain at least the following information considered to be most characteristic for computers 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 band 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.

NOTE 14

For the determination of declared noise emission values, the procedures of Standard ECMA-109 shall be used.

SECTION III

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/or 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 7.

TABLE 7 - UNCERTAINTY IN DETERMINING SOUND POWER LEVELS

Octave band centre frequencies Hz	One-third octave band centre frequencies Hz	Standard deviation of the mean value 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 15

For most computer and business equipment, the A-weighted sound power level will be determined by the levels in the 250 Hz to 4000 Hz octave bands. The A-weighted sound power level is determined with a standard deviation of approximately 1,5 dB. A larger standard deviation may result when the levels in other bands determine the A-weighted level.

NOTE 16

The standard deviations given in Table 7 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 7 would indicate.

NOTE 17

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 a standard deviation which is less than that given in Table 7, provided that the measurements are performed in the same environment with the same shape of measurement surface.

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 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 18

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

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 below and preferably more than 15 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.

6.3.4 Temperature and Relative Humidity

The conditions within the measurement room shall be:

- Barometric pressure : 86 kPa to 106 kPa
- Temperature : 15 °C to 30 °C
- Relative humidity : 40% to 70%

For those units the sound pressure of which varies with temperature, the test temperature shall be 23 °C ± 2 °C.

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. The mean sound pressure level is the level of the squared 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 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. Digital integration is the preferred method.

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 19

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 20

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 measurement. 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 acoustical 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 acoustical and an electrical calibration of the instrumentation system over the entire frequency range shall be performed at intervals of not more than two years.

If a reference sound source is used it shall be checked annually to verify that its output sound power level has not changed.

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 many categories of equipment in Appendix C and shall be followed when declared noise emission values are to be determined.

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 18. 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, unless otherwise specified in Appendix C.

If the equipment being tested consists of several frames bolted together in an installation or is too large for testing purposes, the frames may be measured separately. In such circumstances, additional covers may be required for the frames during the acoustical evaluation. These additional covers shall be acoustically comparable with the other covers on the equipment. If a unit is mechanically or acoustically coupled to another unit so that the noise levels of one are significantly influenced by the other the equipment being tested shall, where practicable, include all units coupled together in this way.

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 in accordance with the manufacturer's instructions. If such information is not available, the distance shall be 0,1 m.

iii) Table-top equipment shall be placed on the floor. A resilient pad may be used only if its use is recommended in the installation specification.

iv) Table-top equipment, such as printers which typically are used 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. The measurement surface terminates on the reflecting floor.

v) Rack-mounted equipment shall be tested as floor-standing or table-top equipment, as appropriate. Rack-mounted equipment which does not include, but requires the use of, air-moving equipment (i.e. cooling-fan assemblies) when in operation shall be tested with such equipment, as supplied or recommended by the manufacturer. Rack-mounted equipment with more than one end-use enclosures may be tested and reported either as individual functional unit or as a complete system.

vi) Wall-mounted equipment shall be mounted on a reflecting (hard) wall at least 1,5 m away from any other reflecting plane, unless otherwise specified. Alternatively, if operation allows and noise emissions are not affected by orientation, the equipment may be laid on its side and attached to the reflecting floor at a sufficient distance from the walls (more than 2 m, if possible).

vii) If the equipment is usually installed by being recessed into a wall or other structure, a representative structure shall be used for mounting during the measurements.

viii) Hand-held equipment shall be supported 0,1 m above the reflecting plane by vibration-isolating elements. The supports shall not interfere with the propagation of airborne sound.

ix) A sub-assembly shall be supported 0,25 m above the reflecting plane by vibration-isolating elements. The supports shall not interfere with the propagation of airborne sound.

NOTE 21

Care shall be taken to ensure that any electrical conduits, piping, air ducts or other auxiliary equipment connected to the equipment being tested do not radiate significant amounts of sound energy into the test room. If practicable, all auxiliary equipment necessary for the operation of the equipment to be tested shall be located outside the test room and the test room shall be cleared of all objects which may interfere with the measurements.

6.5.2 Input Voltage and Frequency

The equipment shall be operated within 5% of either

- the rated voltage, or
- the average voltage of a stated voltage range (e.g. operating at 120 V for a stated range from 110 V to 130 V),

at the rated power line frequency.

Phase-to-phase voltage variations shall not exceed 5%.

6.5.3 Equipment Operation

During the acoustical measurements the equipment shall be operated in a manner typical of normal use. Appendix C specifies such conditions for many different categories of equipment.

For categories of equipment not covered by Appendix C, the test conditions used shall be described and reported.

The noise shall be measured with the equipment in both the idling and the operating modes. If several operating modes exist, the noise of each individual mode shall be determined and recorded. For equipment which in normal functional operation has several operating modes, the mode producing the highest A-weighted sound power level shall be determined, unless otherwise specified in Appendix C.

In the case of rack-mounted equipment in which the operation of several functional units is possible, the unit producing the highest A-weighted sound power level shall be operated together with those other units required for its operation. All other units shall be in the idle mode.

Some equipment does not operate continuously because of its mechanical design or its mode of operation under program control. Long periods may occur during which the equipment is idling. The operating mode measurements should not include these idling periods. If it is not possible to operate the equipment continuously during the acoustical evaluation, the time interval during which measurements have to be made shall be described in the test report.

Some equipment has operational cycles that are too short to allow reliable determination of the noise emissions. In such cases a typical cycle shall be repeated several times.

If the equipment being tested produces attention signals, such as tones or bells, such intermittent sound shall not be included in an operating mode. During the acoustical evaluation in the operating mode(s), such attention signals shall be inoperative.

The equipment shall be operated for a sufficient period of time before proceeding with the acoustical test to allow the temperature to stabilize.

6.6 Measurement Surface and Microphone Positions

6.6.1 General

The Reference Box 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. The microphone positions lie on the measurement surface, a hypothetical surface which envelops the equipment as well as the Reference Box and terminates on the reflecting plane.

For computer and business equipment the preferred measure-

ment surface is the parallelepiped with the surface area S, the sides of which are parallel to those of the Reference Box 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. The co-ordinates are given in Appendix B, Arrangements B1 and B2.

A hemisphere or a quarter-sphere of radius r may be chosen as the measurement surface, if the condition $r > 2d_o$ is met, where d_o is the distance of the farthest corner of the Reference Box from the origin of the co-ordinates. The spherical measurement surface shall have a radius of at least 1 m. The co-ordinates are given in Appendix B, Arrangements B3 and B4.

Co-axial circular paths in parallel planes for microphone traverses in free field over reflecting plane may be used. Either the microphones may be traversed around the equipment under test, or a fixed microphone array may be used and the equipment rotated. The co-ordinates are given in Appendix B, Arrangement B5.

The location of the equipment under test, the measurement surface and the microphone positions are referred to the co-ordinate system with horizontal axes x and y in the reflecting plane parallel to the length and width of the Reference Box and with the vertical axis z passing through the geometric centre of the Reference Box. The x axis points towards the front of the equipment. The origin of the co-ordinates of the microphone positions is on the floor in the centre of the plane of the Reference Box which is co-planar with the room floor.

The number and location of microphones are given in Appendix B.

NOTE 22

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.

Near air exhausts the microphone position shall be selected such that the microphone is not exposed to the air stream, alternatively a windscreen may be fitted to the microphone.

In all cases the microphones shall be oriented in such a way that the angle of sound incidence is the same as that specified by the manufacturer for the most uniform frequency response. For most practical cases this will be an orientation towards the estimated geometrical centre of the equipment.

6.6.2 Reduction in the Number of Microphone Positions

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 in accordance with the calculation procedures speci-

fied in 6.9 do not deviate by more than 0,5 dB from those determined from measurements over the entire measurement surface, microphone positions over only a portion of the measurement surface need be used.

6.6.3 Additional Microphone Positions on the Measurement Surface

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

i) the value of the difference in dB between the highest and the lowest sound pressure levels, measured at the basic microphone positions, exceeds the number of basic measurement positions,

ii) any of the dimensions of the Reference Box 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) and/or ii) apply additional microphone positions as shown in Fig. B.1 in Appendix B shall be used.

If conditions iii) or iv) apply, 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 sound pressure level shall be carried out at the microphone positions specified in 6.6 with A-weighting and for each frequency band within the frequency range of interest, if required. The following data shall be obtained:

- the A-weighted sound pressure levels and band pressure levels, if required, for the specified modes of operation of the equipment;
- the A-weighted sound pressure levels and band pressure levels, if required, produced by the background noise (including noise from support equipment).

NOTE 23

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

NOTE 24

Should spatial fluctuations occur, due to interferences or standing waves, it is recommended that the microphone be moved by approximately 0,1 d in a vertical plane around the nominal measurement position, and the mean value of the sound pressure level be recorded.

NOTE 25

When the equipment noise emissions include short-duration high-amplitude (i.e, impulsive) sounds, a sound level meter that has 1s (or "SLOW") exponential time average may be overloaded and may not provide accurate measurement of the time-average sound pressure level. When such sound is noted to be present, measurement should be made with instruments conforming to the requirements for IEC 651 Type 1 integrating-averaging sound level meters.

6.7.2 Measurement Duration

The measurement duration shall be adjusted to the operation of the equipment. For all idle or operating modes the measurement duration shall be at least 8 s for each measurement position.

For equipment which performs repetitive operation cycles (e.g. enveloping machines), the measurement duration shall include at least three operation cycles. For equipment which perform a sequence of varying operation cycles, the measurement duration shall include the total sequence. Appendix C specifies additional requirements for many types of equipment.

NOTE 26

When the measurement duration over the total sequences of operation cycles exceeds 40 s, time and spatial averaging may be performed in combination by sampling all microphones in sequence at least ten times and dwelling at each microphone each time for at least 4 s. This may be accomplished, for example, with nine microphones, a multiplexer and an integrating analyser or sound level meter. Sampling for a period longer than 4 s shall be carried out, as required, to ensure that 4 s of data at that microphone position are actually acquired and that any settling period (due to exponential averaging, for example) is excluded. Dwell duration and number of samples shall be the same for all microphones.

NOTE 27

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.

6.7.3 Corrections for Background Noise

When the level of the background noise is at least 15 dB below the sound pressure level at each measurement point and in each frequency band, no correction for background noise is required.

When the level of background noise is less than 15 dB below but more than 6 dB below the sound pressure level at each measurement point and in each frequency band, the measured sound pressure levels shall be corrected for the influence of background noise using equation (V):

$$B = L_c - 10 \log (10^{0,1L_c} - 10^{0,1L_b}) \qquad \text{(IX)}$$

where:

B = the correction, in dB, to be subtracted from the sound pressure level measured with the sound source operating to obtain the sound pressure level due to the sound source alone;

L_c = the measured sound pressure level, in dB, with the sound source operating;

L_b = the level of background noise alone, in dB.

When the level of the background noise is less that 6 dB below the sound pressure level at each measurement point and in each frequency band, the accuracy of the measurements is reduced and no corrections shall be applied for that band. The results may, however, be reported and may be useful in determining an upper limit to the sound power level of the equipment being tested. If such data are reported, it shall be clearly stated that the background noise requirements of this Standard have not been satisfied for that frequency band.

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. For laboratory quality, semi-anechoic rooms the qualification procedure of ISO 3745 may be used.

Annex A of ISO 3744 gives the detailed procedure to be followed in determining the magnitude of the environmental correction K (in dB). The allowable range for K is 0 to 2 dB. It is to be subtracted from the measured sound pressure levels (equations (X) and (XI)). If K is determined to be less than 0 dB, a value of 0 dB shall be used. If K is greater than 2 dB, the test environment is not adequate.

NOTE 28

If the environmental correction varies from microphone position to microphone position within the 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, 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 (after corrections for background noise are applied according to 6.7.3, if necessary) by using the following equation:

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

where:

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

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

N = the total number of measurements.

For A-weighted sound pressure level the symbols L_{pm} and L_{pi} are replaced by L_{Am} and L_{pAi}, respectively.

6.9.2 Calculation of Surface Sound Pressure Level, $\overline{L_{pf}}$ and $\overline{L_{pAf}}$

The band surface sound pressure levels $\overline{L_{pf}}$ and the A-weighted surface sound pressure levels $\overline{L_{pAf}}$ 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 free-field conditions over a reflecting plane by the equations:

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

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

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:

$$L_{WA} = \overline{L_{pAf}} + 10 \log \frac{S}{S_0} \qquad \text{(XIII)}$$

$$L_W = \overline{L_{pf}} + 10 \log \frac{S}{S_0} \qquad \text{(XIV)}$$

where:

L_{WA} = the A-weighted sound 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 level determined according to 6.9.2 in dB. Reference: 20 uPa.

$\overline{L_{pf}}$ = the band surface 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 name, model, serial number, principal dimensions and location of sub-assemblies, where applicable).

ii) Operating conditions, including supply frequency and voltage.

iii) Installation conditions.

iv) Location of equipment in the test environment.

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

vi) Location and function of an operator, if present.

6.11.2 Acoustical Environment

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

ii) Acoustical qualification of test environment according to ISO 3744 or ISO 3745.

iii) Air temperature in °C, barometric pressure in kPa and relative humidity in %.

6.11.3 Instrumentation

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

ii) Bandwidth of the 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.

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

6.11.4 Acoustical Data

i) The area S of the measurement surface.

ii) 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.

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

iv) The A-weighted surface sound pressure level $\overline{L_{pAf}}$ and the band surface pressure level $\overline{L_{pf}}$ for each frequency band of interest, rounded to the nearest 0,5 db. Reference: 20 uPa.

v) The A-weighted sound power level L_{WA}, in dB, and the band power level L_W for each frequency band of interest, rounded to the nearest 0,5 dB.

vi) 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.

NOTE 29

For the determination of declared noise emission values, the procedures of Standard ECMA-109 shall be used.

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, noise which contains discrete frequency components, or 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. This method of measurement does not apply to sub-assemblies.

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 8.

TABLE 8 - UNCERTAINTY IN DETERMINING SOUND PRESSURE LEVELS

Octave band centre frequencies Hz	One-third octave band centre frequencies Hz	Standard deviation of the mean value 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 30

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 power level is determined with a standard deviation of approximately 1,5 dB.

7.3 Test Environment

7.3.1 General

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

The conditions for barometric pressure, temperature and/or relative humidity specified in 6.3.1 apply.

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 8, and shall be reported.

7.3.3 Background Noise

At the microphone positions, the sound pressure levels of the background noise shall be at least 6 dB below and preferably more than 15 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.

7.4 Instrumentation

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

i) The microphone shall be stationary during the measurement except when standing waves or interference requires otherwise (see Note 32).

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

iii) 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.

iv) For detection of prominent discrete tones the instrumentation shall be in accordance with Appendix D.

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.

7.6 Microphone Positions

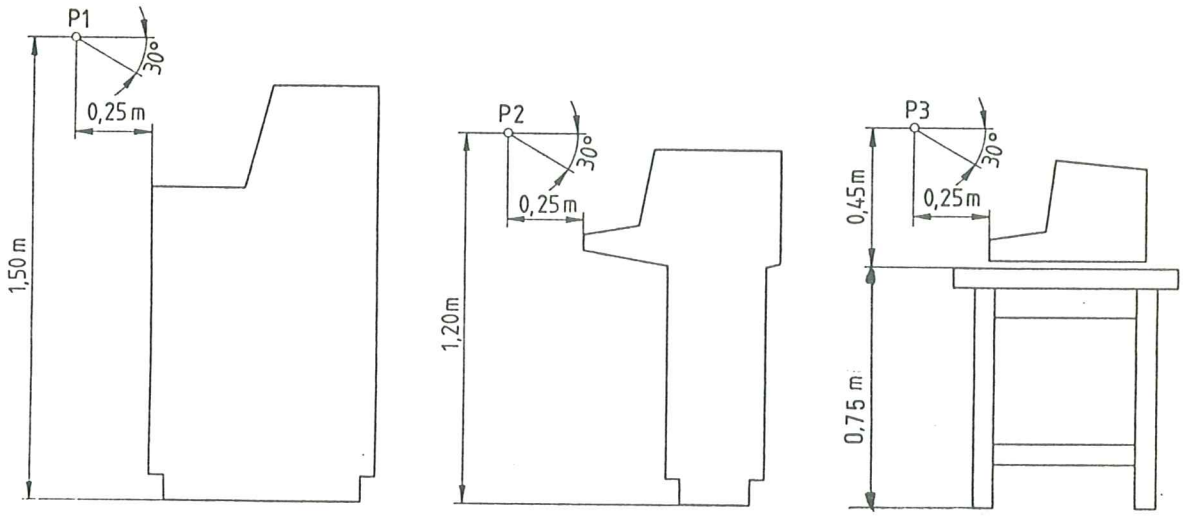
7.6.1 At the Operator Position

One or more operator positions shall be specified for equipment that requires operator attention while in the operating mode.

For equipment which is operated from a standing position, the microphone shall be located 1,50 m ± 0,03 m above the floor. For equipment which is operated from a seated position, the microphone shall be located 1,20 m ± 0,03 m above the floor. The horizontal distance from the Reference Box shall be 0,25 m ± 0,03 m unless this distance is not representative of the operator position.

NOTE 31

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.



Standing Operator

Seated Operator

FIGURE 1 - EXAMPLES OF THE MICROPHONE POSITIONS FOR STANDING AND SEATED OPERATORS

7.6.2 At the Bystander Positions

For equipment which does not require operator attention while in the operating mode, an operator position need not be defined. In this case, at least four bystander positions shall be specified. The bystander positions shall be 1,00 m ± 0,03 m away from the projections of the Reference Box on the horizontal plane and 1,50 m ± 0,03 m above the floor. The four preferred bystander positions shall be centred at the front, rear, right and left of the equipment.

If the length of any side of the Reference Box exceeds 2,0 m, it is recommended that additional bystander positions at 1,0 m intervals from the preferred positions be used.

7.6.3 Microphone Orientation

Near air exhausts the microphone position shall be selected such that the microphone is not exposed to the air stream, alternatively a windscreen may be fitted to the microphone.

The microphones shall be oriented in such a way that the angle of sound incidence is the same as that specified by the manufacturer for the most uniform frequency response. For most practical cases the microphone will be oriented 30° below horizontal (see Fig. 1).

7.7 Measurement of Sound Pressure Levels

7.7.1 General

Measurements of the sound pressure level required by this clause shall be carried out at the microphone positions specified in 7.6 with A-weighting and for each frequency band within the frequency range of interest, if required. The following data shall be obtained:

- the A-weighted sound pressure levels and band pressure levels, if required, for the specified modes of operation of the equipment;
- the A-weighted sound pressure levels and band pressure levels, if required, produced by the background noise (including noise from support equipment).

NOTE 32

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

NOTE 33

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, and the mean value of the sound pressure level be recorded.

NOTE 34

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, a precision impulse sound level meter conforming to IEC Publication 651 shall be used for the determination of both the sound pressure level and the impulse sound pressure level.

7.7.2 Measurement Duration

The measurement duration shall be as specified in 6.7.2.

7.7.3 Measurement of the A-weighted Impulse Sound Pressure Level, L_{pAI}

Aural examination of the noise emitted by the equipment under test shall be made. If the noise is considered to be impulsive the test specified in Appendix E may be performed in addition to the measurement specified in 7.7.1.

7.7.4 Detection of Discrete Tones

Aural examination of the noise emitted by the equipment under test shall be made. If the noise is considered to contain discrete tones, the test specified in Appendix D may be performed in addition to the measurement specified in 7.7.1.

7.7.5 Corrections for Background Noise

When the level of background noise is at least 15 dB below the sound pressure level at each measurement point and in each frequency band, no correction for background noise is required.

When the level of background noise is less than 15 dB below but more than 6 dB below the sound pressure level at each measurement point and in each frequency band, the measured

sound pressure levels shall be corrected for the influence of background noise using equation V:

$$B = L_c - 10 \log (10^{0,1L_c} - 10^{0,1L_b}) \quad \text{(XV)}$$

where:

B = the correction, in dB, to be subtracted from the sound pressure level measured with the sound source operating to obtain the sound pressure level due to the sound source alone;

L_c = the measured sound pressure level, in dB, with the sound source operating;

L_b = the level of background noise alone, in dB.

When the level of the background noise is less that 6 dB below the sound pressure level at each measurement point and in each frequency band, the accuracy of the measurements is reduced and no corrections shall be applied for that band. The results may, however, be reported and may be useful in determining an upper limit to the sound power level of the equipment being tested. If such data are reported, it shall be clearly stated that the background noise requirements of this Standard have not been satisfied for that frequency band.

7.7.6 Corrections for Unwanted Reflections

No corrections are permitted.

7.8 Calculation of the Mean Value of the Sound Pressure Levels at the Bystander Positions

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_{pAi} at the bystander positions (after corrections for background noise are applied according to 7.7.5, if necessary) by using the equation:

$$\overline{L_{pA}} = 10 \log \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0,1L_{pAi}} \right] \quad \text{(XVI)}$$

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

where:

$\overline{L_{pA}}$ = the mean value of the A-weighted sound pressure level from the bystander positions in dB. Reference: 20 uPa.

$\overline{L_{p}}$ = the mean value of the band sound pressure level averaged from the bystander positions in dB. Reference: 20 uPa.

L_{pAi} = the A-weighted sound pressure level resulting from the measurement at the i-th bystander position in dB. Reference: 20 uPa.

L_{pi} = the band sound pressure level resulting from the measurement at the i-th bystander positions in dB. Reference: 20 uPa.

N = the total number of measurements.

7.9 Information to be Recorded

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

7.9.1 Equipment under Test

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

ii) Operating conditions, including supply frequency and voltage.

iii) Installation conditions.

iv) Location of equipment in the test environment.

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

vi) Location and function of an operator, if present.

7.9.2 Acoustical Environment

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

ii) Acoustical qualification of test environment according to ISO 3744 or ISO 3745.

iii) Air temperature in °C, barometric pressure in kPa and relative humidity in %.

7.9.3 Instrumentation

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

ii) Bandwidth of the 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.

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

7.9.4 Acoustical Data

i) 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, where applicable.

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

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

7.10 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(s) is defined, the A-weighted sound pressure level, expressed in dB, for operating and idle modes, rounded to the nearest decibel.

iii) If bystander positions are defined, the mean value of the A-weighted sound pressure level, expressed in dB, for operating and idle modes, rounded to the nearest decibel (see equation XIV).

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

The above information may be supplemented by 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

NOTE 35

For the determination of declared noise emission values, the procedures of Standard ECMA-109 shall be used.

APPENDICES

APPENDIX A : TEST ACCESSORIES

APPENDIX B : MEASUREMENT SURFACES

APPENDIX C : EQUIPMENT CATEGORY

APPENDIX D : IDENTIFICATION OF PROMINENT DISCRETE TONES

APPENDIX E : DETECTION OF IMPULSIVE SOUND PRESSURE LEVELS

APPENDIX F : MAIN DIFFERENCES BETWEEN THE FIRST AND THE SECOND EDITION

APPENDIX A

TEST ACCESSORIES

A.1 STANDARD TEST TABLE

A suitable design for a Standard Test Table is shown below. The top of the table shall be of bounded laminated wood 0,10 m thick, having a minimum area of 0,5 m^2 and a minimum lateral dimension of 0,7 m. The height of the Standard Test Table shall be 0,75 m.

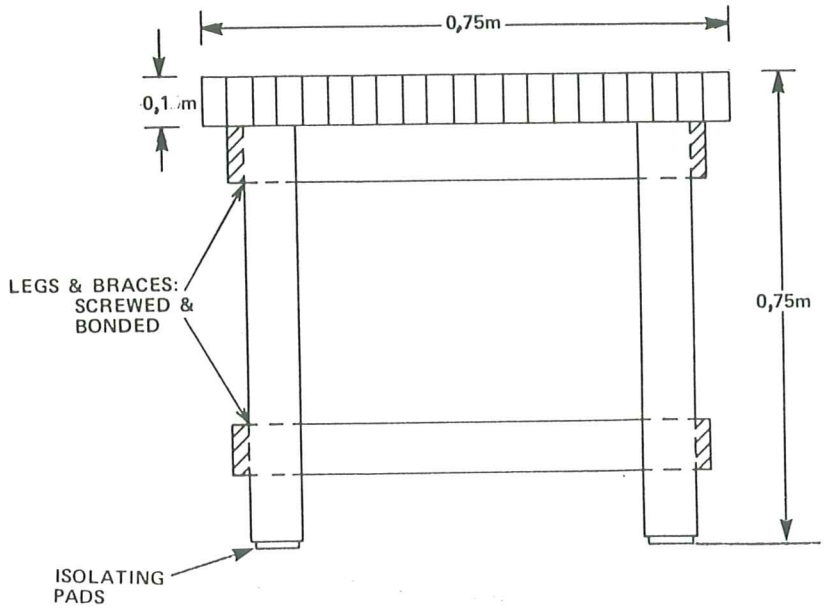


Figure A.1

A.2 TYPING ROBOT

The typing robot shall be designed to operate a keyboard in the manner specified in this Standard. The robot here described uses 8 solenoids, each being individually adjustable to operate one of the selected keyboard keys.

The requirements for this robot are:

- the noise of the robot shall meet the requirements for background noise of this Standard.
- The stroke of each solenoid plunger shall fully release the key in its upper position and push it completely down to its stop a total stroke of 6 mm to 7 mm should be sufficient for many types of keyboards including typewriters.
- The electrical input signal shall be a rectangular pulse of 50 ms duration, and of adjustable amplitude.
- The solenoid characteristics shall provide an increasing force during key-down motion, as shown in Figure A.2. A suitable design is shown in Figure A.3.
- The plunger mass shall be 20 g ± 1 g, its end shall be soft (e.g. closed-cell foam, 40 Shore A).

A complete operation of a single key includes the following three steps, which are shown in Figure A.4:

1. Home position S_a

   The plunger rests under its own weight with its soft end on the key.

2. Key operation

   When excited by the solenoid, the plunger pushes the key down until it has reached its stop position S_e. The adjustment of the solenoid should give a plunger clearance of 1 mm; an appropriate mark at the upper plunger end will facilitate this adjustment.

3. Key return

   The plunger is returned only by the key spring. The plunger return stop shall be soft and allow a maximum overshoot of 0,5 mm; the plunger returns to its home position, resting on the key.

Note A.1

The specification is based on the design of the robot described in "Geräuschemission von Geräten der Büro- und Informationstechnik" Schriftenreihe der Bundesanstalt für Arbeitsschutz Fb 481 Bd. 1 Wirtschaftsverlag NW, Verlag für neue Wissenschaft GmbH, (Postfach 101110, D-2850 Bremerhaven 1, Germany).

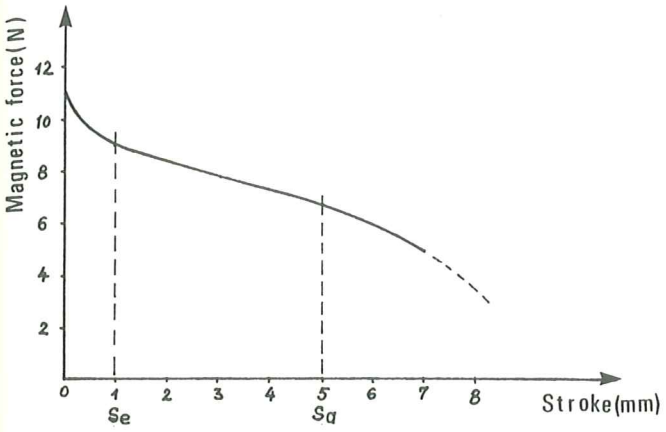


Figure A.2 - Solenoid Characteristics for a plunger stroke of 4 mm

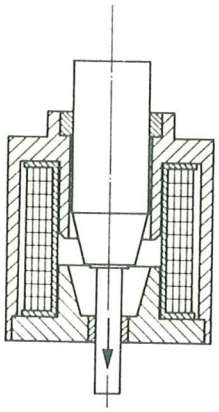
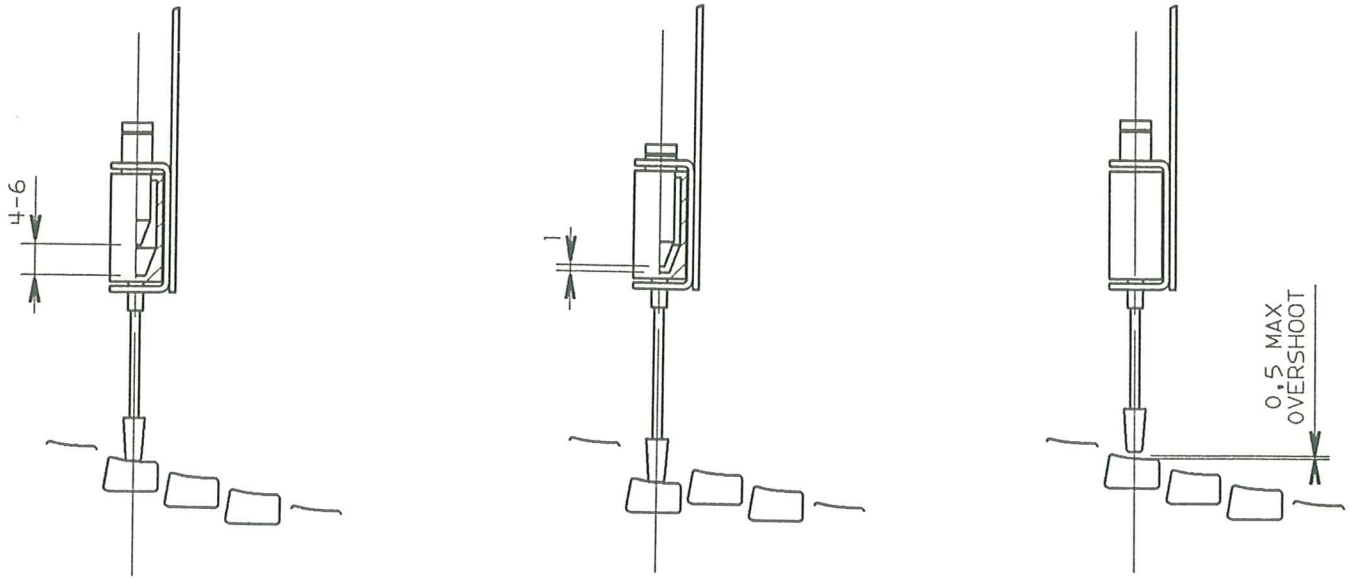


Figure A.3 - Solenoid Cross Section



Step 1.
Home Position

Step 2.
Key Operation

Step 3.
Key Return

Figure A.4 - Individual Steps of the Solenoid Operation
Dimensions in mm.

APPENDIX B

MEASUREMENT SURFACES

For computer and business equipment the preferred measurement surface is the parallelepiped with the surface area S, the sides of which are parallel to those of the Reference Box 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.

A hemisphere or a quarter-sphere of radius r may be chosen as the measurement surface, if the condition $r > 2d_o$ is met, where d_o is the distance of the farthest corner of the Reference Box from the origin of the co-ordinates. The spherical measurement surface shall have a radius of at least 1 m.

Co-axial circular paths in parallel planes for microphone traverses in free field over reflecting plane may be utilized. Either, the microphones may be traversed around the equipment under test, or a fixed microphone array used and the equipment rotated.

B.1 ARRANGEMENT B.1

Parallelipipedal Measurement Surfaces

The number of measurement positions depends on the size of the equipment.

For the conditions :

$L_1 < 2d$

$L_2 \leqslant 2d$

microphone positions No 1 to 9 shall be used, unless the numerical difference between the maximum and minimum A-weighted sound pressure levels measured at microphone positions No 1 to No 9 exceeds 9 dB. Then the number of microphone positions shall be encreased to 17.

For the conditions :

$L_1 > 2d$

$L_2 \leqslant 2d$

microphone positions No 1 to No 15 shall be used, unless the numerical difference between the maximum and minimum A-weighted sound pressure levels measured at microphone positions No 1 to No 9 exceeds 9 dB. Then the number of microphone positions shall be encreased to 17.

For the conditions :

$L_1 > 2d$

$L_2 > 2d$

microphone positions No 1 to No 17 shall be used.

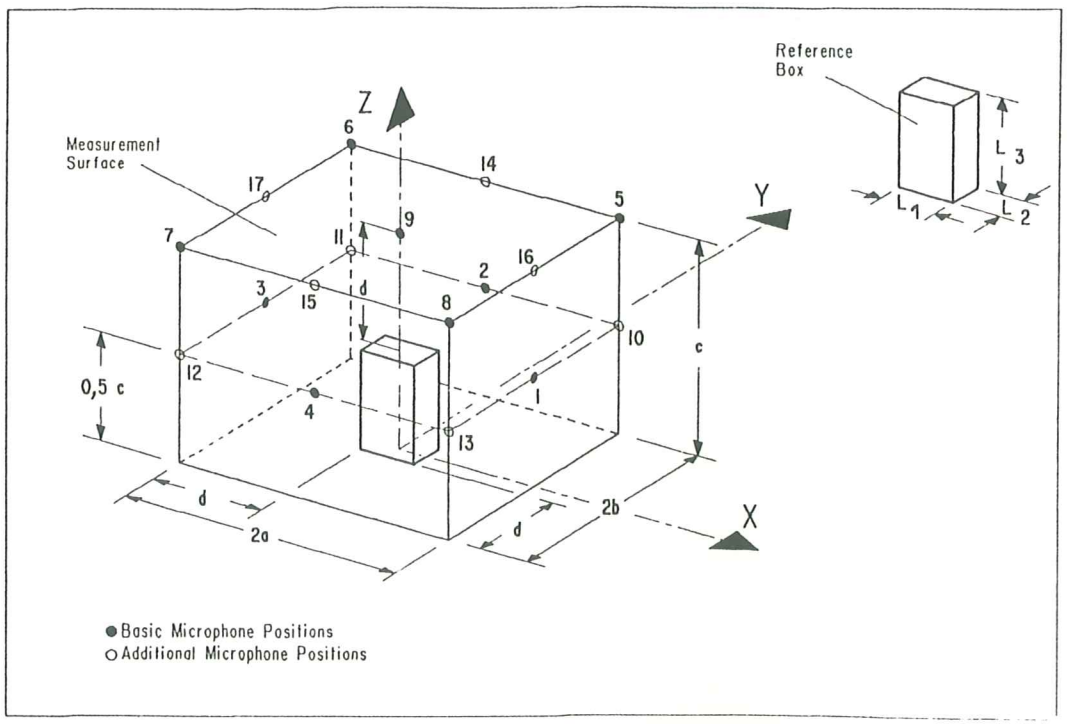


Figure B.1 - Measurement Surface

Position		x	y	z
Basic positions	1	a	0	c/2
	2	0	b	c/2
	3	-a	0	c/2
	4	0	-b	c/2
	5	a	b	c
	6	-a	b	c
	7	-a	-b	c
	8	a	-b	c
	9	0	0	c
Add'l positions	10	a	b	c/2
	11	-a	b	c/2
	12	-a	-b	c/2
	13	a	-b	c/2
	14	0	b	c
	15	0	-b	c
	16	a	0	c
	17	-a	0	c

Area of the Measurement Surface :

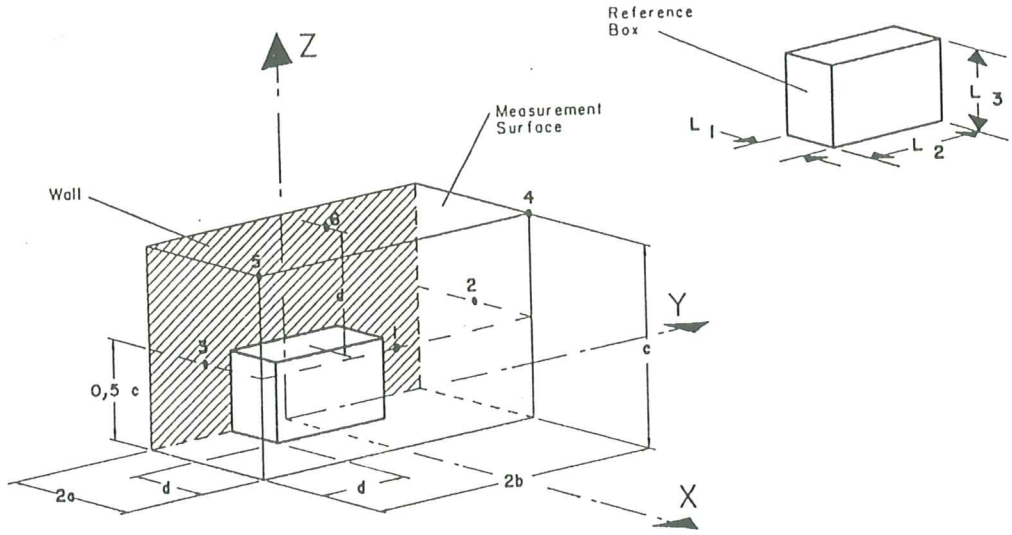
$$S = 4 \times (ab+bc+ca)$$

Table B.1 - Coordinates of the Microphone Positions

B.2 ARRANGEMENT B.2

Parallelipipedal Measurement Surface for Equipment in Front of a Wall

For this arrangement the Reference Box extends to the wall.



- Microphone Positions

Figure B.2 - Measurement Surface for Equipment in Front of a Wall

Position	x	y	z
1	2 a	0	$\frac{1}{2}$ c
2	a	b	$\frac{1}{2}$ c
3	a	-b	$\frac{1}{2}$ c
4	2 a	b	c
5	2 a	-b	c
6	a	0	c

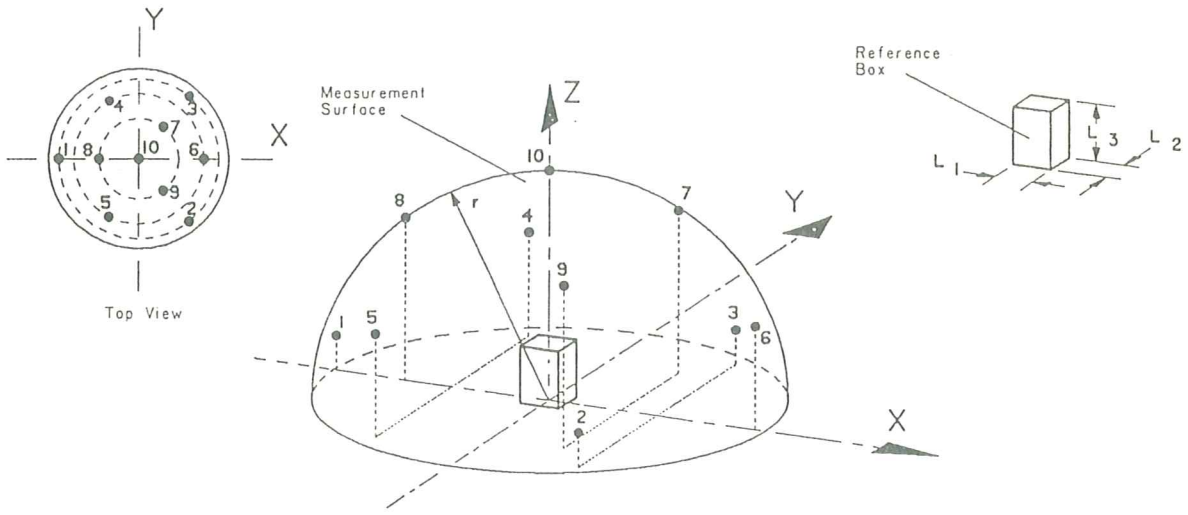
Measurement Surface Area S = 2 (2ab+2ac+bc)

Table B.2 - Coordinates of Microphone Positions

B.3 ARRANGEMENT B.3

Hemispherical Measurement Surface, 10 Measurement Positions

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



● Microphone Positions

Figure B.3 - Hemispherical Measurement Surface - 10 Measurement Positions

Position	x/r	y/r	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

Table B.3a - Coordinates of Microphone Positions for Equipment Not Emitting Discrete Tones

If the equipment emits 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 spiral microphone array with the coordinates given in Table B.3b is recommended.

Position	x/r	y/r	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

Table B.3b - Coordinates of Microphone Positions for Equipment Emitting Discrete Tones

B.4 ARRANGEMENT B.4

Quarter-Sphere Measurement Surface, 5 Measurement Positions

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

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.

B.5 ARRANGEMENT B.5

Coaxial Circular Path in Parallel Planes in a Field over a Reflecting Plane.

In this arrangement either the microphones or the equipment may be rotated. Each path is associated with a zone of the hemisphere. These zones have the same height 0,2 r and thus the same spherical surface area $2\pi r^2$.

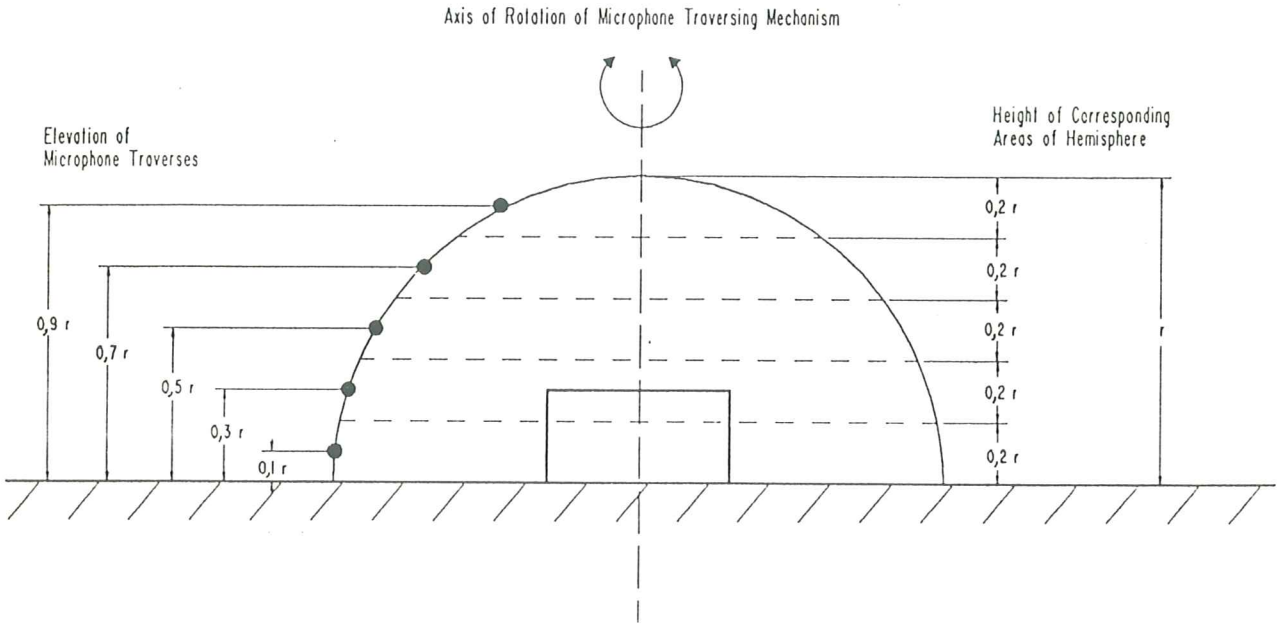


Figure B.4 - Hemispherical Measurement Surface - Circular Paths

APPENDIX C

EQUIPMENT CATEGORY

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 operations). Typewriters which are equipped with a full-page storage are considered as typewriters during a 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. For measurements according to Section III, the measurement surface terminates on the extended top plane of the Standard Test Table. Alternatively, the typewriter may be placed on a hard reflecting floor. The condition used 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 70 g/m^2 to 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 C.1).

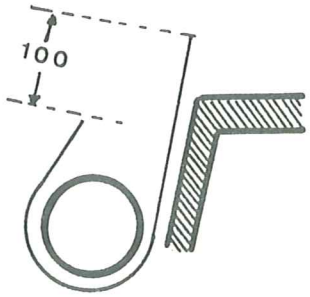


Figure C.1 - Insertion of single sheet paper

C.1.3 Operation

Idle Mode

Power on and ready for information entry and/or print-out. Paper inserted according to Fig. C.1.

Typing Mode

The following settings, when applicable, shall be used:

Impression control

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

Multi-copy control

Set of 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 C.1:

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

etnaiv etnaiv etnaiv etnaiv...

and so on until a full printline of approximately 60 characters is completed. The space between each group of six characters is intentional.

Note C.2:

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

Note C.3:

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

Operating speed

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

Note C.4:

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 operations: 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 (maximum one line) at nominal printing speed is required.

C.1.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2 during the following operations:

- Manual typing: measure during continuous typing over at least 3 full lines.
- Interactive operations: measure during keying-in and print-out 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 band-printers, printwheel, 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 such 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 on the hard reflecting floor.

Type font

If the printer allows the use of different type fonts, type elements or colour, a single type font, pitch and colour typical for normal use shall be selected. If available a pitch of 10 characters per 25,4 mm 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 printers; 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 24 hours 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 - except when the printer characteristics restrict the available line length.

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 spaces. The format should preferably be shifted from line to line.

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

Note C.5:

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 ans small letters, that 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 between margins
40 - 59	20 characters
60 - 110	30 characters
> 110	40 characters

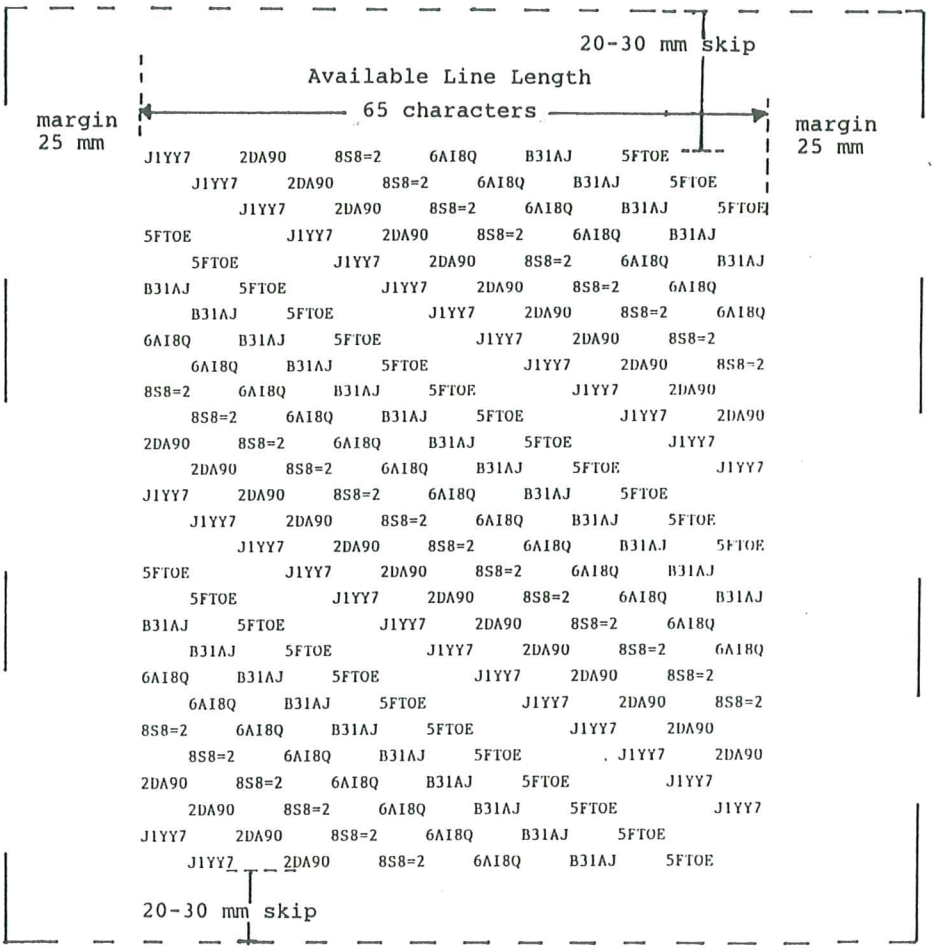


Figure C.2 - Example of the test Pattern for a Line Length of 65 Characters

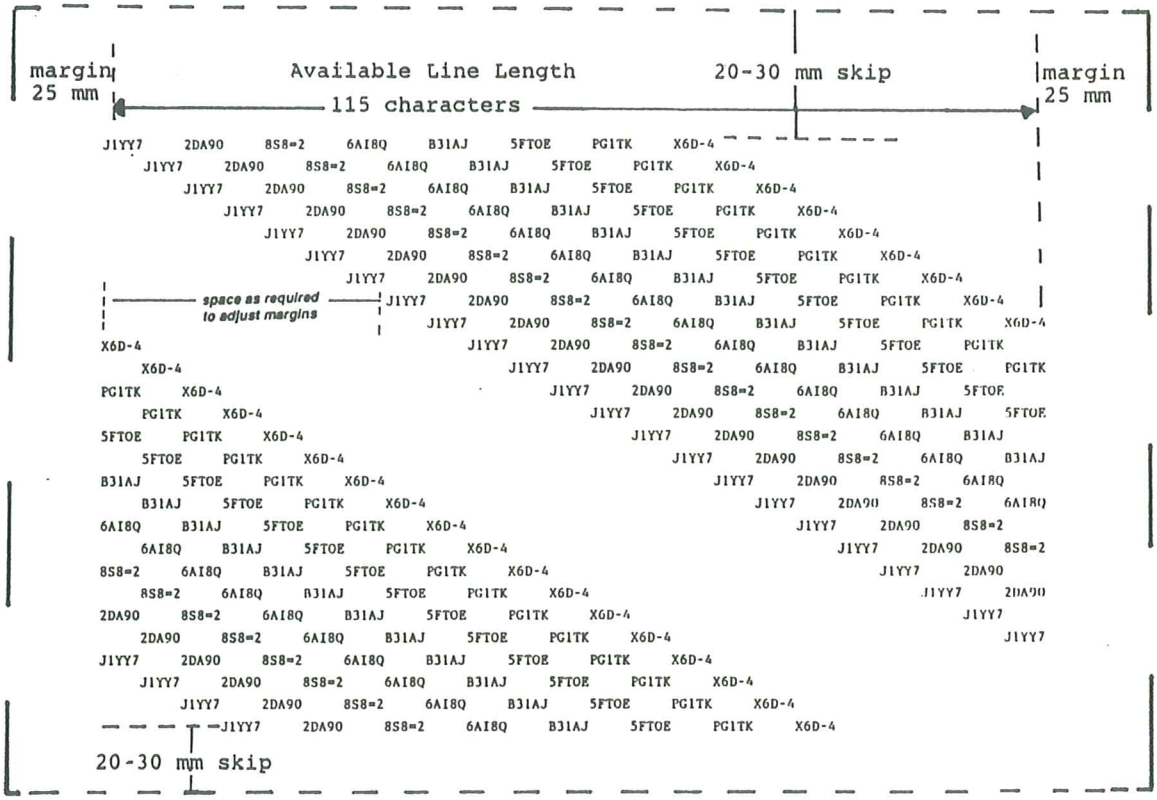


Figure C.3 - Example of the test Pattern for a Line Length greater than 110 Characters

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 time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2 during the following operations:

- 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 continuous 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 - KEYBOARDS

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. Alternatively, the keyboard may be placed on the hard reflecting floor. The condition used shall be reported.

C.3.3 Operation

i) Operation Mode

The keys can be operated manually or by a typing robot.

The typing speed shall be 5 char./s. The stroke has to be adjusted so that the key just touches its stop. If the keyboard has an adjustable acoustical feedback, it shall be set to its minimum volume.

Note C.6:

Keying-in may be performed with the typing robot of Appendix A.2. 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 acoustical feedback this should be reported.

ii) Test pattern

For alphanumeric keyboards the test pattern is that specified in C.1.3. For numeric keyboards the test pattern is:

4 digits plus a function key

Note C.7:

It is possible to generate this latter pattern with one hand. The selected keys shall be reported.

C.3.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2.

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 or 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 immedi-

ately 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 auxiliary unit which produces noise: (paper tape punch/reader, magnetic tape disk 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 operations 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 the transmission rate at which it is intended to be used for the majority of applications. 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 typewriter (C.1.4).

For automatic operation of the teleprinter, see the requirements for printers (C.2.4).

C.5 EQUIPMENT CATEGORY - DUPLICATORS

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 do not take paper from, or stack paper on, the floor, shall be placed on the reflecting floor.
- Table-top duplicators, which 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.
- 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 24 hours 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.

i) Sorting

The operation shall start with an empty sorter. An operation cycle shall comprise the sorting of one copy in one bin. Copies made during additional operation cycles shall be sorted into consecutive bins.

ii) Stacking

If the duplicator is equipped with accessory or integral mechanism to separate copy sets generated sequentially, an operation cycle shall comprise one copy each of two masters.

iii) Automatic stapling

If the sorter or stacker has an integral automatic stapling device, an operation cycle shall comprise consecutive duplication of five masters and stapling of the set of five sheets.

iv) Automatic master loading

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

v) Two-side printing

An operation cycle shall comprise the printing of both sides of one master each on one side of the sheet or of two masters each on one side of the sheet.

vi) Duplication on continuous stationery

An operation cycle shall comprise duplication of one master on ten pages for folded stationery or a 2-meter length for rolled stationery.

vii) Full system operation

When a copying/duplicating system combines several features, a full system operation cycle shall comprise the use of each of the features at least once as described under their respective operation cycle.

C.5.5 Measurement duration

The time-averaged sound pressure level shall be measured for at least five operation cycles and for at least the duration specified in 5.7.1 and 6.7.2.

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 the 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 C.8:

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 spaces:

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

C.6.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2 during the following operation:

Process a random card deck of at least 10 cards.

C.7 EQUIPMENT CATEGORY - MAGNETIC TAPE STORAGE UNITS

C.7.1 Description

Equipment for data storage employing magnetic tape would 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 - command timing for capstan (or equivalent) operation shall be determined as follows:

The capstan on-time in ms is set at the time needed to pass 130 mm of tape at the rated tape speed, given by:

$$\frac{130}{\text{rated tape speed in m/s}} \quad \text{ms}$$

rounded-off to the nearest whole millisecond.

Note C.9:

130 mm of tape corresponds to a block length of 4096 bytes at 32 bpmm. Higher densities should use correspondingly larger block sizes, such that the total on-time for all density machines will be approximately equal. At 63 bpmm, use a block length of 8192 bytes; at 246 bpmm, use a block of 32768 bytes.

ii) Streaming mode

Forward run while writing.

C.7.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2 during the following operations:

Operation mode

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 - RIGID DISK STORAGE UNITS

C.8.1 Description

Equipment for data storage employing one or more rotating magnetic or optical 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 from and respond to, to control line commands. In multiple drive units all drives shall be loaded and ready.

Operating modes

Read/Write mode

Random selection of the tracks or cylinders to be sought. Read or write all sectors of each track sought out. No intentional delay at any track after reading/writing has been finished.

C.8.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2 during the following operations:

Idle mode

Measure during the prescribed time.

Operating mode

Read/Write mode

Measure for at least 20 seeks.

C.9 EQUIPMENT CATEGORY - MAGNETIC FLEXIBLE DISK CARTRIDGE UNITS

C.9.1 Description

Equipment for data interchange employing one removable rotating flexible disk enclosed in a jacket or a case. A unit may contain one or more separately operable disk drives.

C.9.2 Installation

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

C.9.3 Operation

Idle mode

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

Operating mode

Read/Write mode

Random selection of the tracks or cylinders to be sought. Read or write all sectors of each track sought out. No intentional delay at any track after reading/writing has been finished.

C.9.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2 during the following operations:

Idle mode

Measure during the prescribed time.

Operating mode

Read/Write mode

Measure for at least 20 seeks.

C.10 EQUIPMENT CATEGORY - ELECTRONIC UNITS

C.10.1 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.10.2 Installation

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

C.10.3 Operation

Steady state operation with normal load on all cooling devices, power supplies, and distributed power supply elements. No data operations are required. For electronic units the idle and operating modes are deemed to be the same.

C.10.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2.

C.11 EQUIPMENT CATEGORY - CHEQUE PROCESSORS

C.11.1 Description

Equipment of this category may perform a single function such as printing (or encoding) information onto cheques, reading information from cheques, printing lists, storing/retrieving information from a flexible disk cartridge, or sorting cheques.

C.11.2 Installation

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

C.11.3 Operation

Idle mode

Power-on and ready for use (i.e. stand-by mode).

Operating Mode

When a copying/duplicating system combines several features, a full system operation cycle shall comprise the use of each

of the features at least once as described under their respective operation cycle.

Reading mode

Random alpha-numeric data shall be read from the cheques in this mode and any additional operations which typically form part or are a result of this mode shall be performed (e.g. autofeed, listing, storing on flexible disk cartridge and sorting cheques). Repeat read cycles shall be performed at a rate typical of that expected in use.

Printing (or encoding) mode

Equipment of the type described in this category will in some cases contain a number of print mechanisms within one piece of equipment. The equipment shall be operated in a manner most typical of the expected use, with all print mechanisms operating in the proper sequence. Any additional operation which typically form part or result from this mode of operation shall be performed (e.g. autofeed, listing, storing on flexible disk cartridge and sorting cheques). The information to be printed by each type of printing mechanism (where appropriate) is defined in the table below.

Repeat print cycle shall be performed at a rate typical of that expected in use.

PRINTER TYPE	CHARACTERS TO BE PRINTED Print Details
Encoder	*0000000085124* (amount field only)
Program. Endorser	J1YY7 2DA90 8S8=2 6AI8Q
Fixed Endorser	any character

Printing (listing) mode

Repeat cycles of the character pattern shown below shall be printed at a rate typical of that expected in use. The full content of a 40-character pattern is given; if the line contains fewer characters, the left most ones shall be used.

The character shall be arranged in groups of five followed by five spaces and each subsequent line shall be rotated five spaces to the right.

J1YY7 2DA9O 8S8=2 6AI8Q B31AJ 5FTOE PG1TK X6D-4

Any additional operations which typically form part or are a result of this mode shall be performed.

Storing/Retrieving from disk mode

Consecutive seeks to a random track. Any additional operations which typically form part or are a result of this mode shall be performed.

Sorting Mode

The cheques shall be sorted sequentially from the lowest numbered pocket to the highest numbered pocket and this sort pattern repeated as necessary for the duration of the measurement period.

C.11.4 Paper

i) Cheque stock

In typical use a large variety of cheque sizes and paper weights are used. To allow a standard method the following specification defines the properties of the cheques to be used.

Length : 150 mm
Height : 75 mm
Grammage : 95 g/m^2

ii) Printer paper

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

C.11.5 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2 during the following operation:

Idle Mode

Operating Mode

The measurement duration shall be at least that of eight complete operation cycles.

C.12 EQUIPMENT CATEGORY - VISUAL DISPLAY UNITS

C.12.1 Description

Equipment which displays information on a screen, and which may be equipped with a keyboard for information entry. The keyboard may be fixed to the display or connected via a cable.

Note C.10:

The units in this categories may emit significant noise in the 16 kHz octave band. In this case, A-weighted levels should be calculated from octave or one-third octave band measurements. See Standard ECMA-108.

C.12.2 Installation

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

C.12.3 Operation

Idle mode

Power shall be switched on; the equipment shall be in a steady-state condition, with air-moving device(s) running and full character set displayed on the screen i.e. all positions on screen used. (Noise due to keyboard operation

shall not be included).

Typing mode

The typing mode consists of keying-in the information specified for keyboards (see C.3).

C.12.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2.

C.13 EQUIPMENT CATEGORY - MICROFILM READERS

C.13.1 Description

Equipment to display micro-photographs. Microfilm readers may differ from each other, depending on the different types of microforms to be used, such as microfiche, aperture cards and rollfilm.

C.13.2 Installation

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

C.13.3 Operation

Idle mode

Power shall be switched on; on the equipment shall ready for display.

Operating mode

The microform shall be inserted and the micro-photograph adjusted and displayed.

The following two operations may be performed partly or fully automated:

- Equipment for microfiche and aperture cards: the micro-photograph shall be adjusted in two diagonal corners by moving its support; a photograph shall be kept stationary.
- Equipment for rollfilm: full reel of microfilm shall be inserted into the device; the photograph approximately in the middle of the film shall be sought and adjusted.

C.13.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2.

C.14 EQUIPMENT CATEGORY - PERSONAL COMPUTERS AND WORK STATIONS

C.14.1 Description

Small systems such as personal computers, work stations and work processors, which include a keyboard, visual display unit, and a processor unit which itself may contain combinations of one or more flexible disk and/or rigid drives, magnetic tape units or printers.

Note C.11

Some units in this category may emit significant noise in the 16 kHz octave band. In this case, A-weighted levels should be calculated from octave or one-third octave band levels in accordance with ECMA-108.

C.14.2 Installation

The constituent units of the system may be tested individually and reported accordingly. In this case the installation conditions are as in 5.5.1, 6.5.1 and the relevant clauses of Appendix C of this Standard.

Alternatively the equipment may be tested as a complete system. In this case for the measurement of sound power levels the equipment shall be mounted on the hard reflecting floor and the orientation used recorded.

For the measurement of bystander and/or operator sound pressure levels, the separate enclosures shall be arranged in a set-up that is typical of actual use. Table top equipment shall be tested on the Standard Test Table. If some of the separate enclosures are floor-standing equipment and others are table-top equipment, the floor-standing equipment shall be installed next to the Standard Test Table on the left or right of the table and the table-top equipment installed on the Standard Test Table.

C.14.3 Operation

Operation of the equipment shall be in accordance with 5.5.3 and 6.5.3 of this Standard for the following modes of operation.

Idle Mode

Power shall be switched on, the equipment shall be in a steady state condition, with air moving device(s) running, disk drives in the idle mode, a full character set displayed on the screen and all other devices idling. Noise due to keyboard operation shall not be included.

Operating Mode(s)

One or more of the following operating modes shall be used where applicable :

Equipment with flexible disk drives as C9.

Equipment with rigid disk drives as C8.

In combinations of rigid and flexible disk drives the operating mode giving the highest level shall be used.

Equipment with magnetic tape units as C7.

Equipment with built in printers as C2.

C.14.4 Measurement Duration

The time-average sound pressure level shall be measured for at least the duration specified in 5.7.1 and 6.7.2

APPENDIX D

IDENTIFICATION OF PROMINENT DISCRETE TONES

D.1 GENERAL

This Appendix describes a procedure for determining whether or not noise emissions include prominent discrete tones.

The method of this Appendix is primarily applicable to operator-attended equipment. However, the methods may be applied to other equipment that is intended to be installed in low-noise areas.

D.2 BACKGROUND

A discrete tone which occurs in a broadband noise is partially masked by the noise contained in a relatively narrow frequency band, called the critical band, that is centred at the frequency of the tone. Noise at frequencies outside the critical band does not contribute significantly to the masking effect. The width of a critical band is a function of frequency (see D.6). In general, a tone is just audible when the sound pressure level of the tone is about 4 dB below the sound pressure level of the masking noise contained in the critical band around the tone. For the purposes of this Appendix, a discrete tone is defined as being prominent if the sound pressure level of the tone exceeds the sound pressure level of the masking noise in the critical band by 6 dB. This corresponds, in general, to a tone being prominent when it is more than 10 dB above the threshold of audibility.

D.3 MICROPHONE POSITION

The measurements shall be performed at the operator position, or, if none, at the bystander position with the highest A-weighted sound pressure level. If there is more than one operator position, the measurements shall be performed at the operator position with the highest A-weighted sound pressure level.

D.4 INSTRUMENTATION

The information contained in this Appendix is sufficiently complete to allow the identification of prominent discrete tones to be made using a variety of measurement equipment, and, therefore, no specific type of instrumentation is prescribed. The instruments shall meet the requirements of 6.4.1, 6.4.2, 6.4.3 and 6.4.5 However, the procedure of this Appendix requires the measurement of

- the sound pressure level of the tone, and
- the sound pressure level of the noise in the critical band centred at the frequency of the tone.

The instrumentation used should be capable of determining these levels with a tolerance of 1 dB. Commercially available or specially designed analog or digital instruments may be used to measure the levels directly, or raw data may be acquired and then processed by a digital computer. To measure the sound pressure levels, a narrow band analysis shall be performed with the analyser frequency bandwidth resolution less than one per cent of the frequency of the tone.

D.5 MEASUREMENT PROCEDURE

Aural examination of the noise emitted by the equipment under test shall be made at the microphone position. If one or more discrete tones are audible, the procedure described below shall be followed for each tone.

In cases where there is doubt whether audible tones are present or not, the benefit of other, more objective, evidence should be sought (such as a narrow-band analysis of the noise).

The sound pressure level (in dB) of the discrete tone L_t, and the sound pressure level (in dB) of the masking noise L_n, exclusive of the tone, contained within the critical band centred at the frequency of the tone, shall be determined. When band-pass filters are used and the band sound pressure levels are measured, care must be taken to ensure that the measurement of the masking noise is not corrupted by the tone, and vice versa. The tone-to-noise ratio (in dB) is then taken as $(L_t - L_n)$.

NOTE D1

Since the tone-to-noise ratio is a difference in levels, absolute calibration of the instrumentation is not necessary; relative levels may be used.

NOTE D2

When working with linear quantities, the mean square sound pressure of the tone W_t, and the mean square sound pressure of the masking noise W_n, are determined, and the tone-to-noise ratio is taken as (W_t/W_b). Since this is a dimensionless ratio, absolute calibration of the instrumentation is necessary.

D.6 CRITICAL BANDWIDTHS

The width of the critical band Δf_c, centred at any frequency f, can be calculated from the following equation.

$$\Delta f_c = 25{,}0 + 75{,}0 \left[1{,}0 + 1{,}4 (f/1000)^2 \right]^{0{,}69}$$

e.g. $\Delta f_c = 162{,}2$ Hz for $f = 1$ kHz

For the purpose of determining the value of L_n, the critical band is modeled as a rectangular filter with centre frequency f_0, lower band edge frequency f_1, and upper band edge frequency f_2, where

$$f_1 = f_0 - \Delta f_c/2$$

and

$$f_2 = f_0 + \Delta f_c/2$$

D.7 PROMINENT DISCRETE TONES

A discrete tone is identified as prominent if

$$(L_t - L_n) \geqslant 6{,}0 \text{ dB}$$

NOTE D3

When working with linear quantities, the above criterion corresponds to $(W_t/W_n) \geqslant 4{,}0$.

D.8 MULTIPLE TONES IN A SINGLE CRITICAL BAND

The noise emitted by a machine may contain many tones; several of these may fall within a single critical band. There are no special techniques required to deal with this situation. Those tones that are individually audible are identified and the procedure above followed for each tone. For the purposes of this Appendix, other tonal components that are contained within the critical band around the primary tone being evaluated are considered part of the masking noise, and are included in the determination of the masking noise level L_n.

D.9 COMPLEX TONES CONTAINING HARMONIC COMPONENTS

A machine may emit a complex tone comprising a series of harmonic components (partials) at integral multiples of some fundamental frequency. Although several peaks may occur in a narrow-band spectrum of such noise emissions, the tone complex is usually perceived as having a single pitch. For the purposes of this Appendix, when an audible discrete tone comprises two or more harmonic components, only that component with the highest A-weighted sound pressure level need be evaluated. If the criterion in D.7 is met for that component, the discrete tone shall be identified as prominent.

APPENDIX E

DETECTION OF IMPULSIVE SOUND PRESSURE LEVELS

E.1 SCOPE

This Appendix provides an objective test method for determining whether the noise emissions are impulsive in character, viz. are of short duration and relatively high amplitude.

This method is primarily applicable to operator-attended equipment with non-steady noise emissions.

E.2 INSTRUMENTS

The instruments shall meet the requirements of 6.4. The sound level meter shall be equipped with the IMPULSE meter characteristic.

E.3 MICROPHONE POSITION

The measurements shall be performed at the operator position, or, if none, at the bystander position with the highest A-weighted sound pressure level. If there is more than one operator position the measurements shall be performed at the operator position with the highest A-weighted sound pressure level.

E.4 MEASUREMENTS

Aural examination of the noise emitted by the equipment under test shall be made at the microphone position described above. If the noise emissions are perceived to include impulsive sound, the following test shall be performed.

The A-weighted impulse sound pressure level, L_{pAI}, shall be measured for the same mode(s) of operation and measurement conditions as used for the measurements in 7.5 to 7.7. 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 impulsive parameter, ΔL_I. If $\Delta L_I \geqslant 3$ dB the noise is considered to be impulsive.

The A-weighted impulse sound pressure level, L_{pAI}, is used only to determine whether the noise emissions are impulsive. The impulsive parameter ΔL_I is zero for steady, non-impulsive noises, and increases in value with increasing impulsiveness of the noise.

If the impulse sound level is recorded, the DC level output of the impulse sound level meter shall be used. The dynamic response of the recorder shall be such that it will respond to at least 90% of full scale for a rectangular pulse the duration of which is 0,2 s.

APPENDIX F

MAIN DIFFERENCES BETWEEN THE FIRST AND SECOND EDITIONS

F.1 SCOPE

This Appendix lists the main differences between the 1st and the 2nd edition of ECMA-74.

The Standard was rewritten to take into account:

- experience gained by the use of the 1st edition,
- experience from the preparation of ISO 7779,
- experience from the publication of ANSI S12.10-1985,
- experience from the preparation of Standards ECMA-108 and 109,
- the results of laboratory research on the test methods, particularly with respect to the detection of discrete tones and impulsive sound, performed by the members of TC26 and other organizations.

F.2 MAIN DIFFERENCES

F.2.1 General

References to more recent Standards ECMA-108, ECMA-109 and ECMA TR/27 have been added.

Many paragraphs have been reworded for consistency with ISO 7779.

In section II, III and IV, the corrections for background levels now use a formula in place of tabulated values.

F.2.2 Section II: Methods for Determining Sound Power Levels in Reverberation Rooms

The section using the Direct Method has been deleted.

For the Comparison Method, the formulae for calculating the measuring distance and the number of source locations have been amended to eliminate the use of the reverberation time.

F.2.3 Section III: Method for Determining Sound Power Levels under essentially free-field conditions over a reflecting plane

All microphone arrays are now described in Appendix B.

F.2.4 Section IV: Method for measuring Sound Pressure Levels at Operator and Bystander Positions

A new clause has been added to calculate the mean value of the sound pressure level at the bystander positions from the values measured at all bystander positions.

The method for the detection of Prominent Discrete Tones has been revised and moved to Appendix D.

The method for the detection of Impulsive Sound Pressure Levels has been revised and moved to Appendix E.

F.2.5 Appendix A: Test Accessories

The description of the Standard Test Table has been amended.

The specification for a typing robot has been added.

F.2.6 Appendix B: Measurement Surfaces

This Appendix now includes all the permitted microphone arrays including the 5-ring array and an array for large machines.

F.2.7 Appendix C: Installation and Operating Conditions

Existing conditions have been amended and new categories added, including:

- Rigid disk storage units
- Flexible disk cartridge units
- Cheque processors
- Visual display units
- Microfilm readers.
- Personal Computers and Work Stations.