

Standard ECMA-74

8th Edition / December 2003

**Measurement of
Airborne Noise Emitted
by Information
Technology and
Telecommunications
Equipment**

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Brief history

ECMA-74 specifies methods for the measurement of airborne noise emitted by information technology and telecommunications equipment. Hitherto, a wide variety of methods have 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 simplifies such comparisons and is the basis for declaration of the noise emission level of information technology and telecommunications equipment.

In order to ensure accuracy, validity and acceptability, this Standard is based on the basic Standards for determining the sound power level and for determining the emission sound pressure level at the operator position(s) and bystander position(s). Furthermore, implementation is simplified by conformance with these International Standards.

In many cases free-field conditions over a reflecting plane are realised by hemi-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 measuring the emission sound pressure level at the operator or bystander positions (based on ISO 11201) is specified in a separate clause, as this level is not considered to be primary noise emission declaration information. The measurements can, however, be carried out in conjunction with those for sound power determination in a free field over a reflecting plane.

For comparison of similar equipment it is essential that the installation conditions and mode of operation are the same. In Annex 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 7779:1988, first edition. The second edition of ECMA-74 was issued in December 1987. The third edition was issued in December 1992 and was submitted to ISO for Fast Track processing as a revision to ISO 7779 in the spring of 1993. The document was balloted by ISO from November 1994 to May 1995 and was approved with 18 of 20 P members in favour and 2 of 22 member bodies opposed. The fourth edition was issued in December 1996, taking into account most of the comments that accompanied the voting. The fifth edition was issued December 1997 to add a new equipment category – CD- and DVD-ROM drives as C.19.

ISO 7779, second edition, was published August 1st, 1999. The sixth edition of ECMA-74 was adapted to the final wording of new ISO 7779 and also included additional provisions for CD- and DVD-ROM drives as C.19. Now C.19 with minor modifications was adopted as ISO/DIS 7779 Amendment 1.

The C.19 changes that are in ISO/DIS 7779 Amendment 1 along with a revised Annex B and a revised Annex D are included in the seventh edition of ECMA-74, which was approved in December, 2002. The Annex B includes a provision allowing the use of a 0,5 m radius hemispherical surface for measuring the sound power emitted by small noise sources such as disk drives. Annex B also allows the use of a cylindrical measurement surface. The revised Annex D in the seventh edition includes prominence ratio in addition to tone-to-noise ratio, provides improved figures illustrating the tone-to-noise and prominence ratio calculations, and contains new criteria for prominent tones. The new criteria are a result of a three-year study by Ecma TC26 and ITI TC6.

For the eighth edition, the reference list was updated and some text modified to account for the changes. The cylindrical measurement surface section of Annex B was re-worded to more closely follow the wording used in the draft of ISO 3744. Annex C contains additional figures in section C.15 on personal computers and workstations. A new equipment category, C.20, for data projectors was added. Also Annex D was expanded with additional figures, equations and examples.

The December 2003 General Assembly adopted this, 8th edition, of ECMA-74.

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1 Scope

This Ecma Standard specifies procedures for measuring and reporting the noise emission of information technology and telecommunications equipment. This Standard is considered part of a *noise test code* for this type of equipment, and is based on *basic noise emission standards* ISO 3741, ISO 3744, ISO 3745 and ISO 11201. The basic emission quantity is the A-weighted sound power level which may be used for comparing equipment of the same type but from different manufacturers, or for comparing different equipment.

Three basic noise emission standards for determining the sound power levels are specified in this Ecma Standard in order to avoid undue restriction on existing facilities and experience. The first basic standard (ISO 3741) specifies comparison measurements in a reverberation room; the other two (ISO 3744 and ISO 3745) specify measurements in an essentially free field over a reflecting plane. Any one of these three basic noise emission standards may be selected and shall then be used exclusively according to this Standard when determining sound power levels of a machine.

The A-weighted sound power level is supplemented by the A-weighted emission sound pressure level measured at the operator position(s) or the bystander positions, based on the *basic noise emission standard* ISO 11201. This sound pressure level is not a worker's immission rating level, but it may assist in identifying any potential problems that could cause annoyance, activity interference, or hearing damage to operators and bystanders.

Methods for determining whether the noise emission includes prominent discrete tones or is impulsive in character are specified in Annexes D and E respectively.

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 a unit tested individually.

The procedures may be applied to equipment which emits broad-band noise, narrow-band noise and noise which contains discrete-frequency components, or impulsive noise.

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

If sound power levels obtained are determined for a number of units of the same production series, they can be used to determine a statistical value for that production series (see ECMA-109).

2 References

ECMA-108	Measurement of High-frequency Noise Emitted by Information Technology and Telecommunication Equipment (3rd edition - December 1996)
ECMA-109	Declared Noise Emission Values of Information Technology and Telecommunication Equipment (4th edition - December 1996)
ECMA TR/27	Method for the prediction of installation noise levels (2nd edition - June 1999)
ISO 266:1997	Acoustics — Preferred frequencies
ISO 3741:1999	Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for reverberation rooms
ISO 3744:1994	Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free-field condition over a reflecting plane

- ISO 3745:2003 Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for anechoic and hemi-anechoic rooms
- ISO 6926:1999 Acoustics — Requirements for the performance and calibration of reference sound sources used for the determination of sound power levels
- ISO 7779:1999 Acoustics — Measurement of airborne noise emitted by information technology and telecommunications equipment
- ISO 9295:1988 Acoustics — Measurement of high-frequency noise emitted by computer and business equipment
- ISO 9296:1988 Acoustics — Declared noise emission values of computer and business equipment
- ISO 10302:1996 Acoustics — Methods for the measurement of airborne noise emitted by small air-moving devices
- ISO/IEC 10561:1999 Information technology — Office equipment — Printing devices — Method for measuring printer throughput — Class 1 and class 2 printers

NOTE

C.3 of this Standard refers to ISO/IEC 10561.

- ISO 11160-1:1996 Information technology — Office equipment — Minimum information to be included in specification sheets — Printers — Part 1: Class 1 and class 2 printers

NOTE

C.3 of this Standard refers to ISO 11160.

- ISO 11201:1995 Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Engineering method in an essentially free field over a reflecting plane
- ISO 11203:1995 Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions from the sound power level

- IEC 61672-1:2002 Electroacoustics — Sound level meters — Part 1: Specifications
- IEC 60942 Electroacoustics — Sound calibrators
- IEC 61260 Electroacoustics — Octave-band and fractional-octave-band filters
- IEC 61947-1:2002 Electronic projection — Measurement and documentation of key performance criteria – Part 1: Fixed resolution projectors

NOTE

C.20 of this Standard refers to IEC 61947-1.

- IEC 61947-2:2001 Electronic projection — Measurement and documentation of key performance criteria – Part 2: Variable resolution projectors

NOTE

C.20 of this Standard refers to IEC 61947-2.

CAUTION

IEC document numbering was recently modified to add 60000 to the original number. This rule applies to not only new standards, but also already published ones. Therefore, for instance, IEC 60942 is the identical standard which had been referred as to IEC 942 herein.

3 Terms and definitions

For the purposes of this Standard, the terms and definitions given in ISO 3744 and ISO 11201 and the following apply.

3.1 General definitions

3.1.1 basic noise emission standard (B-type standard)

A standard which specifies procedure for determining the noise emission of machinery and equipment in such a way as to obtain reliable, reproducible results with a degree of accuracy.

3.1.2 noise test code (C-type standard)

A standard that is applicable to a particular class, family or type of machinery or equipment which specifies all the information necessary to carry out efficiently the determination, declaration and verification of the noise emission characteristics under standardized conditions.

NOTE

This Standard (ECMA-74) together with ECMA-108 and ECMA-109 comprise the noise test code for Information Technology and Telecommunications Equipment. These Standards are Ecma counterparts of ISO 7779, ISO 9295 and ISO 9296, respectively. Both set of noise test codes (Ecma and ISO) are consistent with guidelines specified in ISO 12001.

3.1.3 information technology and telecommunications equipment

Equipment for information processing, and components thereof, used in homes, offices, computer installations, telecommunications installations, or similar environments.

3.1.4 functional unit

An entity of physical equipment, which has been allocated an identification number, capable of accomplishing a specified task.

NOTE 1

A functional unit may be supported by a frame or frames and may be self-enclosed or designed to be attached to another device.

NOTE 2

An end-use enclosure in the form of a rack, populated with sub-assemblies or other functional units, may be considered a functional unit whether or not it has a separate identification number.

3.1.5 work station

Place in the working environment where an operator performs work.

NOTE 1

It does not refer to a computer "workstation", which denotes a high-performance, single-user computer.

NOTE 2

See ISO 11201.

3.1.6 operating mode

Condition in which the equipment being tested is performing its intended function(s).

3.1.7 idle mode

One or more steady-state conditions in which the equipment being tested is energized but is not operating.

3.1.8 floor-standing equipment

Functional unit which is intended to be installed on the floor with or without its own stand.

3.1.9 table-top equipment

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

3.1.10 wall-mounted equipment

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

3.1.11 sub-assembly

Functional unit intended to be installed in another unit or assembled with other units in a single enclosure.

NOTE

The unit may or may not have its own enclosure and identification number.

3.1.12 rack-mounted equipment

One or more sub-assemblies installed in an end-use enclosure.

3.1.13 standard test table

Rigid table having a top surface of at least 0,5 m² and length of the top plane not less than 0,7 m.

NOTE

The design for the standard test table is shown in Annex A.

3.2 Acoustical definitions

3.2.1 sound pressure, p

Square root of the time mean-square sound pressure during the measurement duration.

NOTE 1

Sound pressure is expressed in pascals.

NOTE 2

See ISO 3744:1994.

3.2.2 time-averaged sound pressure level, L_{pT}

Sound pressure level of a continuous steady sound that, within a measurement time interval, T , has the same mean-square sound pressure as a sound under consideration which varies with time.

NOTE 1

Time averaged sound pressure levels are expressed in decibels.

NOTE 2

See ISO 3744.

3.2.3 emission sound pressure level, L_p

Sound pressure level at a specified position near a noise source, measured with a particular time weighting and a particular frequency weighting, when the source is in operation under specified operating and mounting conditions on a reflecting plane surface, excluding the effects of background noise.

NOTE

Clause 8 specifies the method for measurement of emission sound pressure level.

3.2.4 time-averaged emission sound pressure level, L_{peqT}

Emission sound pressure level of a continuous steady sound that, within a measurement time interval, T , has the same mean-square sound pressure as a sound under consideration which varies with time.

$$L_{peqT} = 10 \lg \frac{1}{T} \int_0^T \frac{p^2(t)}{p_0^2} dt \text{ dB}$$

NOTE 1

It is expressed in decibels.

NOTE 2

The emission sound pressure level is determined at the specified position(s) required by the test code (i.e. this Standard, for this specific family of information technology and telecommunications equipment).

NOTE 3

See ISO 11201.

3.2.5 A-weighted impulse sound pressure level, L_{pAI}

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

NOTE

It is expressed in decibels.

3.2.6 C-weighted peak emission sound pressure level, L_{pCpeak}

The highest instantaneous value of the C-weighted emission sound pressure level determined over an operational cycle.

3.2.7 sound power, W

The rate per unit time at which airborne sound energy is radiated by a source.

NOTE 1

It is expressed in watts.

NOTE 2

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

3.2.8 reference sound source,

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.

3.2.9 frequency range of interest

Octave bands with centre frequencies from 125 Hz to 8 000 Hz.

NOTE 1

Under special circumstances the frequency range may have to be extended; see 6.10.2 and Table 4.

NOTE 2

The 16 kHz octave band is included if a preliminary investigation indicates that it may affect the A-weighted sound pressure or sound power levels. However, if the noise in the 16 kHz octave band contains discrete tones, then the 16 kHz octave band is not included in the determination of the A-weighted levels. The range and centre frequencies of the octave bands are specified in ISO 266. See 6.10.2 and Table 4 for additional information.

NOTE 3

If the 16 kHz octave band is included in the measurements, the procedures of this Standard may yield measurement uncertainties greater than those stated in 6.2, 7.2 and 8.2.

NOTE 4

For equipment which emits sound in the 16 kHz octave band, the procedures specified in ECMA-108 should be used; see 6.10.2 and Table 4.

4 Conformance requirements

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

- a) The measurement procedures, the installation and the operating conditions specified by this Standard are taken fully into account.
- b) For the determination of sound power levels, one (and only one) of the methods specified in 6 or 7 is used.
- c) For measurement of emission sound pressure level at the operator or bystander positions, the method specified in 8 is used.

5 Installation and operating conditions

5.1 Equipment installation

5.1.1 General

The equipment shall be installed according to its intended use. Installation conditions for many different categories of information technology and telecommunications equipment are specified in Annex C; these shall be followed when noise emission declaration information is to be obtained. If the normal installation is unknown or if several possibilities exist, a representative condition shall be chosen and reported.

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 free from all objects which may interfere with the measurements.

NOTE

If the equipment is mounted near one or more reflecting planes, the sound power radiated by the equipment may depend 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.

5.1.2 Floor-standing equipment

5.1.2.1 Requirements for reverberation rooms

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.

5.1.2.2 Requirements for hemi-anechoic rooms

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 Annex C.

The equipment shall be installed in a way which allows access to all sides except the reflecting plane(s). The dimensions of the reflecting plane(s) shall extend beyond the test object by at least the measurement distance. The requirements for reflection are specified in the note to 7.3.1. The plane(s) shall not contribute to the sound radiation due to their own vibrations.

5.1.2.3 Common requirements

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 emission levels of one are significantly influenced by the other, the equipment being tested shall, where practicable, include all units coupled together in this way.

Floor-standing equipment which is to be installed only in front of a wall shall be placed on a hard floor in front of a hard wall (see the note in 7.3.1). The distance from the wall shall be in accordance with the manufacturer's instructions or as specified in Annex C. If such information is not available, the distance shall be 0,1 m.

5.1.3 Table-top equipment

5.1.3.1 Requirements for reverberation rooms

Table-top equipment shall be placed on the floor at least 1,5 m from any wall of the room unless a table or stand is required for operation according to Annex C (e.g. printers which take paper from or stack paper on the floor). Such equipment shall be placed in the centre of the top plane of the standard test table (see Annex A).

5.1.3.2 Requirements for hemi-anechoic rooms

Table-top equipment shall be placed on the floor unless a table or stand is required for operation according to Annex C (e.g. printers which take paper from or stack paper on the floor). Such equipment shall be placed in the centre of the top plane of the standard test table (see Annex A). In any case the measurement surface defined in 7.6 terminates on the floor.

5.1.4 Wall-mounted equipment

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 permits, the equipment may be laid with its mounting surface on the floor at least 1,5 m (more than 2 m, if possible, in hemi-anechoic rooms) from any wall of the room.

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 and described in the test report.

5.1.5 Rack-mounted equipment

Rack-mounted equipment shall be placed in an enclosure which complies with the installation specifications for the equipment. The location of all units within the enclosure shall be described. The enclosure shall be tested as floor-standing or table-top equipment. 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 enclosure may be tested and reported either as individual functional units or as a complete system.

5.1.6 Hand-held equipment

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.

5.1.7 Sub-assemblies

A sub-assembly shall be supported $0,25\text{ m} \pm 0,03\text{ m}$ above the reflecting plane by vibration-isolating elements. If a hemispherical measurement surface is used with any radius less than 1 m but at least 0,5 m, the sub-assembly test height shall be reduced to $0,125\text{m}^{+0,03\text{m}}_{-0,005\text{m}}$. The supports shall not interfere with the propagation of airborne sound.

5.2 Input voltage and frequency

The equipment shall be operated at its nominal rated voltage and the rated power line frequency.

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

5.3 Equipment operation

During the acoustical measurements the equipment shall be operated in a manner typical of normal use.

Annex C specifies such conditions for many categories of equipment and shall be followed. However, if the specified conditions are clearly contrary to the objective of providing uniform conditions closely corresponding to the intended use of the product, then an additional mode or modes closely related to intended use shall be defined, tested and documented. Any subsequent declaration shall either:

- declare both values, indicating that one is based on Annex C, and indicating that the other is declared by the manufacturer to be typical use for the intended application; or
- declare only the latter, indicating that it is not based on Annex C, but is declared by the manufacturer to be typical use for the intended application.

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

The noise shall be measured with the equipment in both the idle and operating modes. If the equipment is designed for performing different functions, such as manually typing and automatic printing of stored information, or for printing in different print qualities, unless otherwise specified in Annex C, the noise of each individual mode shall be determined and recorded. For equipment which, in normal functional operation, performs several operating modes, such as document insertion, reading, encoding, printing and document eject, and for which a typical operation cycle has not been defined in Annex C, such a typical cycle shall be defined for the measurements and described in the test report.

In the case of rack-mounted equipment or other equipment in which the operation of several functional units is possible, the units intended to operate together shall be operated during the test; all other units shall be in idle mode. In the absence of operational guidelines provided by the manufacturer, 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. However, if the operation of the unit which has the highest A-weighted sound power level occurs only once and less than 5 % of the time during a typical 8 hour working day, the unit producing the next 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. If none of the operations occurs for more than 5 % of the time of a typical 8 hour working day, then the aforementioned conditions with the unit with the highest A-weighted sound power level shall apply.

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 idle. The operating mode measurements shall 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 plan, equipment specifications or other documentation.

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 or, if this is not possible, they shall be set to a minimum.

NOTE

For certain applications, such signals as well as the maximum response of feedback signals of keyboards may be of interest. Such measurements may be made, but they are not part of the methods specified in this Standard.

6 Method for determining sound power levels of equipment in reverberation rooms

6.1 General

The method specified in this Clause provides a comparison procedure for determining the sound power levels produced by information technology and telecommunications equipment in a reverberation room, according to the comparison method specified in ISO 3741.

It is strongly recommended that the room be qualified in accordance with ISO 3741, Annex A. This avoids the need to determine the number of microphone positions and equipment locations each time equipment is measured.

6.2 Measurement uncertainty

Measurements carried out in accordance 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 in a reverberation room

Octave band centre frequencies	One-third octave band centre frequencies	Standard deviation
Hz	Hz	dB
125	100 to 160	3,0
250	200 to 315	2,0
500 to 4 000	400 to 5 000	1,5
8 000	6 300 to 10 000	3,0

NOTE 1

For most information technology and telecommunications equipment, the A-weighted sound power level is determined by the sound power levels in the 250 Hz to 4 000 Hz octave bands. The A-weighted sound power level is determined with a standard deviation of approximately 1,5 dB. A larger standard deviation may result when the sound power levels in other bands determine the A-weighted level.

NOTE 2

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 indicate.

NOTE 3

If the method specified in this Clause 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 carried out in the same environment.

6.3 Test environment

6.3.1 General

Guidelines specified in ISO 3741 for the design of the reverberation room, as applicable, shall be used. Criteria for room absorption and the procedure for room qualifications, specified in ISO 3741 shall be used.

ISO 3741 shall be followed with regard to the following:

- a) test room volume;
- b) level of background noise.

6.3.2 Meteorological conditions

The requirements of ISO 3741 shall be followed.

The following conditions are recommended:

- a) barometric pressure: 86 kPa to 106 kPa;
- b) temperature: within the range defined by the manufacturer for the equipment, if a range is defined; if no range is so defined by the manufacturer, the recommended range is 15 °C to 30 °C;
- c) relative humidity: within the range defined by the manufacturer for the equipment, if a range is defined; for processing of paper and card media only, if no range is so defined by the manufacturer, the recommended range is 40 % to 70 %.

In addition, for equipment the sound pressure level of which varies with temperature, the room temperature during the measurement shall be 23 °C ± 2 °C.

6.4 Instrumentation

6.4.1 General

The requirements of 6.4 as well as the instrumentation requirements of ISO 3741 shall be followed.

Digital integration is the preferred method of averaging (see IEC 61672-1).

6.4.2 The microphone and its associated cable

The requirements of ISO 3741 shall be followed. In addition, the microphone and its associated cable shall be chosen so that their sensitivity does not change by more than 0,2 dB over the temperature range encountered during measurement. If the microphone is moved, care shall be exercised to avoid introducing acoustical or electrical noise (e.g. from gears, flexing cables, or sliding contacts) that could interfere with the measurements.

6.4.3 Frequency response of the instrumentation system

The requirements of ISO 3741 shall be followed.

6.4.4 Reference sound source

The reference sound source shall meet the requirements specified in ISO 6926 over the frequency range of interest.

6.4.5 Filter characteristics

The requirements of a class 1 instrument specified in IEC 61260 shall be followed.

6.4.6 Calibration

During each series of measurements, a sound calibrator with an accuracy of 0,3 dB (class 1 as specified in IEC 60942) shall be applied to the microphone to verify the calibration of the entire measuring system at one or more frequencies over the frequency range of interest. The compliance of the calibrator shall be verified with the requirements of IEC 60942 once a year, and the compliance of the instrumentation system with the requirements of IEC 61672-1 at least every 2 years in a laboratory making calibrations traceable to appropriate standards.

The reference sound source shall be fully calibrated every 2 years according to ISO 6926.

The reference sound source shall be checked annually in accordance with ISO 6926, note 5, to determine whether or not recalibration of the reference sound source is necessary prior to the 2-year calibration period. If changes in any one-third-octave-band space/time averaged sound pressure level exceed 0,5 dB, then the reference sound source shall be fully calibrated according to ISO 6926 before further use.

The date of the last verification of the compliance with the relevant ISO/IEC standards shall be recorded.

6.5 Installation and operation of equipment: General requirements

See Clause 5.

6.6 Microphone positions and source locations

6.6.1 General

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.

It is strongly recommended that the room be qualified in accordance with ISO 3741, Annex A. This avoids the need to determine the number of microphone positions and equipment locations each time equipment is measured.

Otherwise (if the room is not qualified in accordance with Annex A of ISO 3741) the procedure specified in Clause 8 of ISO 3741 shall be used to determine the minimum number of equipment locations and microphone positions, and to determine microphone positions prior to each measurement. The results of the procedure depend on the presence or absence of

significant discrete-frequency components or narrow bands of noise in the sound emitted by the source. However, the number of microphone positions and equipment locations is usually large.

6.6.2 Number of microphone positions, reference source locations and equipment locations

The requirements of ISO 3741, Clause 8, shall be followed.

6.6.3 Microphone arrangement

The requirements of ISO 3741, Clause 8, shall be followed.

6.7 Measurement of sound pressure level

6.7.1 General

The requirements of ISO 3741 shall be followed, as applicable.

6.7.2 Measurement duration

The requirements below in addition to those of ISO 3741 shall be followed, as applicable.

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. Annex C specifies additional requirements for many categories of equipment.

6.7.3 Corrections for background noise

The requirements of ISO 3741 shall be followed, as applicable.

6.8 Measurement of the sound pressure level of the reference sound source

The requirements below in addition to those of ISO 3741 shall be followed.

For the purposes of determining the sound power level of the equipment by means of reverberant rooms, this Standard uses exclusively the comparison method specified in 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 in the presence of the operator, if required to operate the equipment.

6.9 Calculation of space/time-averaged band sound pressure level

The requirements of ISO 3741 shall be followed.

6.10 Calculation of sound power level

6.10.1 Calculation of band sound power levels

The sound power level of the equipment in each octave band or one-third-octave band within the frequency range of interest is obtained by using the comparison method of ISO 3741.

6.10.2 Calculation of A-weighted sound power level

The A-weighted sound power level, L_{WA} , in decibels, shall be calculated according to ISO 3741, Annex F.

For computations with octave-band data, the A_j values are specified in Table 2, and $j_{max} = 7$, except as described below.

For computations with one-third-octave band data, the A_j values are specified in Table 3, and $j_{max} = 21$, except as described below.

Table 2 — Values of A-weighting, A_j , for octave bands

j	Octave band centre frequency Hz	A_j dB
1	125	- 16,1
2	250	- 8,6
3	500	- 3,2
4	1 000	0,0
5	2 000	1,2
6	4 000	1,0
7	8 000	- 1,1
8	16 000	- 6,6

Table 3 — Values of A-weighting, A_j , for one-third-octave bands

j	One-third-octave-band centre frequency Hz	A_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	1 000	0,0
12	1 250	0,6
13	1 600	1,0
14	2 000	1,2
15	2 500	1,3
16	3 150	1,2
17	4 000	1,0
18	5 000	0,5
19	6 300	-0,1
20	8 000	-1,1
21	10 000	-2,5
22	12 500	-4,3
23	16 000	-6,6
24	20 000	-9,3

For the determination of A-weighted sound power levels from band levels, this Standard extends the frequency range of interest to include the 16 kHz octave band under some conditions. If the noise from the 16 kHz octave band is broad-band in character, the A-weighted level shall be calculated from the one-third-octave band measurements which include the 16 kHz octave band. In this case, $j_{\max} = 8$ for computations with octave-band data and $j_{\max} = 24$ for computations with one-third-octave-band data. If the noise in the 16 kHz octave band contains discrete tone(s), then the 16 kHz octave band shall not be included in the determination of the A-weighted levels. For equipment which emits noise in the 16 kHz octave band, the procedures specified in ECMA-108 for reporting sound power levels shall be used (see Table 4).

NOTE 1

Tables 2 and 3 of this Standard replace Table F.1 of ISO 3741 in order to include the A-weighting values, A_j , in the 16 kHz octave band.

NOTE 2

If the noise source emits strong discrete frequency components, it is recommended that the calculation be performed using one-third-octave band A-weighted values, if available.

Table 4 — Type of noise and determination of sound power levels

Type of noise in the frequency range of the octave bands centred at		Sound power level to be determined
125 Hz to 8 kHz	16 kHz	
Broad-band or narrow-band noise	Broad-band noise	Combined A-weighted level (125 Hz to 16 kHz) according to this Standard.
Broad-band or narrow-band noise	Discrete tone	A-weighted level (125 Hz to 8 kHz) according to this Standard and the level and frequency of the discrete tone according to ECMA-108.
	Multiple tones	A-weighted level (125 Hz to 8 kHz) according to this Standard and the levels and frequencies of all tones in the 16 kHz octave band that are within 10 dB of the highest tone level in the band according to ECMA-108.
No significant noise	Discrete tone	Level and frequency of the discrete tone in the 16 kHz octave band according to ECMA-108.
	Multiple tones	Levels and frequencies of all tones in the 16 kHz octave band that are within 10 dB of the highest tone level in the band according to ECMA-108.

7 Method for determining sound power levels of equipment under essentially free-field conditions over a reflecting plane

7.1 General

The method specified in this Clause provides a direct procedure for determining the sound power levels produced by information technology and telecommunications equipment using essentially free-field conditions over a reflecting plane as specified in ISO 3744 or ISO 3745. It applies to equipment which radiates broad-band noise, narrow-band noise, noise which contains discrete frequency components or impulsive noise.

The measurement shall be carried out in an environment qualified in accordance with ISO 3744 or ISO 3745.

7.2 Measurement uncertainty

Measurements carried out in accordance with this method yield standard deviations of reproducibility for the frequency range of interest of this Standard which are equal to, or less than the values given in Table 5.

Table 5 — Uncertainty in determining sound power levels in a free field over a reflecting plane

Octave band centre frequencies Hz	One-third-octave band centre frequencies Hz	Standard deviation dB
125	100 to 160	3,0
250 to 500	200 to 630	2,0
1 000 to 4 000	800 to 5 000	1,5
8 000	6 300 to 10 000	2,5

NOTE 1

For most information technology and telecommunications equipment, A-weighted sound power level will be determined by the sound power levels in the 250 Hz to 4 000 Hz octave bands. The A-weighted sound power level is determined with a standard deviation of approximately 1,5 dB. A larger standard deviation may result when the sound power levels in other bands determine the A-weighted level.

NOTE 2

The standard deviations given in Table 5 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 5 indicate.

NOTE 3

If the method specified in this Clause 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 5, provided that the measurements are carried out in the same environment.

7.3 Test environment

7.3.1 General

The test environment shall provide an essentially free field over a reflecting plane. Criteria for suitable test environments are defined in ISO 3744 and ISO 3745.

NOTE

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

7.3.2 Meteorological conditions

The requirements of ISO 3744 or 3745 as applicable shall be followed.

The following conditions are recommended:

- a) barometric pressure: 86 kPa to 106 kPa;
- b) temperature: within the range defined by the manufacturer for the equipment, if a range is defined; if no range is so defined by the manufacturer, the recommended range is 15 °C to 30 °C;
- c) relative humidity: within the range defined by the manufacturer for the equipment, if a range is defined; for processing of paper and card media only, if no range is so defined by the manufacturer, the recommended range is 40% to 70%.

In addition, for equipment the sound pressure level of which varies with temperature, the room temperature during the measurement shall be 23 °C \pm 2 °C.

7.4 Instrumentation

7.4.1 Microphone and its associated cable

The instrument system, including the microphone and its associated cable, shall meet the requirements of ISO 3744 or ISO 3745 as applicable. If the microphone is moved, care shall be exercised to avoid introducing acoustical or electrical noise (e.g. from wind, gears, flexing cables or sliding contacts) that could interfere with the measurements.

7.4.2 Calibration

During each series of measurements, a sound calibrator with an accuracy of 0,3 dB (class 1 as specified in IEC 60942) shall be applied to the microphone to verify the calibration of the entire measuring system at one or more frequencies over the frequency range of interest. The compliance of the calibrator shall be verified with the requirements of IEC 60942 once a year and the compliance of the instrumentation system with the requirements of IEC 61672-1 at least every 2 years in a laboratory making calibrations traceable to appropriate standards.

The reference sound source shall be fully calibrated every 2 years according to ISO 6926.

The reference sound source shall be checked annually in accordance with ISO 6926, note 5, to determine whether or not recalibration of the reference sound source is necessary prior to the 2-year calibration period. If changes in any one-third-octave band space/time averaged sound pressure level exceed 0,5 dB, then the reference sound source shall be fully calibrated according to ISO 6926 before further use.

The date of the last verification of the compliance with the relevant ISO/IEC standards shall be recorded.

7.5 Installation and operation of equipment: General requirements

See 5.

7.6 Measurement surface and microphone positions

7.6.1 General

Except as specified in Annex B, the requirements of ISO 3744 or ISO 3745 shall be followed as applicable. For information technology and telecommunications equipment, the preferred measurement surfaces are hemispherical and are described in Annex B of ISO 3744. The conditions of 5 above shall however be followed. The number and location of the microphone positions shall be as specified in Annexes B or C of ISO 3744, or in Annexes D, E, F or G of ISO 3745, as applicable, except as specified in Annex B of this Standard.

NOTE 1

In some cases, for example when small equipment emits relatively low sound power levels, it may be helpful to use a smaller hemispherical surface with a radius of at least 0,5 m. To minimize near field effects, the 0,5 m radius would have a corresponding lower frequency limit of approximately 172 Hz (based on a requirement of $r \geq \lambda/4$).

NOTE 2

B.2 defines a cylindrical measurement surface as an alternative to the parallelepiped surface in ISO 3744.

In order to facilitate the location of the microphone positions, a hypothetical reference surface is defined. This reference surface is the smallest possible rectangular box (i.e. rectangular parallelepiped) that just encloses the equipment and terminates on the reflecting plane(s). It has length l_1 , width l_2 and height l_3 . Elements protruding from the equipment being tested which are unlikely to contribute to the noise emission may be disregarded. The microphone positions lie on the measurement surface, a hypothetical surface of area S which envelops the equipment as well as the reference box and terminates on the reflecting plane.

The location of the equipment being tested, the measurement surface and the microphone positions are defined by a co-ordinate system with horizontal axes x and y in the ground 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 position of the origin for the coordinates of the microphone positions is specified as follows:

- a) for floor-standing equipment: on the floor in the centre of the plane of the reference box which is coplanar with the room floor;
- b) for table-top equipment on a table or on the floor: same conditions as for floor-standing equipment described in a);
- c) for wall-mounted equipment: in the centre of that plane of the reference box which is coplanar with the mounting surface;
- d) for rack-mounted equipment: same conditions as for floor-standing equipment described in a);
- e) for hand-held equipment: same conditions as for floor-standing equipment described in a);
- f) for sub-assemblies: same conditions as for floor-standing equipment described in a);

NOTE 3

For fixed microphone arrays, either a single microphone may be moved from one position to the next sequentially or a number of fixed microphones may be used and their outputs sampled sequentially or

simultaneously. Alternatively, a continuous microphone traverse may be used as described in Annex B of ISO 3744.

Near air exhausts, the microphone position shall be selected in such a way that the microphone is not exposed to the air stream, otherwise a windscreen shall be used.

The microphones shall be oriented in such a way that the angle of sound incidence is the same as the angle for which the microphone has the most uniform frequency response as specified by the manufacturer. For most practical cases this will be an orientation towards the approximate geometric centre of the equipment.

7.6.2 Microphone positions on the measurement surface

Except as stated immediately below, microphone positions shall meet the requirements of ISO 3744 or ISO 3745, as applicable, including the requirements for additional microphone positions and for reduction in the number of microphone positions, where applicable.

When the equipment emits prominent discrete tones, microphone positions given in Annex B shall be used. If large equipment is to be measured in small rooms providing free-field conditions over a reflecting plane in accordance with ISO 3745, it may be easier to place the equipment not in the centre of the room but closer to a corner and to arrange the microphone positions in the free field of the room. The equipment should be turned around so that noise radiation from the different sides of the machine can be determined sequentially.

7.7 Measurement of sound pressure levels

7.7.1 General

Measurements of the sound pressure levels shall be carried out in accordance with ISO 3744 or ISO 3745 and with the following requirements.

Measurements of the sound pressure level shall be carried out at the microphone positions specified in 7.6 with A-weighting and/or 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/or the band sound pressure levels, for the specified modes of operation of the equipment;
- the A-weighted sound pressure levels and/or the band sound pressure levels of the background noise (including noise from support equipment).

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

7.7.2 Measurement duration

The requirements below, in addition to those of ISO 3744, shall be followed, as applicable.

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

When the measurement duration over the total sequence 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 integrating-averaging sound level meter. Sampling for a period longer than 4 s should 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.

7.8 Calculation of surface sound pressure level and sound power level

Calculation of sound pressure level averaged over the measurement surface shall be according to Clause 8 of ISO 3744. This includes corrections for background noise and test environment. For hemi-anechoic rooms meeting the requirements of ISO 3745, no K_2 correction is applied.

For the determination of A-weighted sound pressure levels from band levels, this Standard extends the frequency range of interest to include the 16 kHz octave band under some conditions. If the noise from the 16 kHz octave band is broad-band in character, the A-weighted level shall be calculated from the one-third-octave band measurements which include the 16 kHz octave band. If the noise in the 16 kHz octave band contains discrete tone(s), then the 16 kHz octave band shall not be included in the determination of the A-weighted levels. For equipment which emits noise in the 16 kHz octave band, the procedures specified in ECMA-108 for reporting sound power levels shall be used (see Table 4 of this Standard).

Tables 2 and 3 of this Standard replace Table 2 of ISO 3744 in order to include the A-weighting values A_j in the 16 kHz octave band.

If the noise source emits strong discrete frequency components, it is recommended that the calculation be performed using one-third-octave band A-weighted levels, if available.

8 Method for measuring emission sound pressure levels at defined operator and bystander positions

8.1 General

The method specified in this Clause defines the conditions of measurement of emission sound pressure levels at the work station (operator) position and at the bystander position(s) in an essentially free field over a reflecting plane in accordance with ISO 11201. The method is applicable to equipment which radiates broad-band noise, narrow-band noise, noise which contains discrete frequency components, or impulsive noise.

This method of measurement does not apply to sub-assemblies. However, where emission sound pressure levels are desired for sub-assemblies, the method specified in ISO 11203 to determine an emission sound pressure level value from a previously measured sound power level using $Q = Q_1 = 8$ dB shall be followed. This value of Q corresponds to a radial distance of 1 m from a small sub-assembly radiating hemispherically; for uniformity this value of Q is applicable to all sub-assemblies. Optionally, actual emission sound pressure levels may be measured at operator or bystander positions as described below.

NOTE

The methods for determining whether the noise at the operator position or at the bystander positions contains prominent discrete tones and/or is impulsive in character are specified in Annex D and Annex E, respectively. These methods are applicable to equipment and sub-assemblies.

8.2 Measurement uncertainty

Measurements carried out in accordance with this method yield standard deviations which are equal to, or less than, those given in Table 6.

Table 6 — Uncertainty in determining time-averaged emission sound pressure level at the operator and bystander positions over a reflecting plane

Octave band centre frequencies Hz	One-third-octave band centre frequencies Hz	Standard deviation dB
125	100 to 160	3,0
250 to 500	200 to 630	2,0
1 000 to 4 000	800 to 5 000	1,5
8 000	6 300 to 10 000	2,5

NOTE 1

For most information technology and telecommunications equipment, the A-weighted emission sound pressure level is determined by the sound pressure levels in the 250 Hz to 4 000 Hz octave bands. The A-weighted emission sound pressure level is determined with a standard deviation of approximately 1,5 dB. A larger standard deviation may result when the sound pressure levels in other bands determine the A-weighted sound pressure level.

NOTE 2

In free-field conditions over a reflecting plane, the standard deviations given in Table 6 reflect 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 or from test to test which may be caused, for example, by changes in the installation or operating conditions of the equipment.

8.3 Test environment

8.3.1 General

The measurements shall be carried out in a qualified environment in accordance with ISO 11201. For convenience, the measurements may be carried out in conjunction with those performed in accordance with 7.

CAUTION

Installation conditions are not always identical between 7 and 8.

8.3.2 Meteorological conditions

The environmental conditions shall be as specified in 7.3.2.

8.4 Instrumentation

Instrumentation shall meet the provisions of ISO 11201 and the additional requirements of 7.4 of this Standard.

8.5 Installation and operation of equipment

Equipment shall be installed and operated in accordance with the requirements of 5 except that table-top equipment shall be installed centred on a standard test table. Any table-top equipment combination which includes a keyboard shall be installed such that the smallest rectangle in the plane of the table and encompassing the keyboard and other units is centred on the top of the standard test table. Any table-top equipment combination which normally is operated with a detachable keyboard but which is tested without the keyboard shall be centred on the test table as in the preceding sentence, as if the keyboard were present.

For optional measurement of sub-assemblies intended for use in table-top products, install the sub-assembly in the centre of a standard test table and isolated from the surface by three or four elastomeric feet, approximately 12 mm high. For optional measurement of sub-assemblies intended for use in other enclosures or racks, install the sub-assembly as specified in 5.1.7.

8.6 Microphone positions

NOTE

These requirements are in accordance with, but more specific than, those of ISO 11201.

8.6.1 At the operator position(s)

One or more operator positions shall be specified for equipment which 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 \pm 0,03 m above the floor (see Figure 1, position P1).

For equipment which is operated from a seated position, the microphone shall be located 1,20 m \pm 0,03 m above the floor (see Figure 1, position P2 or P3).

The horizontal distance from the reference box shall be 0,25 m \pm 0,03 m unless this distance is not representative of the operator position; in the latter case the representative operator position shall be described and shall be used.

For table-top equipment which normally has a detachable keyboard and which is tested without the keyboard (e.g. a desk-top personal computer or a video display unit that is tested without a keyboard), the distance from the front end of the reference box, for purposes of determining the operator position, shall be $0,50\text{ m} \pm 0,03\text{ m}$ in front of such equipment (see Figure 1, position P4).

For optional measurement of sub-assemblies intended for use in equipment with a defined operator position, this operator position shall be used for the sub-assembly measurement.

NOTE 1

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

NOTE 2

If sound pressure level at the operator position is measured on operator-attended equipment, then measurement of sound pressure level at the bystander position is not required.

8.6.2 At the bystander positions

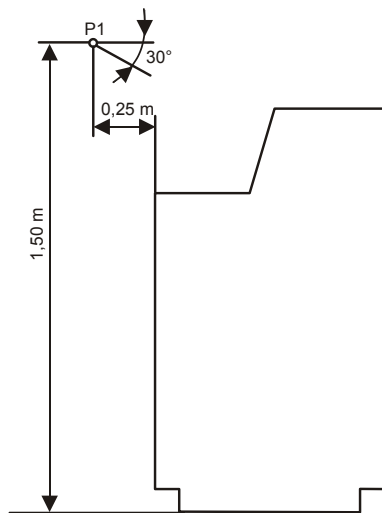
For equipment which does not require operator attention while in the operating mode, an operator position need not be specified. In this case, at least four bystander positions shall be selected and specified.

The bystander positions shall be $1,00\text{ m} \pm 0,03\text{ m}$ away from the projection of the reference box on the horizontal plane $1,50\text{ m} \pm 0,03\text{ m}$ above the floor. The four preferred bystander positions are centred at the front, rear, right and left sides of the equipment. If the length of any side of the reference box exceeds $2,0\text{ m}$, additional bystander positions at $1,0\text{ m}$ intervals should be used. For wall-mounted equipment or for equipment placed against the wall, the three preferred bystander positions are centred at the front, right and left sides of the measurement surfaces.

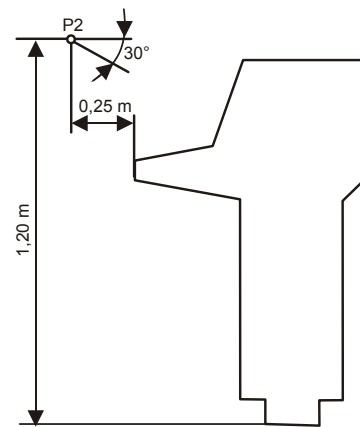
For optional measurement of sub-assemblies intended for use in equipment which does not require operator attention while in the operating mode, the provisions of the preceding two paragraphs apply.

8.6.3 Microphone orientation

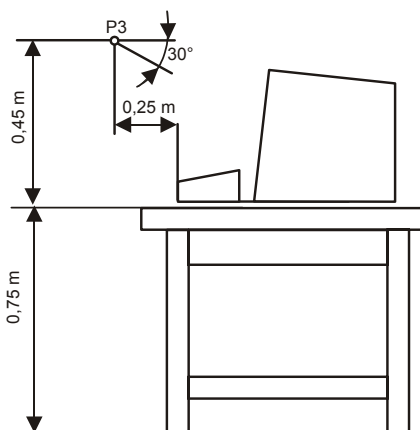
The microphones shall be oriented in such a way that the angle of sound incidence is the same as the angle for which the microphone has the most uniform frequency response. For most practical cases, the primary sound source is assumed to be 30° below horizontal (see Figure 1).



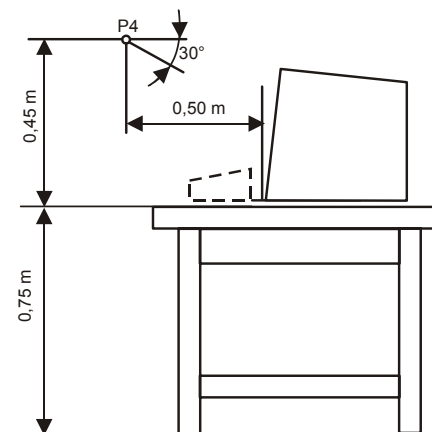
a) Standing operator



b) Seated operator for floor-standing equipment



c) Seated operator for table-top equipment (case 1: with keyboard)



d) Seated operator for table-top equipment (case 2: without keyboard)

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Figure 1 — Examples of microphone positions for standing and seated operators

8.7 Measurement of sound pressure levels

8.7.1 General

Measurements of the emission sound pressure level required by this Clause shall be carried out at the microphone positions specified in 8.6 with A-weighting and/or for each frequency band within the frequency range of interest. The following data shall be obtained:

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

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

Should 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 average sound pressure level be recorded.

NOTE 1

The methods for determining whether the emission sound pressure at the operator position or at the bystander positions contains discrete tones and/or is impulsive in character are specified in Annex D and Annex E, respectively.

Measurements of the C-weighted peak emission sound pressure level, L_{pCpeak} , shall be carried out at the microphone positions specified in 8.6 if any of the L_{pCpeak} levels at the specified positions exceeds 120 dB.

NOTE 2

Some regulations require declaration of C-weighted peak emission sound pressure levels greater than 130 dB. Contemporary information technology and telecommunications equipment is unlikely to emit C-weighted peak emission sound pressure levels (L_{pCpeak}) greater than 120 dB, which is set in this Standard as a conservative threshold above which measurement and reporting are required.

8.7.2 Measurement duration

The measurement duration shall be as specified in 7.7.2.

8.7.3 Calculation of A-weighted emission sound pressure levels from band levels

A-weighted emission sound pressure levels L_{pA} may be measured directly or determined from the following equation:

$$L_{pA} = 10 \lg \sum_{j=1}^{j_{max}} 10^{0,1 L_{pj}} \text{ dB} \quad (1)$$

where

L_{pj} is the level in the j -th octave or one-third-octave band;

A_j is the j -th value of A-weighting from Table 2 or 3.

For the determination of A-weighted emission sound pressure levels from band levels, this Standard extends the frequency range of interest to include the 16 kHz octave band under some conditions. If the noise from the 16 kHz octave band is broad-band in character, the A-weighted level shall be calculated from the one-third-octave band measurements which include the 16 kHz octave band. If the noise in the 16 kHz octave band contains discrete tone(s), then the 16 kHz octave band shall not be included in the determination of the A-weighted levels. For equipment which emits noise in the 16 kHz octave band, the procedures specified in ECMA-108 for reporting sound power levels shall be used (see Table 4).

NOTE

If the noise source emits strong discrete frequency components, it is recommended that the calculation be performed using one-third-octave-band A-weighted levels, if available.

8.8 Calculation of the mean emission sound pressure level at the bystander positions

If bystander positions are defined, the mean A-weighted emission sound pressure level, L_{pA} , and the mean band emission sound pressure levels, L_p , if required, at bystander positions defined in 8.6.2, shall be calculated as specified in the following formula:

$$L_p = 10 \lg \left[\frac{1}{N} \sum_{i=1}^N 10^{0,1 L_{pi}} \right] \text{ dB} \quad (2)$$

where

L_p is the band emission sound pressure level averaged over the bystander positions, in decibels (reference: 20 μ Pa);

L_{pi} is the band emission sound pressure level resulting from measurement at the i -th bystander position, in decibels (reference: 20 μ Pa);

N is the number of bystander positions.

For A-weighted emission sound pressure level, the symbols L_p and L_{pi} are replaced by L_{pA} and L_{pAi} .

9 Information to be recorded and reported

9.1 Information to be recorded

The information specified in 9.1.1 to 9.1.5 shall be recorded, when applicable. In addition, any deviation from any requirement in this noise test code or from the basic standards upon which it is based shall be recorded together with the technical justification for such deviation.

All requirements for recording and reporting specified in the basic standards are also requirements of this Standard. That is, the requirements below are necessary but not sufficient.

9.1.1 Equipment under test

The following information shall be recorded:

- a) a description of the equipment under test (including main dimensions; name, model and serial number of each unit; name, model and serial number of noise producing components and sub-assemblies in the unit under test);
- b) a complete description of the idle and operating modes, including operating speed, data medium used and the test programme in terms that are meaningful for the type of equipment being tested;
- c) a complete description of the installation and mounting conditions;
- d) the location of the equipment in the test environment;
- e) the location and functions of an operator, if present;
- f) the nominal power line frequency, in hertz (e.g. 50 Hz), and the measured power line voltage, in volts;
- g) a sample of typical hardcopy output of the product being tested, when applicable, should be filed as part of the recorded data;
- h) a statement as to whether the noise emission depends on room temperature, if known.

The following information is recommended to be recorded; a tape recording is recommended as follows.

For each operating mode, for the operator position (if defined), otherwise for the bystander position (if defined) with the highest A-weighted emission sound pressure level, a high quality magnetic tape recording may be made, of at least 1 min duration, annotated by voice on the second track with the name of the product, the test mode, the microphone position, and the A-weighted sound pressure level of the signal. Dolby or other magnetic tape noise reduction features SHALL NOT be used. This Standard does not require that a calibration signal be recorded. The bias used in recording shall be noted on the cassette.

9.1.2 Acoustical environment

The following information shall be recorded.

- a) If the sound power is determined in accordance with 6 (ISO 3741):
 - 1) a description of the test room, including dimensions, shape, surface treatment of the walls, ceiling and floor; a sketch showing location of source and room contents;
 - 2) a description of diffusers, or rotating vanes, if any;
 - 3) qualification of reverberation room in accordance with Annex A of ISO 3741;

- 4) the air temperature, in degrees Celsius, relative humidity as a percentage, and barometric pressure in kilopascals.
- b) If the sound power is determined in accordance with 7 (ISO 3744 or ISO 3745):
- 1) a description of the acoustical environment, if indoors, the size and acoustic characteristics of the room, including absorptive properties of the walls, ceiling and floor; a sketch showing the location of the equipment under test;
 - 2) environmental correction K_2 resulting from the acoustical qualification of test environment in accordance with Annex A of ISO 3744, unless the environment has been qualified in accordance with ISO 3745; in the case of compliance with ISO 3745, this fact should be stated;
 - 3) the air temperature in degrees Celsius, relative humidity as a percentage, and barometric pressure in kilopascals.
- c) For emission sound pressure levels at the operator and bystander positions in accordance with 8 (ISO 11201):

NOTE 1

The type of information below is the same as for sound power determination, just described, but the values may differ from those recorded for sound power. If the information recorded for sound power determination in accordance with the preceding paragraph is applicable here, it is sufficient to so note in the test file.

- 1) a description of the acoustical environment, if indoors, the size and acoustic characteristics of the room, including absorptive properties of the walls, ceiling and floor; a sketch showing the location of the equipment under test;
- 2) environmental correction K_2 resulting from the acoustical qualification of test environment in accordance with ISO 3744, Annex A;

NOTE 2

Environmental correction K_2 is not to be used to modify the measured values, but is included as part of the test record as in indication of the quality of the measurement.

- 3) the air temperature in degrees Celsius, relative humidity as a percentage, and barometric pressure in kilopascals.

9.1.3 Instrumentation

The following information shall be recorded:

- a) equipment used for the measurements, including name, type, serial number and manufacturer;
- b) bandwidth of frequency analyser;
- c) frequency response of the instrumentation system;
- d) method used for daily checking of the calibration of the microphones and other system components;
- e) the date and place of annual calibration;
- f) the test method used for determining:
 - 1) the band space/time-averaged sound pressure level in accordance with Clause 5 of ISO 3741; or
 - 2) the surface sound pressure level in accordance with Clause 8 of ISO 3744; and
 - 3) the mean value of the emission sound pressure level at the operator or bystander positions in accordance with Clause 8 of ISO 11201; and
- g) impulsive parameter ΔL_I , in decibels, in accordance with Annex E, if measured.

9.1.4 Acoustical data

The following information shall be recorded.

- a) If the sound power is determined according to 6 (ISO 3741):
- 1) location and orientation of the microphone traverse (path) or array (a sketch should be included if necessary);
 - 2) the corrections, if any, in decibels, applied in each frequency band for the frequency response of the microphone, frequency response of the filter in the passband, background noise, etc.;
 - 3) the values of the difference between the sound power and sound pressure levels produced by the reference sound source ($L_{Wr} - L_{pr}$), in decibels, as a function of frequency;
 - 4) the band pressure level readings, in decibels, to at least the nearest 0,1 dB (preferred), 0,5 dB (required) for the calculations in accordance with ISO 3741;
 - 5) the sound power levels in decibels (reference: 1 pW) in octave and/or one-third-octave bands, tabulated or plotted to the nearest 0,1 dB (preferred), 0,5 dB (required);
 - 6) the A-weighted sound power level in decibels (reference: 1 pW) rounded to the nearest 0,1 dB (preferred), 0,5 dB (required);
 - 7) the date, time and place that the measurements were carried out, and the name of the person who carried out the measurements.
- b) If the sound power level is determined according to 7 (ISO 3744 or ISO 3745):
- 1) the shape of the measurement surface, the measurement distance, the location and orientation of microphone positions or paths; if traversing microphones were used, the maximum traversing speed along a path and microphone orientation shall be reported;
 - 2) the area, S , of the measurement surface;
 - 3) the corrections, if any, in decibels, applied in each frequency band for the frequency response of the microphone, and frequency response of the filter in the passband;
 - 4) the background noise correction K_1 (A-weighted or in frequency bands) for the surface sound pressure levels;
 - 5) the background noise level measured at each point and the average background sound pressure levels;
 - 6) the environmental corrections K_2 (A-weighted or in frequency bands) and the method by which it was determined in accordance with one of the procedures of Annex A of ISO 3744;
 - 7) the A-weighted surface sound pressure level and the band surface-averaged sound pressure level L_{pf} , for each frequency band of interest, rounded to at least the nearest 0,1 dB (preferred), 0,5 dB (required);
 - 8) the sound pressure levels L_{pi} (A-weighted or in frequency bands) at each measuring point i ;
 - 9) the A-weighted sound power level L_{WA} , and the band sound power level L_W , for each frequency band of interest, rounded to the nearest 0,1 dB (preferred), 0,5 dB (required);
 - 10) the date, time and place that the measurements were carried out, and the name of the person who carried out the measurements.
- c) For emission sound pressure levels at the operator and bystander positions according to 8 (ISO 11201):
- 1) the measurement positions and microphone orientations (preferably including a sketch);
 - 2) if an operator position is defined according to 8.6.1, the A-weighted emission sound pressure level L_{pA} , the band emission sound pressure levels if required, and the C-weighted peak emission sound pressure level L_{pCpeak} if greater than 120 dB, measured at the operator position(s) for both the idle and operating modes, in decibels, rounded to the nearest 0,1 dB (preferred) 0,5 dB (required);

- 3) if bystander positions are defined according to 8.6.2, the A-weighted emission sound pressure levels at the bystander positions, if required, the mean A-weighted emission sound pressure level L_{pA} , and the mean band emission sound pressure levels, if required, calculated according to 8.8 and the C-weighted peak emission sound pressure level L_{pCpeak} if greater than 120 dB (see note 2 in 8.7.1) at the bystander position with the highest A-weighted emission sound pressure level for both the idle and operating modes, in decibels rounded to the nearest 0,1 dB preferred (0,5 dB required);
- 4) optionally, the impulsive parameter ΔL_I , in decibels, if $\Delta L_I > 3$ dB, in accordance with the procedure outlined in Annex E;
- 5) optionally, the frequency and level (e.g., ΔL_T and/or ΔL_P) of any prominent discrete tones identified in accordance with Annex D.
- 6) A-weighted background noise levels and background noise correction K_{1A} at each specified position, and as required, background noise levels and correction K_1 in frequency bands;
- 7) the date, time and place where the measurements were carried out, and the name of the person who carried out the measurements.

9.2 Test report

The test report shall contain at least the following information.

- a) A statement as to whether or not the sound power levels and the emission sound pressure levels at operator or bystander positions have been obtained in full conformity with the procedures specified in this Standard and ISO 3741, ISO 3744 or ISO 3745, as applicable, and ISO 11201. Any deviation from any requirement of these International Standards shall be reported together with the technical justification for such deviation.
- b) A statement that these sound power levels are expressed in decibels (reference 1 pW) to the nearest 0,1 dB (preferred), 0,5 dB (required) and that these emission sound pressure levels are expressed in decibels (reference: 20 μ Pa) rounded to the nearest 0,1 dB (preferred) 0,5 dB (required).
- c) A statement that "Measured values in this report are for use in planning or in determining declared values. They are not to be confused with the declared values."
- d) The name(s) and model number(s) of the equipment under test.
- e) The A-weighted sound power level, L_{WA} , in decibels, for the idle mode and the operating mode(s) (reference: 1 pW).
- f) The sound power levels, L_W , in decibels, in octave or one-third-octave bands, if required, for the idle mode and the operating mode(s); the bandwidth used shall be stated (reference: 1 pW).
- g) If an operator position is defined according to 8.6.1, the A-weighted emission sound pressure level, L_{pA} , and if required, the band emission sound pressure levels, in decibels, at the operator position(s) for the idle and operating modes.
- h) If bystander positions are defined according to 8.6.2, the mean A-weighted emission sound pressure level, L_{pA} , and, if required, the mean band emission sound pressure levels in decibels, measured at the positions specified in 7.6.2 around the equipment for the idle and operating modes.
- i) A detailed description of operating and installation conditions of the equipment being tested with reference to Annex C, if applicable.

NOTE 1

To avoid confusion between emission sound pressure level in decibels (reference: 20 μ Pa) and sound power levels in decibels (reference: 1 pW), sound power level may be expressed in bels, using the identity 1 bel = 10 decibels.

NOTE 2

For the determination of declared noise emission values for information technology and telecommunications

equipment in accordance with ECMA-109, a positive number is added to the average measured value of the sound power level based on statistical considerations to account for both random measurement errors and production variations; the sum is divided by ten and expressed in bels.

The above information may be supplemented by one of the following statements, which describe the character of the noise as determined in accordance with Annexes D and E:

- a) no impulsive noise, no prominent discrete tones;
- b) impulsive noise, no prominent discrete tones;
- c) prominent discrete tones, no impulsive noise;
- d) impulsive noise and prominent discrete tones.

Items a) through d) shall be supplemented with a statement of the method used to identify prominent discrete tones.

NOTE 3

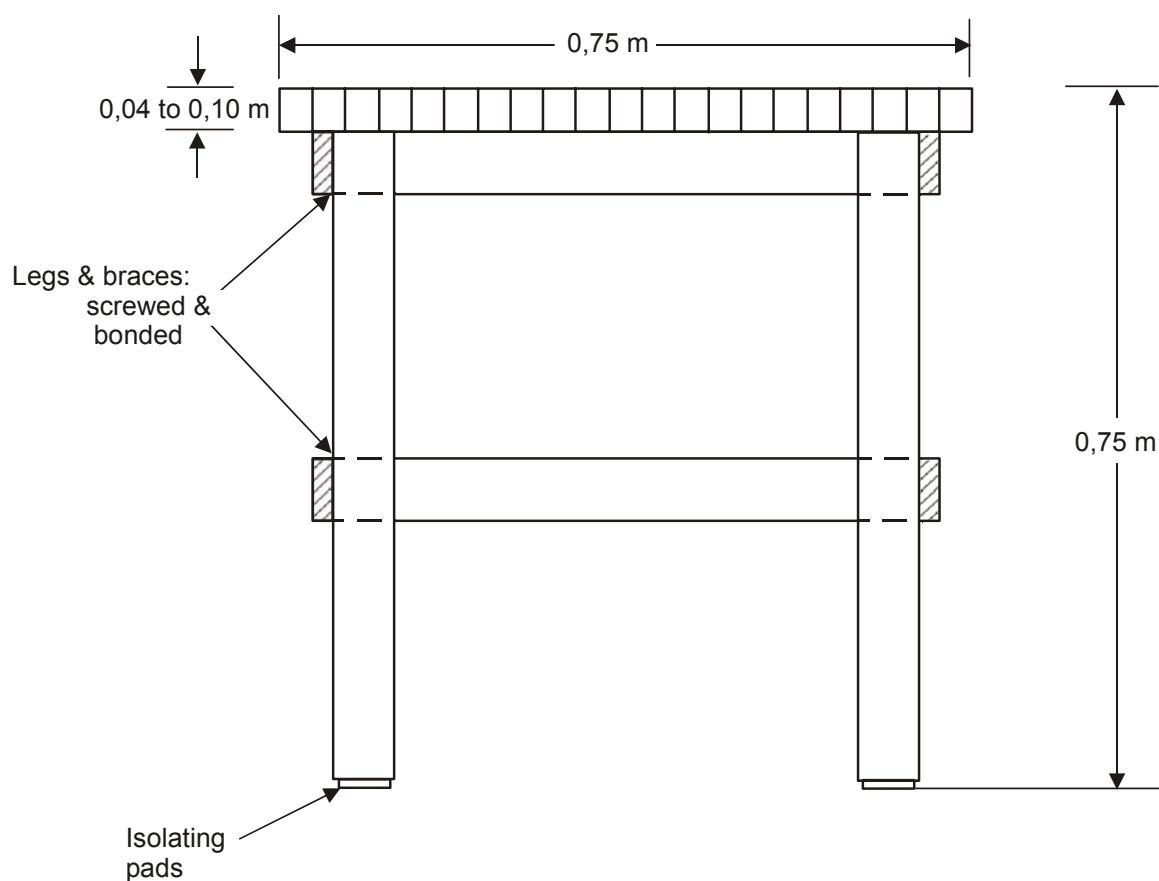
Some regulations require the reporting of the C-weighted peak emission sound pressure level if greater than 130 dB.

Annex A (normative)

Test accessories

A.1 Standard test table

The design for the standard test table is shown in Figure A.1. The top of the table shall be $0,75\text{ m} \pm 0,03\text{ m}$ of bonded laminated wood $0,04\text{ m}$ to $0,10\text{ m}$ thick. The height of the table shall be $0,75\text{ m} \pm 0,03\text{ m}$. The table may have a slot in its top plate to allow paper to be inserted for printers which feed the paper from underneath their bottom cover. A slot $0,015\text{ m}$ by $0,400\text{ m}$ in lateral dimensions has been found practical for most printer paper.



97-0036-A

Figure A.1 — Standard test table

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 eight solenoids, each being individually adjustable to operate one of the selected keyboard keys.

The requirements for this robot are as follows.

- a) The noise of the robot shall meet the requirements for background noise of this Standard.
- b) 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 most types of keyboards including typewriters.
- c) The electrical input signal shall be a rectangular pulse of 50 ms duration, and of adjustable amplitude.
- d) 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.
- e) The plunger mass shall be $20 \text{ g} \pm 1 \text{ g}$; 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:

- a) Home position S_a

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

- b) 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.

- c) 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

The specification is based on the design of the robot described in reference [1] in the bibliography.

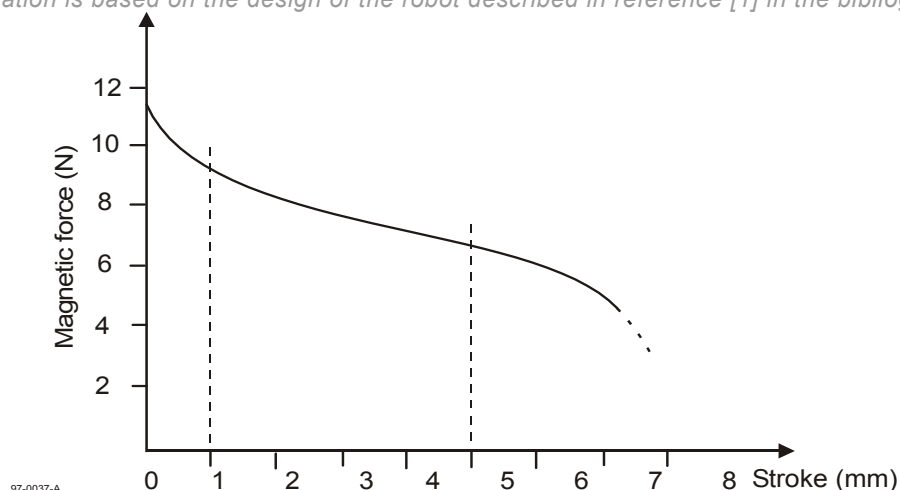


Figure A.2 — Solenoid characteristics for a plunger stroke of 4 mm

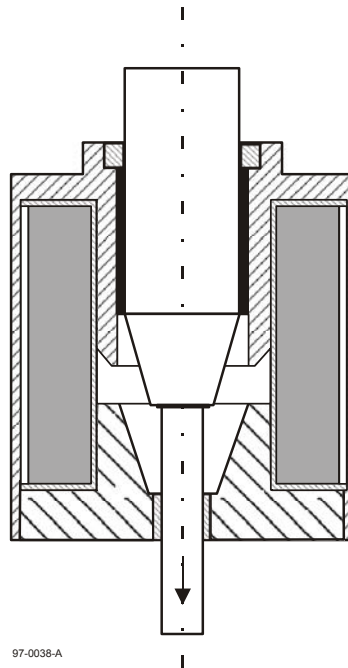


Figure A.3 — Solenoid cross section

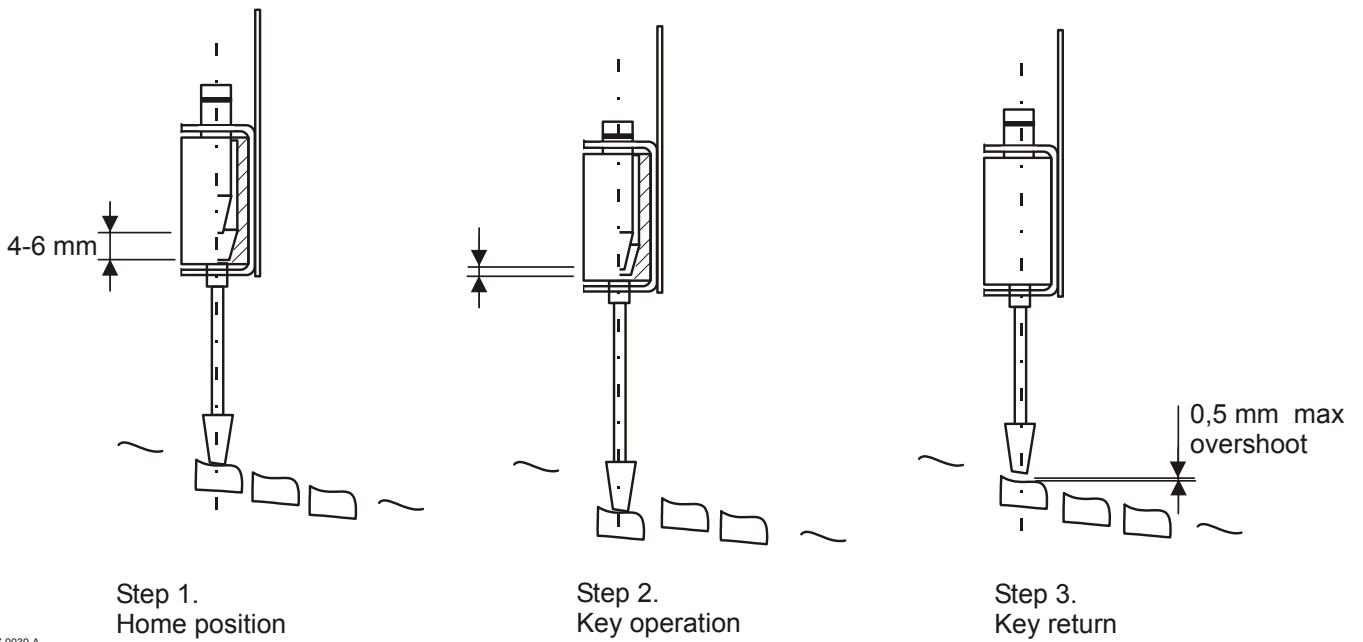
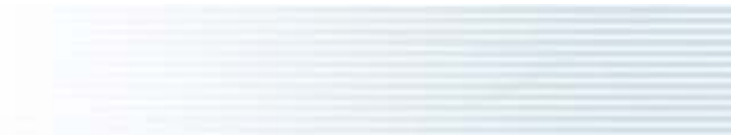


Figure A.4 — Individual steps of the solenoid operation



Annex B (normative)

Measurement surfaces

B.1 Hemispherical surface

Refer to ISO 3744 for the requirements for microphone locations and geometry of the hemispherical measurement surface and microphone array, supplemented by the following recommendations:

- a) When using fixed microphone positions, it is recommended that the microphone positions given in ISO 3744 for sources emitting discrete tones be used for all sources. The coordinates for this array are reproduced below in Table B.1.
- b) When using the coaxial circular paths arrangement specified in ISO 3744, it is recommended that a minimum of 10 heights be used.

Other acceptable alternatives are described in Annexes D, E, F, and G of ISO 3745.

Table B.1 - Co-ordinates of microphone positions for equipment emitting discrete tones

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

For small equipment, a hemispherical surface with a radius of at least 0,5 m may be used. To minimize the near field effects, the 0,5 m radius would have a corresponding lower frequency limit of approximately 172 Hz (based on a requirement of $r \geq \lambda/4$). Additional information is in references [2], [3] and [4].

B.2 Cylindrical surface

B.2.1 General

Figure B.1 illustrates the cylindrical measurement surface, having microphones located along the side and top of the cylinder. The cylinder shall be centred around the reference box with the centre of the cylinder's base corresponding to the centre of the reference box base. The dimensions of the reference box, l_1 , l_2 , and l_3 , and the reference distances to the cylinder, d_1 , d_2 , and d_3 are as shown. For the purposes of this Standard, the dimensional labels shall be assigned so that $l_1 \geq l_2$. All dimensions are in metres.

B.2.2 Selection of size of cylindrical surface

The microphone positions lie on the measurement surface, a hypothetical cylindrical surface enveloping the source and having a total area S equal to the sum of the area of the top circular surface, S_T , and the area of the side vertical surface, S_S . The radius of the cylinder is $R = l_1/2 + d_1 = l_2/2 + d_2$ and the height of the cylinder is $H = l_3 + d_3$. The area of the top surface of the cylinder is $S_T = \pi R^2$ and the area of the vertical side surface is $S_S = 2\pi RH$. Due to the fact that the microphones are associated with unequal sub-areas, both d_3 and d_1 may be selected arbitrarily based on the size of the machine under test or other considerations. It is recommended that both of these be set to the same value, preferably 1 m, but neither shall be less than 0,5 m. Furthermore, none of the distances d_1 , d_2 , or d_3 shall be greater than 1,5 times either of the others (e.g., this condition will be met for d_1 and d_2 provided $d_1 \geq l_1 - l_2$). With d_3 and d_1 selected, H and R are defined and d_2 defaults to $d_2 = R - l_2/2$.

B.2.3 Selection of microphone positions on the cylindrical surface

The microphones on the cylindrical measurement surface are associated with unequal sub-areas, as described below. It is strongly recommended that continuous paths (circular traverses) be used for the microphones. However, if fixed microphone positions are used to sample over the circular traverses, at least 12 equally-spaced angular positions (i.e., at 30-degree spacing or less) shall be used. The traverses may be implemented by either rotating the microphones keeping the source stationary, or rotating the source keeping the microphones stationary.

The following requirements govern the number of side microphones, N_S , and the number of top microphones, N_T , and the associated sub-areas: (1) $N_S \geq H / 0,5$ (to achieve adequate vertical sampling); (2) as a minimum, $N_S \geq 4$ (for relatively short sources); and (3) $N_T \geq N_S / 2$.

The vertical side microphones are associated with equal sub-areas and positioned such that the i -th microphone is $h_i = (i - 1/2) H / N_S$ from the floor. The sound pressure level averaged over the side surface is:

$$\overline{L_{p,side}} = 10 \lg \left[\frac{1}{N_S} \sum_{i=1}^{N_S} 10^{0,1L_{p_i}} \right] \quad \text{dB} \quad (\text{B},1)$$

The top microphones are associated with unequal sub-areas, S_j , and are spaced equally along the radius of the top surface. The radius of the j -th sub-area is $R_j = j R / N_T$, and the position of each top microphone is $r_j = R_{j-1} + (R_j - R_{j-1}) / 2$ for $j > 1$, and $r_1 = R_1 / 2$. The sound pressure level averaged over the top surface is:

$$\overline{L_{p,top}} = 10 \lg \left[\frac{1}{S_T} \sum_{j=1}^{N_T} S_j 10^{0,1L_{p_j}} \right] \quad \text{dB} \quad (\text{B},2)$$

where $S_j = \pi(R_j^2 - R_{j-1}^2)$ for $j > 1$ and $S_1 = \pi R_1^2$.

Figure B.2 illustrates an example of the cylindrical microphone array for 5 vertical side microphones and 4 top microphones.

B.2.4 Calculation of the average sound pressure level over the cylindrical surface

The sound pressure level averaged over the cylindrical measurement surface is given by:

$$\overline{L_p} = 10 \lg \frac{1}{S} \left[S_T 10^{0,1 \overline{L_{p,top}}} + S_S 10^{0,1 \overline{L_{p,side}}} \right] \text{ dB} \quad (\text{B.3})$$

where $S = S_T + S_S$ and $\overline{L_{p,top}}$ and $\overline{L_{p,side}}$ are given above.

NOTE

The quantity $\overline{L_p}$ in equation (B.3) corresponds to either $\overline{L_p}$ or $\overline{L_p}$ in 8.1 of ISO 3744, depending on whether the measurement is of the source or of the background noise, respectively.

Additional details about the cylindrical surface can be found in references [5], [6] and [7] in the bibliography.

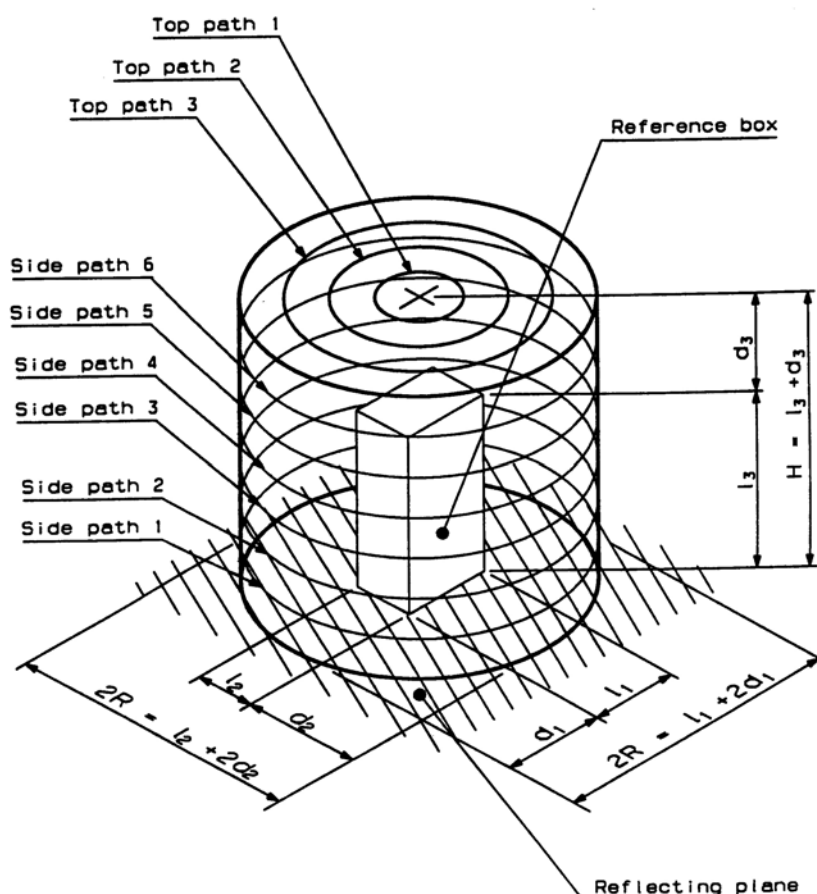
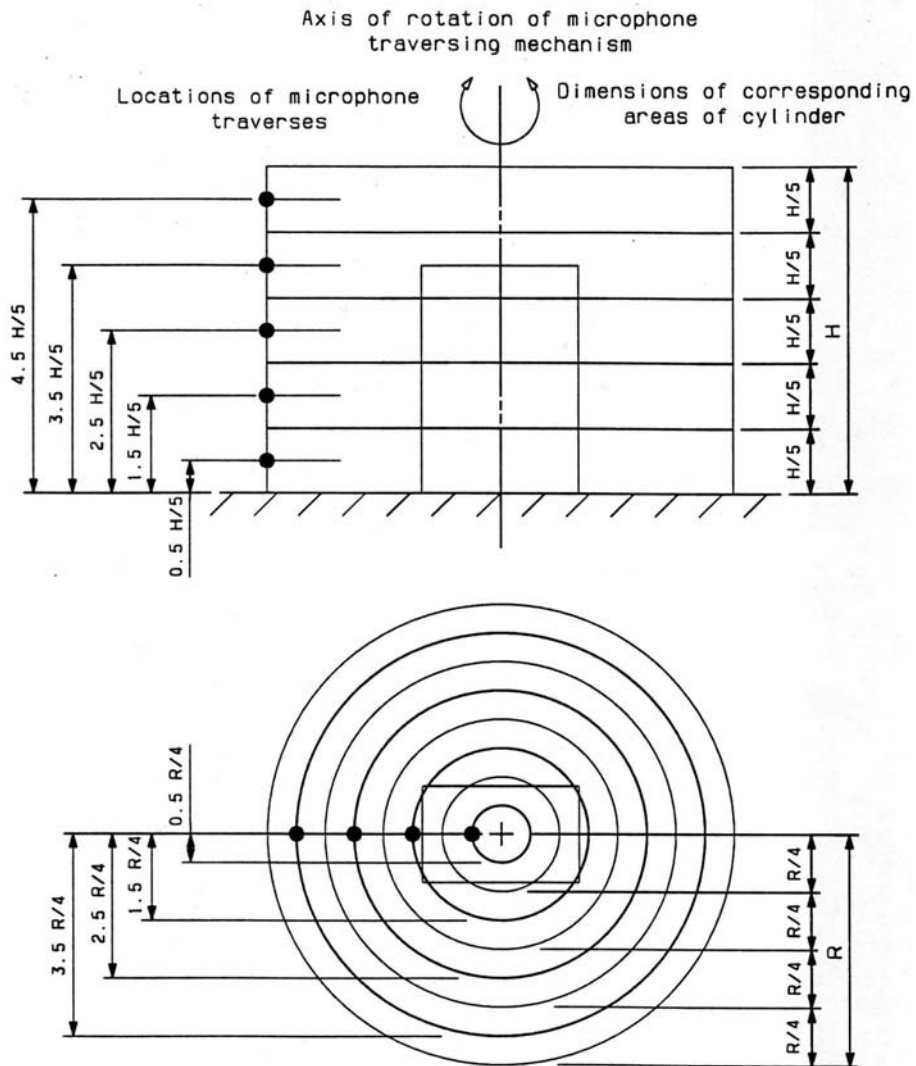


Figure B.1 — Illustration of the cylindrical measurement surface and cylindrical microphone array. Shown are the side and top circular microphone traverses for a configuration of 6 side microphones and 3 top microphones.

EXAMPLE FOR $N_S=5$, $N_T=4$



NOTE: The paths are selected so that the radial distance between each path is the same.

Figure B.2 — Cylindrical measurement surface and microphone array showing an arrangement using 5 side microphones and 4 top microphones.

Annex C (normative)

Installation and operating conditions for specific equipment categories

C.1 General

This Annex specifies installation and operating conditions for many specific categories of equipment. During testing of such equipment, the conditions shall be satisfied in order to comply with this Standard. When possible, the conditions specified in this Annex are considered to be typical of average end use. They are specified with a view to facilitate the operation of the equipment and to enhance the reliability of the acoustical measurements.

For categories of equipment not covered in this Annex, the actual test conditions used shall be described and justified in the test report.

The operating conditions are strictly the same for the determination of both sound power levels and emission sound pressure levels at specified positions. (See 3 for definitions of these quantities.)

The following categories of equipment are included.

C.2	Typewriters
C.3	Character- and line-printers
C.4	Teleprinters
C.5	Keyboards
C.6	Copiers (duplicators)
C.7	Card readers — card punches
C.8	Magnetic tape units
C.9	Disk units and storage sub-systems
C.10	Visual display units
C.11	Electronic units
C.12	Microform readers
C.13	Facsimile machines (Telecopiers) and page scanners
C.14	Cheque processors
C.15	Personal computers and workstations
C.16	Page printers
C.17	Self-service automatic teller machines
C.18	Enclosures or rack systems
C.19	CD- and DVD-ROM drives
C.20	Data projectors

For equipment capable of performing the functions of more than one category, for example printing and facsimile transmission, see 5.3.

Fans, also called “air moving devices”, are often incorporated into the design of information technology and telecommunications equipment to provide airflow for cooling. To measure such a fan as a component, for example as part of the process of selection for design use in a computer, refer to ISO 10302.

C.2 Equipment category: Typewriters

C.2.1 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 manual typing and as printers (see C.3) during automatic print-out on a full page.

C.2.2 Installation

C.2.2.1 General

The typewriter shall be placed in the centre of the top plane of the standard test table. For measurements according to 7, the measurement surface terminates on the floor. Alternatively, the typewriter may be placed on a hard reflecting floor. The condition used shall be reported.

C.2.2.2 Type font

If the typewriter allows the use of different type fonts or different type elements, a fine line typestyle (e.g. pica, elite, and not bold) shall be used with a character pitch of 10 characters per 25,4 mm.

C.2.2.3 Paper

Single sheets of paper of grammage (surface density) 70 g/m² to 80 g/m² in the ISO A4 or equivalent format shall be used unless the typewriter is designed for special paper having a different grammage; in this case, the special paper shall be used. Paper shall be inserted in vertical format with the left-hand edge at zero; the leading edge of the paper sheet shall be fed through to approximately one-third of the paper length, or 100 mm lower than the trailing edge (see Figure C.1). Paper shall have been stored unpacked and exposed to the environmental conditions specified in 6.3.2 for at least 24 h immediately prior to the test.

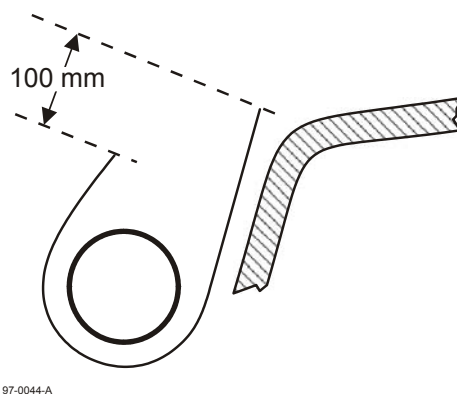


Figure C.1 — Insertion of single sheet of paper

C.2.3 Operation

C.2.3.1 Idle mode

The power shall be switched on. Paper shall be inserted according to Figure C.1.

NOTE

If the typewriter has both standby and ready mode, the idle mode corresponds to the standby mode.

If the typewriter has several idle modes, the mode(s) used for measurement shall be reported.

C.2.3.2 Typing mode

C.2.3.2.1 General

The typing mode consists of keying-in the specified character pattern and printing it on paper. Keying-in should preferably be performed with a suitable robot (see A.2 in Annex A) to simulate manual keystrokes. The noise level due to the operation of the robot alone shall be at least 6 dB and preferably more than 10 dB below the level of operation.

Typing shall start after the paper has been inserted, as specified in Figure C.1 and shall continue for not more than 100 mm.

NOTE

If a typing robot is not available, manual typing may be used.

C.2.3.2.2 Settings

The following settings, when applicable, shall be used.

- a) Impression control: as recommended for a single sheet of paper.
- b) Multi-copy control: set for a single sheet.
- c) Line spacing: double-line spacing.
- d) Margin: 25 mm from the edges; the end-of-line indicator (bell) shall be disconnected.
- e) Paperbail rollers: the paperbail rollers shall be set 25 mm in from the edges of the paper; the others shall be equally spaced between.

C.2.3.2.3 Character pattern

The test pattern characters shall be

etnaiv etnaiv etnaiv etnaiv...

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

The single space between each group of six characters is required as part of the pattern. The carriage return after each line is part of the operation.

NOTE 1

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

NOTE 2

Should small letters not be available, capital letters may be used instead; equivalent conditions may be selected for typewriters with non-Latin character sets.

C.2.3.2.4 Operating speed

For manual operations the typing speed shall be five characters per second.

The specified characters shall be keyed in at a rate of five characters per second until the buffer is filled up; a maximum buffer capacity of one printline shall not be exceeded. The stored information shall then be immediately printed (maximum one line) at the maximum printing speed.

C.2.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2 during the following operations.

- a) For manual operations: measure during continuous typing over at least three full lines.
- b) For interactive operations: measure during keying-in and printing-out until at least three full lines have been printed.

C.3 Equipment category: Character and line printers

C.3.1 Description

This category covers electronically controlled equipment which prints stored information on paper and is not normally keyboard-operated, and the noise output of which depends on the print pattern. 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, or thermal printers).

NOTE

For teleprinters, see C.4; for page printers which have noise output independent of the print pattern, see C.16.

C.3.2 Installation

C.3.2.1 General

Floor-standing printers shall be installed on the hard reflecting floor. Printers which are normally placed on a special stand shall be installed on such a stand on the reflecting floor. Printers which are placed on an 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 7, 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 for measurements according to 6 or 7 and on the test table for measurements according to 8.

For the purposes of declaring A-weighted emission sound pressure level according to ECMA-109, the bystander positions are applicable unless the printer also has a data entry keyboard. In this latter case, the operator position is applicable.

C.3.2.2 Type style

If the printer allows the use of different type styles or different type elements, a type style typical of normal use (resident standard type style), with a character pitch of 10 characters per 25,4 mm and with a number of 6 lines per 25,4 mm shall be used. If this is not possible an adjustment as close as possible to these values shall be chosen. Condensed or extended characters, shall not be used.

C.3.2.3 Paper

Either single sheets of paper of grammage 70 g/m² to 80 g/m² or continuous, folded or rolled stationery of grammage 50 g/m² to 60 g/m² shall be used, unless the printer is designed for special paper having a different mass. In this latter case, the special paper shall be used. The quantity of paper available for printing shall be as close as possible to the maximum capacity of the printer. The form width shall be the widest that is commonly available for the printer and shall be described in the test report. For special applications (e.g. when the material to be printed is a passbook or cheque) the material shall be typical for customer usage and shall be described in the test report.

Paper storage and unpacking shall be carried out in accordance with the machine manufacturer's instructions. If there are no such instructions, paper shall have been stored unpacked and exposed to the environmental conditions specified in 6.3.2 for at least 24 h immediately prior to the test.

C.3.3 Operation

C.3.3.1 Paper position

Except when single sheets are being used, the paper shall be loaded and fed through for a length of at least ten times its width. If single sheets are being used, the paper should be inserted in such a way that it can be printed on for at least 60 % of the page length with the printing area centred vertically.

C.3.3.2 Idle mode

The power shall be switched on.

NOTE

If the printer has both standby and ready modes, the idle mode corresponds to the standby mode.

If the printer has several idle modes, the mode(s) used for measurement shall be reported.

C.3.3.3 Operating mode (Print mode)

C.3.3.3.1 General

Printers with single-sheet feeding devices shall be tested in best quality mode. Paper of size A4 or of an equivalent format (portrait) is automatically fed.

Printers with continuous stationery shall be tested in draft mode with maximum paper width.

Printers capable of printing both single sheets of paper and continuous stationery shall be tested in both configurations.

The print mode consists of printing a character pattern specified in C.3.3.3.3.

For graphic printers whose print speed is specified per ISO 11160-1 while printing graphic mode per ISO/IEC 10561, a second operating mode shall be tested and reported: the second mode consists of printing the test pattern in ISO/IEC 10561, Annex D.

C.3.3.3.2 Settings

The following settings, when applicable, shall be used.

- a) Impression control: as recommended for a single sheet of paper.
- b) Multi-copy control: set for a single sheet.
- c) Line spacing: double-line spacing and skip 20 mm to 30 mm on each side of the paper fold.
- d) Margin: 25 mm from the edges (excluding the perforation strip) except when the printer characteristics restrict the available line length; in the latter case, typical margin length shall be used and reported.

C.3.3.3.3 Character pattern

The full content of a 40-character test pattern is specified below. The character pattern shall be arranged in groups of five printed characters followed by five spaces. The position of the pattern should preferably be shifted by five characters on each line, using an end-around shift over the available line length. The printing area shall be left-justified and centred vertically. If the line comprises fewer characters, the left-most ones shall be used.

J1YY7 2DA90 8S8=2 6A18Q B31AJ 5FTOE PG1TK X6D-4

If some of the specified characters are not available, alternative characters of up to 20 % of the characters in one line may be substituted. For printers which print only non-Latin characters or numerical information a random set of characters or numbers shall be selected and reported.

NOTE

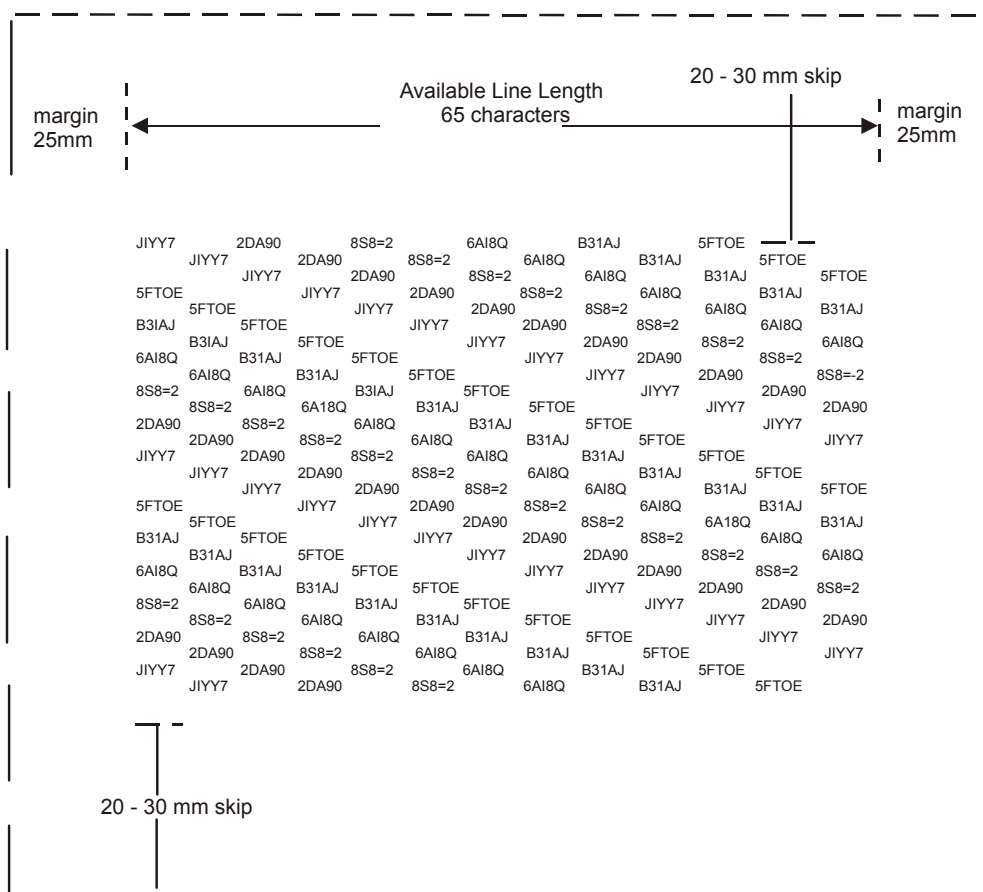
The number of characters to be printed in one line depends on the printer itself and is specified in Table C.1. Examples of test patterns are shown in Figures C.2 and C.3.

C.3.3.3.4 Operating speed

The rated 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 selected and described in the test report. Additional conditions may be specified for special applications and shall be described in the test report.

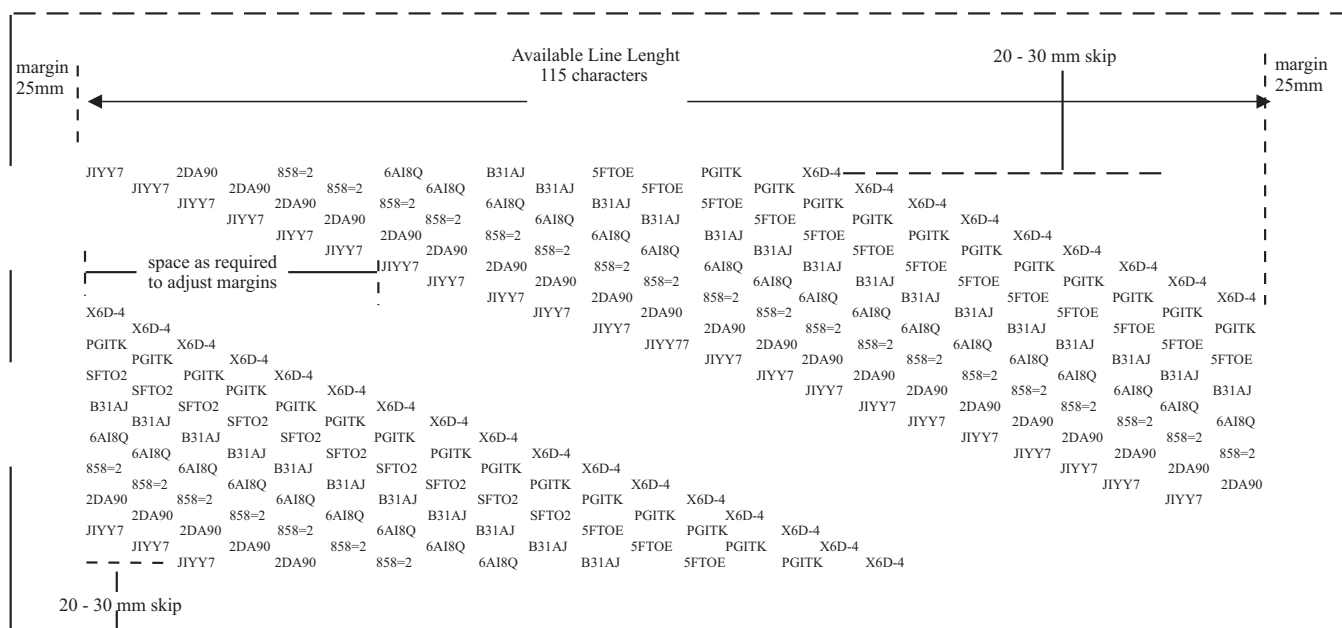
Table C.1 — Number of characters to be used

Available line length in characters	Number of characters to be used
< 40	50 % of maximum line length between margins
40-59	20 characters
60-110	30 characters
> 110	40 characters



97-0045-A

Figure C.2 — Example of the test pattern for a line length of 65 characters



97-0046-A

Figure C.3 — Example of the test pattern for a line length greater than 110 characters

C.3.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2 during the following operations:

- Single-page form: measure during continuous printing over at least 60 % of the page length; if the printer has an automatic paper feed mechanism, at least three pages shall be printed.
- Folded stationery: measure during continuous printing over at least three pages.
- Rolled stationery: measure during continuous printing over a length equal to at least the paper width.
- Passbook: measure during printing of a single line on the middle pages during a complete operation cycle from insertion to ejection (for details see C.17).

C.4 Equipment category: Teleprinters

C.4.1 Description

This category covers equipment operating as a send/receive machine basically comprising a keyboard, a printing unit, a mechanical 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:

- Keyboard operation (when in local or transmission mode): the information is keyed-in by manual typing and immediately printed on paper and/or stored in the memory.
- Automatic operation (when in local or on-line mode): the machine prints automatically the information received from line network or from the memory unit.

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

In some cases a teleprinter can be available in receive-only configuration (without keyboard). That machine is considered to be a character or line printer (according to C.3).

C.4.2 Installation

C.4.2.1 General

For keyboard operation of the teleprinter, the general installation conditions for typewriters shall apply (see C.2).

For automatic operation of the teleprinter, the general installation conditions for printers shall apply (see C.3).

C.4.2.2 Paper

Either single sheets of paper of grammage 70 g/m² to 80 g/m² or continuous, folded or rolled stationery of grammage 50 g/m² to 60 g/m² shall be used, unless the printer is designed for special paper having a different grammage. In this latter case, the special paper shall be used. The quantity of paper available for printing shall be as close as possible to the maximum capacity of the printer. The form width shall be the widest that is commonly available for the printer and shall be described in the test report. For special applications (e.g. when the material to be printed is a passbook or cheque) the material shall be typical for customer usage and shall be described in the test report.

If in typical use, multi-part stationery is employed, an additional test with such stationery shall be carried out and described in the test report.

Paper storage and unpacking shall be carried out in accordance with the machine manufacturer's instructions. If there are no such instructions, paper shall have been stored unpacked and exposed to the environmental conditions specified in 6.3.2 for at least 24 h immediately prior to the test.

C.4.3 Operation

C.4.3.1 Idle mode

The power shall be switched on and paper shall be inserted.

NOTE

If the teleprinter has both standby and ready modes, the idle mode corresponds to the standby mode.

C.4.3.2 Operating mode (Print mode)

For keyboard operation of the teleprinter, the operating conditions specified for keyboards shall apply (see C.5).

For automatic operation of the teleprinter, the operating conditions specified for printers shall apply (see C.3).

C.4.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2.

For keyboard operation of the teleprinter, the requirements specified for typewriters shall apply (see C.2.4).

For automatic operation of the teleprinter, the requirements specified for printers shall apply (see C.3.4).

C.5 Equipment category: Keyboards

C.5.1 Description

This category covers equipment for manual data entry fixed or connected (via a cable or other data transmission means) to other units, e.g. visual display units, computer console, hand-held calculator, etc.

C.5.2 Installation

Keyboards shall be installed in accordance with the relevant clauses of this Standard, except for measurements according to 6 or 7. The keyboard may be placed in the centre of the top plane of the standard test table if required for operation, provided this is reported.

C.5.3 Operation

C.5.3.1 Operating mode (keying-in)

Keying-in shall be performed at a rate of five characters per second.

A suitable robot (see A.2) should be used to simulate manual keystrokes. The noise level due to the operation of the robot alone shall be at least 6 dB and preferably more than 10 dB below the level of operation.

If the keyboard has acoustical feedback, the minimum volume setting shall be used for the test.

NOTE

If a typing robot is not available, manual keying-in may be used.

C.5.3.2 Test pattern

- a) For alphanumeric keyboards, the test pattern shall be as specified for typewriters (see C.2.3.2.3).
- b) For numeric keyboards, the test pattern shall be four digits plus function key, the keys selected shall be reported.

C.5.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2; the requirements specified for typewriters shall apply (C.2.4).

C.5.5 Measurement uncertainty

The measurement uncertainty for determining noise emission levels for keyboard operation has not yet been verified and may be greater than those given in 6.2, 7.2 and 8.2.

C.6 Equipment category: Copiers (duplicators)

C.6.1 Description

This category covers equipment which can produce one or more copies from a master. Such equipment can be coupled with one or more additional attachments and features. These may be in the form of input, output or internal devices for a variety of copying needs. Input devices can be in the form of master document loading, handling and registering, or special paper feeders for continuous stationery or label printing. Output devices can be in the form of copy handlers such as sorters, automatic staplers, stackers and binders. The equipment may have an internal reversing device(s) for handling two-sided originals and producing two-sided copies; i.e. automatic duplexing. The copier may also offer full colour copying from full colour masters, or highlight colour copying.

C.6.2 Installation

C.6.2.1 General

Due to the nature of product operation, noise emitted by the copier in operating mode(s) may fluctuate significantly with time. Therefore, for this category of equipment, sound power level

determination according to 6 (reverberation chamber) may have restrictions to achieve reliable test results: only sound power level of repeated, or cyclic operations will be determined with the uncertainty stated, and measurement duration longer than that in free field over a reflecting plane may be required.

Floor-standing copiers shall be installed on the hard reflecting floor. Copiers which are normally placed on a special stand or special table shall be installed on such a stand or table on the reflecting floor. Copiers 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 standard test table, using the floor to support the paper. For such measurements according to 7, the measurement surface terminates on the reflecting floor.

Table-top copiers, which do not use the floor for the paper supply or exit stack, shall be placed on the hard reflecting floor for measurements according to 6 or 7 and on the standard test table for measurements according to 8.

The same installation conditions shall be followed when the copier has attachments.

C.6.2.2 Paper

Either single sheets of paper of grammage 70 g/m² to 80 g/m² or continuous, folded or rolled stationery of grammage 50 g/m² to 60 g/m² shall be used, unless the copier is designed for special paper having a different grammage; in this case, the special paper shall be used. The quantity of paper available for copying shall be as close as possible to the maximum capacity of the copier. The form width shall be the widest that is commonly available for the copier and shall be described in the test report. For special applications (e.g. when the material to be printed is a passbook or cheque) the material shall be typical for customer usage and shall be described in the test report.

Paper storage and unpacking shall be carried out in accordance with the machine manufacturer's instructions. If there are no such instructions, paper shall have been stored unpacked and exposed to the environmental conditions specified in 6.3.2 for at least 24 h immediately prior to the test.

C.6.3 Operation

C.6.3.1 Idle mode

Power shall be switched on and the copier shall be loaded with a suitable paper supply.

C.6.3.2 Operating mode

C.6.3.2.1 General

The nominal speed for which the copier 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. The copier shall be adjusted to normal exposure, and tests shall be carried out without using any reduction/enlargement facility, if provided.

Additional machine set-up conditions may be considered, as follows.

a) Copying without additional attachments

An operation cycle shall consist of continuously copying a single master.

b) Copying with additional attachments: input and output devices

When a copying system combines several features/attachments, a "full system" operation cycle shall comprise the use of the maximum number of features/attachments allowable at least once. This may include using all the features/attachments on the copier or just some of them. Where all the features/attachments cannot be used together in one operation cycle, several different operating combinations should be considered. The combination which is typical of use shall be selected and described in the test report.

C.6.3.2.2 Input devices

a) Automatic loading of originals

An operation cycle shall consist of placing five masters in the device input tray and making five copies of each master. Copies are ejected into a single stationery output tray.

b) Copying from continuous stationery

An operation cycle shall consist of feeding five pages of continuous stationery through the registering device and making five copies of each master. Copies are ejected into a single stationery output tray.

C.6.3.2.3 Output devices

a) Sorting

The operation shall start with an empty sorter. An operation cycle shall comprise the registering of one master and making five copies ejected into five consecutive sorter bins. (Any copies made during additional operation cycles shall be sorted into the same five consecutive bins.)

b) Stacking

If the copier is equipped with an integral mechanism to separate copy sets generated sequentially, it will generally be fitted with an input master loading device. The operation cycle shall comprise the placing of five originals into the device input tray and one copy of each shall be ejected into the stacker.

c) Automatic stapling

Automatic stapling may be provided in the form of a separate output device, or being fitted as integral to a sorter or stacker. Copiers equipped with this device will generally be fitted with an input master loading device. The operation cycle shall comprise the stapling of a set of copies from five masters for a total of five stapled sets, and ejected into the output tray.

d) Copying on continuous stationery

An operation cycle shall comprise copying one master on five pages for folded stationery or a 2-m length for rolled stationery.

e) Auxiliary equipment

If a copier is supplied with an accessory or integral equipment (e.g. a binder), the tests shall be carried out with and without the use of this equipment in the operation cycle.

f) Two-sided copying

Copiers equipped with this feature can either

- 1) handle two-sided masters and produce from them one-sided or two-sided copies, or
- 2) handle one-sided masters only, and produce from them one-sided or two-sided copies.

Copiers equipped with this device will generally be fitted with an input master loading device.

An operation cycle for type 1) above shall comprise the making of two one-sided copies (one of each of the sides of the master) or one two-sided copy from one two-sided master. This operation cycle is to be repeated five times. An operation cycle for type b) above shall comprise the making of one two-sided copy from two one-sided masters, this operation cycle is to be repeated five times.

g) Colour copying

The operation cycle for copiers fitted with this feature shall be the copying from one one-sided full colour master; one copy is made and automatically ejected into a single stationery output tray.

h) Highlight-colour copying

The operation cycle for copiers fitted with this feature shall be as for monochrome. (Copies should contain highlight-colour from a full text master, e.g. four lines in highlight-colour using the test pattern as specified in C.3).

C.6.4 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 6.7.2 or 7.7.2.

C.7 Equipment category: Card readers and card punches

C.7.1 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 of 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.

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.7.2 Installation

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

C.7.3 Operation

C.7.3.1 Idle mode

The power shall be switched on and the equipment shall be ready for reading or punching cards.

C.7.3.2 Operating mode (Reading or punching mode)

If equipment of this category is capable of both reading and punching in one process, the operating mode shall consist of both punching and reading cards as specified below. If equipment allows only the use of these functions separately, the operating mode shall be punching.

The specified character pattern shall be read from, or punched into and/or read from, each card; approximately 40 % of the maximum number of columns (usually 80) shall contain information. The specified 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.7.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2 during processing of a random card deck of at least 10 cards.

C.8 Equipment category: Magnetic tape units

C.8.1 Description

This category covers equipment for writing on, and reading from, a magnetic tape wound on reels or within a cassette or a cartridge. A unit may contain one or more separately operable tape drives.

C.8.2 Installation

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

C.8.3 Operation

C.8.3.1 Idle mode

C.8.3.1.1 Idle unloaded mode

The power shall be switched on and the tape shall not be in the tape path.

C.8.3.1.2 Idle loaded mode

The power shall be switched on and the tape shall be loaded and the equipment shall be ready to receive and respond to control line commands to any drive. In multiple drive units, all drives shall be loaded and ready.

C.8.3.2 Operating modes

One of the modes specified below shall be used as applicable.

In multiple drive units, only one drive shall be in operating mode; all other drives shall be in the idle loaded mode.

C.8.3.2.1 Read/Write mode

Start, read or write, stop — with command timing for capstan (or equivalent) operation as follows.

Capstan on-time, in milliseconds, is set at the time needed to pass 130 mm of tape at the rated tape speed, s , defined as

$$\frac{130 \text{ mm}}{s \text{ m/s}} \text{ ms}$$

rounded to the nearest millisecond.

The off-time is equal to 0,7 to 1 times the on-time.

NOTE

For a magnetic tape of 12,7 mm width, 130 mm of tape corresponds to a block length of 4 096 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 8 192 bytes; at 246 bpmm, use a block of 32 768 bytes.

C.8.3.2.2 Streaming mode

Logical forward run while writing.

C.8.4 Measurement duration

The time-averaged sound pressure level shall be measured, for at least the duration specified in 6.7.2 or 7.7.2, for at least twenty consecutive start/stop operations in accordance with C.8.3.2.1 or streaming operations in accordance with C.8.3.2.2.

C.9 Equipment category: Disk units and storage subsystems

C.9.1 Description

This category covers equipment for writing on, and reading from, one or more rotating magnetic or optical disks. Disks may be removable or non-removable. Magnetic disks may be flexible or rigid. A unit may contain one or more separately operable disk drives.

NOTE

For read-only optical disk drives (e.g. CD- and DVD-ROM drives), see C.19.

C.9.2 Installation

Installation shall be in accordance with 5.1 and 8.5. Disk units which form part of a personal computer or rack-mounted equipment shall be tested according to C.15 or C.18 as appropriate. Disk units which are tested as sub-assemblies shall be installed as sub-assemblies per 5.1.7.

C.9.3 Operation

C.9.3.1 Idle mode

C.9.3.1.1 Idle ready

Disk(s) shall be loaded, power on, unit ready to receive and respond to control link commands with spindle up to speed and read/write heads in track-following mode.

For systems having a single drive, the drive shall be as described above. For systems with multiple drives or for storage subsystems, the number of drives that are simultaneously operable by the host CPU shall be operated as specified above. All other drives shall be in the idle mode typical of normal use for the system.

C.9.3.1.2 Idle standby

If power-saving modes are available, such modes may be tested and if tested shall be described in the report.

C.9.3.2 Operating mode

For units having a single drive, the drive shall be operating as described below.

For units with multiple drives, or for storage subsystems, the number of drives that are simultaneously operable by the host CPU shall be operated as specified below. All other drives shall be in the idle mode, typical of normal use for the system.

Randomly select a cylinder/track to be sought in such a way that every cylinder/track has equal probability of being selected. (If the drive incorporates an algorithm to perform seeks in a more efficient non-random order, then this algorithm may be used. In this case the drive should be given a command or commands to read or write a random selection of files, and the drive algorithm will decide the order in which the commands are executed. The file length shall be adjusted to achieve the seek rate defined below). Seek to that track, then delay for a time period t_D achieving the required seek rate n_s within $\pm 10\%$ according to the following formula:

$$n_s = 0,4 / (t_T + t_L)$$

$$t_D = 1,5 t_T + 2,5 t_L$$

where

n_s is the average seek rate, expressed in seeks per second;

t_T is the manufacturer's published time to seek from one random track to another without including rotational latency;

t_L is the time, in seconds, for the drive to rotate by half a revolution.

Repeat the seek process. No other intentional delay while selecting the cylinder is allowed. The average number of seeks per second along with the seek algorithm shall be reported with the acoustical data.

If the drive is operating in a system and if the system is not capable of achieving the required seek rate, the drive shall be operated at the maximum seek rate achievable.

If the drive is operating in a multiple drive system in a Redundant Array of Inexpensive Disks (RAID) environment, the drive shall be operated at the maximum seek rate achievable compatible with the system RAID level in use.

C.9.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2.

NOTE

Acoustical "beating" in multi-drive arrays can occur over periods of time that are long relative to the requirements of 6.7.2 and 7.7.2. The resulting variation in sound pressure level at microphone positions can have a significant effect on the variability of A-weighted sound power level determined for the equipment. This variability can be reduced by increasing the measurement time to include several beating cycles.

C.10 Equipment category: Visual display units and terminals

C.10.1 Description

This category covers 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 unit or connected to it by means of a cable or other means of data transmission.

The units in this category may emit significant noise in the 16 kHz octave band. If the noise from the 16 kHz octave band is broad-band in character, the A-weighted levels shall be calculated from one-third-octave band measurements which include the 16 kHz octave band. If the noise in the 16 kHz octave band contains discrete tone(s), then the 16 kHz octave band shall not be included in the determination of the A-weighted levels.

For equipment which emits sound in the 16 kHz octave band, the procedures specified in ECMA-108 for reporting sound power levels shall be used (see Table 4).

C.10.2 Installation

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

C.10.3 Operation

C.10.3.1 Idle mode

The power shall be switched on and the equipment shall be in a steady-state condition, with air-moving device(s), if any, running and the representative pattern shall be displayed on the screen. The keyboard shall not be operated.

Preliminary tests should be run to determine if the emissions are significantly sensitive to the pattern displayed on the screen. If so, a pattern representative of maximum emission values for a typical user shall be determined. If not, the representative pattern shall be defined to be a full character set displayed on the screen and repeated until all positions on the screen are used. The representative pattern used shall be documented and reported.

C.10.3.2 Operating mode (Typing mode), if applicable

The typing mode consists of keying-in the information specified for keyboards (see C.5).

C.10.3.3 Power saving mode

If power saving modes are available, such modes may be tested in addition to the modes defined in C.10.3.1, described and reported.

C.10.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2.

C.11 Equipment category: Electronic units

C.11.1 Description

This category covers 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.11.2 Installation

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

C.11.3 Operation

C.11.3.1 Operating mode

Operate in the steady-state condition 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.11.3.2 Power saving mode

If power saving modes are available, such modes may be tested in addition to the modes defined in C.11.3.1, described and reported.

C.11.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2.

C.12 Equipment category: Microform readers

C.12.1 Description

This category covers equipment to display micro-images. Microform readers may differ from each other, depending on the different types of microforms to be used, such as microfiche, aperture cards and rollfilm.

C.12.2 Installation

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

C.12.3 Operation

C.12.3.1 Idle mode

The power shall be switched on and the equipment shall be ready to display.

C.12.3.2 Operating mode

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

The following two operations may be performed with partial or full automation.

- a) Equipment for microfiche and aperture cards: the micro-image shall be adjusted in two diagonal corners by moving its support; an image shall be kept stationary.
- b) Equipment for rollfilm with a full reel of microfilm loaded into the device: the image approximately in the middle of the film shall be sought and adjusted; the rollfilm shall be transported automatically.

The operation used during the test shall be described in the test report.

C.12.4 Measurement duration

The time-averaged sound pressure level shall be measured for a minimum of three operation cycles and for at least the duration specified in 6.7.2 or 7.7.2.

C.13 Equipment category: Facsimile machines (telecopiers) and page scanners

C.13.1 Description

C.13.1.1 Facsimile machines

This category covers equipment operating as a send/receive machine, basically comprising a numeric keyboard, a paper feeding device, a scanner, a print unit and an electronic send/receive control unit. Telecopiers are used for transmitting text, drawings and graphic information via public transmission networks.

C.13.1.2 Page scanners

This category covers equipment operating as a scanner which detects text, drawing and graphical information from full sheets of paper and comprises a paper feeding device and a scanning mechanism.

C.13.2 Installation

C.13.2.1 General

The facsimile machine shall be installed in accordance with the relevant clauses of this Standard. For the purposes of reporting A-weighted emission sound pressure levels in accordance with ECMA-109, the bystander positions are applicable.

C.13.2.2 Paper

The paper that is used shall be in accordance with the machine manufacturer's instructions. If there are no instructions, either single sheets of paper of grammage 70 g/m² to 80 g/m², or continuous, folded or rolled stationery of grammage 50 g/m² to 60 g/m² shall be used. The width of the rolled stationery shall be typical for the device; if different widths can be used, the most common one shall be used and shall be described in the test report.

Paper storage and unpacking shall be carried out in accordance with the machine manufacturer's instructions. If there are no such instructions, paper shall have been stored unpacked and exposed to the environmental conditions specified in 6.3.2 for at least 24 h immediately prior to the test.

C.13.3 Operation

C.13.3.1 Idle mode

Power shall be switched on and the equipment shall be ready for sending or receiving.

C.13.3.2 Operating mode (Sending or receiving mode)

Information shall be transmitted at a rate and resolution for which the facsimile machine or scanner is designed to be used. If more than one speed and resolution are provided, the one which is typical of the majority of uses shall be employed and reported. If the printing of transmission receipts is the default setting for the equipment, then such printing shall be included in the measurement. Additional conditions may be specified and described in the test report. Both the sending and the receiving modes shall be measured for the facsimile machine. The highest value so determined shall be reported.

C.13.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least one full transmission cycle, in either the sending or the receiving mode, and for at least the duration specified in 6.7.2 or 7.7.2.

C.14 Equipment category: Cheque processors

C.14.1 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.14.2 Installation

C.14.2.1 General

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

C.14.2.2 Paper

C.14.2.2.1 Cheque stock

Typically, a large variety of cheque sizes and grammage of paper are used. To allow a standard method, the following specification defines the properties of the cheques to be used.

- a) Length: 140 mm to 160 mm.
- b) Height: 70 mm to 90 mm.
- c) Grammage: 90 g/m² to 100 g/m².

C.14.2.2.2 Printer paper

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

C.14.3 Operation

C.14.3.1 Idle mode

The power shall be switched on and the equipment ready for use (i.e. stand-by mode).

C.14.3.2 Operating mode

When a cheque-processing system combines several features, a full system operation cycle shall comprise the use of each of those features at least once as described below under their respective operation cycle.

a) Reading

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). Repeated read cycles shall be performed at a rate typical of that expected in use.

b) Printing (or encoding)

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 Table C.2.

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

c) Printing (listing)

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

J1YY7 2DA90 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.

d) Storing/retrieving from disk

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

e) Sorting

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.

Table C.2 — Cheque processor printer types and corresponding print patterns

Printer type	Characters to be printed Print details
Encoder	*0000000085124* (amount field only)
Programmable endorser	J1YY7 2DA90 8S8=2 6A18Q
Fixed endorser	any character

C.14.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2. For the operating mode, the measurement duration shall be at least that of eight complete operation cycles.

C.15 Equipment category: Personal computers and workstations

C.15.1 Description

This category covers small systems such as personal computers, workstations and word 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 disk drives, magnetic tape units or printers.

For equipment which emits sound in the 16 kHz octave band, the procedures specified in ECMA-108 for sound power levels shall be used (see Table 4).

C.15.2 Installation

The constituent units of the system may be tested individually and reported accordingly. In this case the installation conditions are as in 5.1, 8.5 and the relevant clauses of this Annex.

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 setup used recorded.

For the measurement of emission sound pressure levels at operator position, the separate enclosures which comprise the system shall be arranged in a set-up that is typical of actual use. Solely table-top systems shall be installed on the standard test table with all equipment front faces parallel to the front edge of the table. A “flat” table-top system (i.e. the system’s width is greater than its height) shall be centered left to right on the test table (Figure C.4a).

A small tower table-top system (system’s height is greater than its width) shall be placed 0,05 m from the right edge of the test table (Figure C.4b). If a monitor is placed on the table alongside the small tower, then a gap of 0,05 m shall be left between the monitor and the small tower. The keyboard shall be 0,05 m from the front edge of the table. If the system has a detachable keyboard, the system shall be 0,30 m from the front edge of the table. The operator position microphone then is 0,25 m in front of the keyboard or 0,50 m from a system with a detachable keyboard per 8.6.1. It is recommended that the screens of notebook computers be adjusted to be perpendicular to an imaginary line passing from the microphone at the operator’s position to the centre of the screen. If parts of the system are floor-standing and others are table-top, the floor-standing equipment shall be installed on the floor to the operator’s right of the test table and oriented such that the front face of the equipment is parallel to the front edge of the table and even with the table and in the same vertical plane (Figure C.4c). Equipment adjacent to the table

shall be spaced 0,075 m away from the vertical plane formed by the edge of the top of the table. The table-top equipment shall be installed on the test table with all front faces parallel to the front edge of the table. For non-parallelepiped equipment, the orientation shall represent typical use and shall be documented in detail. If the processor is tested individually without the presence of keyboard or monitor, the processor shall be installed according to this paragraph and Figure C.4a, C.4b, or C.4c.

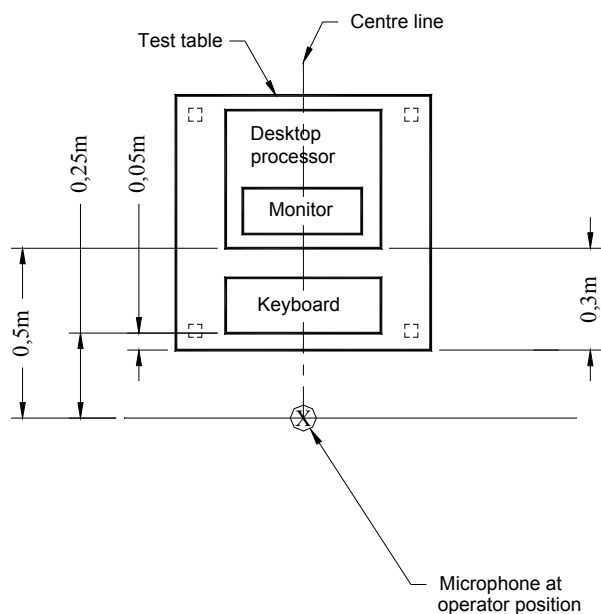


Figure C.4a — Installation for system comprising “flat” table-top equipment

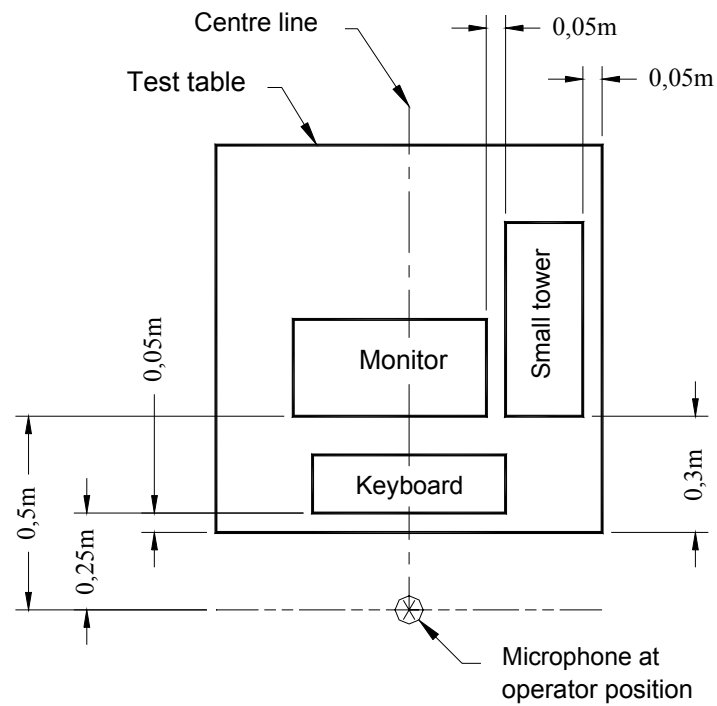


Figure C.4b — Installation for a small tower table-top system

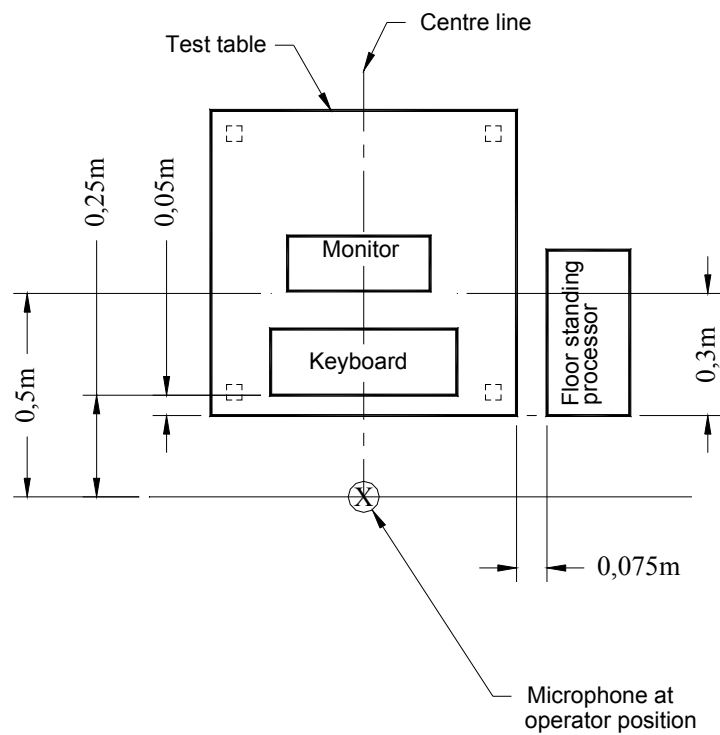


Figure C.4c — Installation for a floor standing system

NOTE

The microphone position shown at a distance 0,25 m from the keyboard was erroneously omitted from ISO 7779.

C.15.3 Operation

Operation of the equipment shall be in accordance with 5.3 and 8.5 for the following modes of operation.

C.15.3.1 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.

If power saving modes are available, such modes may be tested in addition to the above idle mode, and shall be described in the test report.

C.15.3.2 Operating mode(s)

One or more of the following operating modes shall be used where applicable. Noise due to keyboard operation shall not be included.

- a) Equipment with flexible disk drives as specified in C.9.
- b) Equipment with rigid disk drives as specified in C.9.
- c) In combinations of rigid and flexible disk drives, the operating mode is defined as one rigid disk drive operating and all other drives idle as specified in C.9.
- d) Equipment with magnetic tape units as specified in C.8.
- e) Equipment with built-in character and line printers as specified in C.3; equipment with page printers as specified in C.16.
- f) Equipment with optical drives as specified in C.19.
- g) Other types of equipment, as required.

C.15.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2.

C.16 Equipment category: Page printers

C.16.1 Description

This category covers equipment which produces printed output from computers, the noise output of which is independent of what is printed on the page. Such equipment may have peripheral equipment such as envelope feeders, sorters, and special paper feeders. It may print single-sided or two-sided output.

C.16.2 Installation

C.16.2.1 General

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 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 Clause 7 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 for measurements according to 6 or 7 and on the standard test table for measurements according to 8.

C.16.2.2 Paper

The paper to be used shall be in accordance with the machine manufacturer's instructions. If there are no such instructions, either single sheets of paper of grammage 70 g/m^2 to 80 g/m^2 , or continuously folded or rolled stationery of grammage 50 g/m^2 to 60 g/m^2 shall be used. Paper dimensions shall be typical of normal use and shall be described in the test report. For special applications (e.g. when the material to be printed is a label or an envelope) the material shall be typical of customer usage and described in the test report).

Paper storage and unpacking shall be carried out in accordance with manufacturer's instructions. If there are no such instructions, paper shall have been stored unpacked and exposed to the environmental conditions specified in 6.3.2 for at least 24 h immediately prior to the test.

C.16.3 Operation

C.16.3.1 Idle mode

The power shall be switched on and the printer shall be ready for printing.

NOTE

If the page printer has both standby and ready modes, the idle mode corresponds to the standby mode.

C.16.3.2 Operating mode (Print mode)

A print job (consisting of a text pattern) shall be sent to the printer such that it will print at its rated speed.

C.16.3.2.1 Single-sheet printers

Operation of such printers shall comprise the continuous printing of one side of single sheets for at least three sheets. If printing on both sides of sheets is available, this mode shall also be measured. The mode having the higher A-weighted sound power level shall be reported. Operation shall be performed for the required measurement duration.

C.16.3.2.2 Continuous-form printers

Operation of such printers shall comprise the continuous printing of at least three pages of folded stationery or a length of 2 m for rolled stationery.

C.16.3.2.3 Operation cycle with features

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

a) Sorter

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

b) Stacking

If the printer is equipped with an accessory or integral mechanism to separate jobs generated sequentially, an operation cycle shall comprise two jobs and print one page for each of them.

c) Auxiliary equipment

If the printer is supplied with auxiliary equipment (e.g. a mechanism for cutting continuous forms), the tests shall be carried out with and without the use of such equipment in the operation cycle.

C.16.4 Measurement duration

For each set-up the time-averaged sound pressure level shall be measured, for at least the duration specified in 6.7.2 or 7.7.2, for a minimum of three operation cycles for single-sheet printers (C.16.3.2.1) and for one operation cycle for continuous-form printers (C.16.3.2.2) and for at least one operation cycle with auxiliary features (C.16.3.2.3).

C.17 Equipment category: Self-service automatic teller machines

C.17.1 Description

Equipment of this category is mainly used in banking environments and provides various services to customers, such as cash dispense, funds transfer between accounts, account balance inquiry, balance statement issuing and envelope deposit.

Depending on the purpose of the equipment, a variety of different functions can be performed and combined in one machine. Typical examples for operating modes are specified in C.17.3; it is not assumed that these conditions apply to all cases, therefore, the test conditions used shall be described in the test report.

C.17.2 Installation

The equipment shall be installed in accordance with the relevant clauses of this Standard. For the purposes of reporting A-weighted emission sound pressure levels in accordance with ECMA-109, the bystander positions are applicable.

C.17.3 Operation

C.17.3.1 Idle mode

The power shall be switched on and the equipment shall be ready for use.

C.17.3.2 Operating mode

The operating mode which is typical for average customer usage shall be defined and reported. For some equipment, examples are defined as follows.

a) Money dispenser

Operation comprises card insertion, key-in personal identification number (PIN), task selection (e.g. cash issue), selection of amount of money, issue card, open cash gate, issue cash, issue receipt and close cash gate.

b) Passbook operation

Operation comprises

- insert passbook, read magnetic stripe data, key-in PIN, print one line in passbook, write and verify magnetic stripe data and issue passbook, or
- insert passbook, read magnetic stripe data, key-in PIN, task selection (e.g. cash issue), selection of amount, write and verify magnetic stripe data, issue passbook and issue cash.

c) Banking information print-out

Operation comprises check card insertion, key-in PIN, task selection (e.g. statement of account), issue card, print output and issue output.

d) Cash envelope deposit

Operation comprises card insertion, key-in PIN, task selection (e.g. cash deposit), key-in amount of deposit, insert envelope into depository device, remove card and receipt.

C.17.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2. For the operating mode, an average value shall be determined for at least three typical transactions, during which manual access may be needed, which however shall not be intentionally delayed.

C.18 Equipment category: Enclosures or rack systems

C.18.1 Description

This category covers systems comprising several similar or different system sub-assemblies which are installed in a rack or enclosure. The sub-assemblies can have different configurations as required by the user to meet specific requirements. The sub-assemblies may be self-contained with their own power supplies and cooling assemblies, or may rely on power supplies and cooling assemblies installed separately in the rack or enclosure.

NOTE

This equipment category does not include sub-assemblies not installed in a rack or enclosure.

C.18.2 Installation

The constituent sub-assemblies of the system may be tested in the rack or enclosure and reported individually, or the system may be tested and reported as a whole for a specified configuration.

When sub-assemblies are tested individually in the rack or enclosure, they shall be installed in the position specified in the rack or enclosure manufacturer's installation manual with all other positions either empty with blanking plates in place and/or filled with unpowered sub-assemblies. Only the noise of the sub-assembly shall be reported together with its position in the rack or enclosure. All necessary external devices such as power supplies and cooling assemblies housed separately in the rack or enclosure shall be considered as sub-assemblies and measured and reported accordingly.

For configurations tested as complete systems the sub-assemblies shall be installed in the positions specified in the rack or enclosure manufacturer's installation manual for a given configuration and shall be described in the test report.

The installation conditions for the rack or enclosure systems are as specified in 5.1, 8.5 and the relevant clauses of this Annex.

C.18.3 Operation

Operation of the equipment shall be in accordance with 5.3 for the following modes of operation.

C.18.3.1 Idle mode

The power shall be switched on, and all sub-assemblies shall be in idle mode ready to receive command signals from the system CPU.

C.18.3.2 Operating mode

One or more of the following operating modes should be used as applicable:

- a) rigid and flexible disk drives as specified in C.9;
- b) magnetic tape units as specified in C.8;
- c) built-in character and line printers as specified in C.3; equipment with page printers as specified in C.16;
- d) other types of equipment as required.

NOTE

Measurements on individual disk drives should be made at the seek rate typical of the multiple-drive configuration if system limitations do not allow the seek rate specified in C.9. This is necessary so as not to overestimate the system noise emission levels as calculated in accordance with C.18.5 from individual measurements.

C.18.4 Measurement duration

The time-averaged sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2 and as further required in this Annex for the operation of the sub-assemblies.

C.18.5 Calculation of the system A-weighted sound power level and system A-weighted emission sound pressure level from sub-assembly sound levels

The system A-weighted emission sound power level shall be calculated using the following equation:

$$L_{WA,sys} = 10 \lg \sum_{i=1}^n 10^{(0,1L_{WAi})} \text{ dB}$$

where

$L_{WA,sys}$ is the system A-weighted sound power level, in decibels;

L_{WAi} is the A-weighted sound power level of the i-th sub-assembly installed in a rack or enclosure;

n is the number of sub-assemblies.

The system A-weighted emission sound pressure level shall be calculated using the following equation:

$$L_{pA,sys} = 10 \lg \sum_{i=1}^n 10^{(0,1L_{pAi})} \text{ dB}$$

where

$L_{pA,sys}$ is the system A-weighted emission sound pressure level, in decibels;

L_{pAi} is the A-weighted emission sound pressure level of the i-th sub-assembly installed in a rack or enclosure;

n is the number of sub-assemblies installed and tested.

C.18.6 Calculation of A-weighted sound power level and A-weighted emission sound pressure level for low noise level sub-assemblies

In some cases the noise level of sub-assemblies may be within 6 dB of the background noise level which would preclude an accurate value if measured individually. In this case enough identical sub-assemblies shall be tested and measured in the enclosure, so that the noise level of the n sub-assemblies is sufficiently greater than the background noise level (it may be convenient to test the maximum number allowed).

The sub-assembly A-weighted sound power level shall be calculated from the following equation:

$$L_{WA,s} = L_{WA,sn} - 10 \lg n \text{ dB}$$

where

$L_{WA,s}$ is the averaged individual sub-assembly A-weighted sound power level, in decibels;

$L_{WA,sn}$ is the total A-weighted sound power level for n identical installed sub-assemblies, in decibels;

n is the number of sub-assemblies installed and tested.

The sub-assembly A-weighted emission sound pressure level shall be calculated from the following equation:

$$L_{pA,s} = L_{pA,sn} - 10 \lg n \text{ dB}$$

where

$L_{pA,s}$ is the sub-assembly A-weighted emission sound pressure level, in decibels;

$L_{pA,sn}$ is the total A-weighted sound pressure level for n identical installed sub-assemblies, in decibels;

n is the number of sub-assemblies installed and tested.

C.19 Equipment category: CD-and DVD-ROM drives

C.19.1 Description

Equipment for reading electronic information from a rotating read-only optical disk (for example, CD-ROM or DVD-ROM) or other optical media operated in a substantially sequential access manner.

C.19.2 Installation

C.19.2.1 General

Installation shall be according to 5.1 and 8.5. A drive which forms part of a personal computer or rack mounted equipment shall be installed according to C.15 or C.18 as appropriate. A drive which is tested as a sub-assembly shall be installed as a sub-assembly per 5.1.7.

C.19.2.2 Media

The unbalance U_d of test media, defined in the following equation, shall be $2,5 \text{ g}\cdot\text{mm} \pm 10\%$.

$$U_d = m_d \cdot r$$

where

m_d is the mass of the disk, in grams (g),

r is the distance between the centre of gravity and the geometrical centre of the disk, in millimetres (mm)

NOTE 1

More detailed and specific information on the disk media is available [8].

Since (1) the measurement of unbalance is not an objective of this Standard, (2) test media satisfying this requirement is commercially available from several sources¹, and (3) it is not possible for most users of this Standard to adjust media to meet the criteria for unbalance, while they can only measure the value, it is recommended to use a dedicated test media which has the unbalance specified above.

NOTE 2

This media unbalance requirement is based on several considerations as follows.

C.1 requires that the operation be "typical of average end use". Conditions are to be "specified with a view to facilitate the operation of the equipment and to enhance the reliability of the acoustical measurements". The disk unbalance of $2,5 \text{ g}\cdot\text{mm} \pm 10\%$ is specified as "typical of average end use" and is also consistent with reliable acoustical measurements, since this degree of unbalance avoids causing some drives to slow down. Technical details justifying this are contained in [9].

C.19.3 Operation

C.19.3.1 Idle mode

Except for short-duration transients, idle modes are considered non-rotational and inaudible. Therefore measurement of the idle mode is not required.

In cases where the drive under test incorporates cooling assemblies for its normal operation, the cooling noise shall be measured as a part of noise of the drive.

¹ For instance, Almedio, 2-32-13 Sakae-cho, Higashimurayama, Tokyo, Japan, offers such disks (<http://www.almedio.co.jp>).

C.19.3.2 Operating mode

For units having a single drive, the drive shall be operating as described below.

For units with multiple drives the number of drives that are simultaneously operable by the host CPU shall be operated as specified below. All other drives shall be in the idle mode, typical of normal use for the system.

Start sequential read at the inner radius of the disk (or media) such that the disk spins continuously at the fastest speed sustainable with the specified media. Repeat the above read process until the measurement duration specified in C.19.4 elapses.

C.19.4 Measurement duration

The time-average sound pressure level shall be measured for at least the duration specified in 6.7.2 or 7.7.2.

C.20 Equipment category: Data projectors

C.20.1 Descriptions

This category covers equipment driven by a computer input signal, for making an image projection, and by using a built-in light valve (see below definition) or other technology.

The scope of this Standard does not include equipment that is intended or designed for permanent outdoor installation.

The equipment may also have video input, but equipment having only video input is excluded.

Definition C.1 light valve

A sub-system or key component of a projector which builds up an optical image from that produced electrically within the image displaying element, by casting light from another light source

NOTE

Still-projectors for film media (e.g. slide, OHP etc.) are covered by ISO 10996.

C.20.2 Installation

C.20.2.1 General

The equipment shall be installed in accordance with the relevant clauses of this Standard (i.e., 5.1 and 8.5 as applicable).

If the projector under test can make both front and rear screen projection, front screen projection configuration is applicable.

Definition C.2 front screen projection

Image projected on the audience side of a light-reflecting screen

Definition C.3 rear screen projection

Image projected through a light transmitting screen to the audience side of the screen

NOTE

Definitions C.2 and C.3 above are consistent with those specified in IEC 61947-1 and IEC 61947-2.

For the purpose of declaring A-weighted emission sound pressure level according to ECMA-109, the bystander positions are applicable.

C.20.2.2 Warm up time

The equipment shall be operated for a sufficient period of time before proceeding with the acoustical test to allow the temperature to stabilize. If this time is unknown, the equipment shall be operated at least 30 min before the acoustical test.

C.20.2.3 Special considerations for test personnel safety

Due to the nature of these products, a data projector emits a strong light beam. Therefore, it is necessary to pay special attention to protect the test personnel's eyes.

For the purposes of this Standard, it is strongly recommended to switch the lamp off while positioning the microphones.

C.20.3 Operation

C.20.3.1 General

For the operation of this category of equipment (including idle mode), the lamp on or off are expressions based on light valve technology. For projectors based on other technology, the corresponding operations are to be defined in a similar manner to those contained below.

C.20.3.2 Idle mode

A stable condition in which the equipment is powered, but the lamp is not on. Transient periods, such as that immediately after switching the lamp off, are excluded. For some projectors, operation during idle mode may not be possible in which case noise measurements are not required.

C.20.3.3 Operating mode

A stable condition in which the equipment is powered with the lamp on. For the purposes of this Standard, if the noise emissions are dependent upon the image projected, the equipment shall project the image of Figure A.1 of IEC 61947-1 or of Figure A.1 of IEC 61947-2, as applicable.

NOTE

IEC 61947-1 and IEC 61947-2 are applicable to projectors with fixed and variable resolution respectively.

Transient periods, such as those immediately after switching the lamp on, are excluded.

C.20.4 Measurement duration

The time-averaged sound pressure levels shall be measured for at least the duration specified in 6.7.2 and 7.7.2.



Annex D (informative)

Identification and evaluation of prominent discrete tones

D.1 Field of application

This Annex describes two procedures for determining whether or not noise emissions contain prominent discrete tones: the tone-to-noise ratio method and the prominence ratio method.

Declaration of product noise emissions in accordance with ECMA-109 offers the option of stating whether or not there are prominent discrete tones in the noise emissions of a product, as determined by this Annex. Other standards, or other test codes relating to products besides information technology and telecommunications equipment, may also refer to this Annex for the declaration of prominent tones. For the purposes of such declarations, either the tone-to-noise ratio method or the prominence ratio method may be used, unless otherwise specified in the standard or test code.

NOTE 1

The tone-to-noise ratio method may prove to be more accurate for multiple tones in adjacent critical bands, for example when strong harmonics exist. The prominence ratio method may be more effective for multiple tones within the same critical band, and is more readily automated to handle such cases.

NOTE 2

In the methods prescribed in this Annex a difficulty arises when a tone exists within, but near the upper or lower limit of, the frequency range of interest. One needs a measurement of masking noise outside this stated range to determine whether the tone is prominent, but such a measurement outside the range does not have well-defined measurement precision, calibration tolerance, reverberant sound limits, or background noise limits.

This Annex permits measurement outside the stated frequency range of interest for the purposes of determining whether an audible tone is prominent. No correction shall be made for background noise or reflections.

D.2 Background

A discrete tone which occurs together with broadband noise is partially masked by that part of 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 in the presence of noise 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 centred around the tone. This is the threshold of audibility. For the purposes of this Annex, a discrete tone is classified as *prominent* when using the tone-to-noise ratio method if the sound pressure level of the tone exceeds the sound pressure level of the masking noise in the critical band by 8 dB for tone frequencies of 1 000 Hz and higher, and by a greater amount for tones at lower frequencies. This corresponds, in general, to a tone being prominent when it is more than 12 dB above the threshold of audibility. When using the prominence ratio method, a tone is classified as *prominent* if the difference between the level of the critical band centred on the tone and the average level of the adjacent critical bands is equal to or greater than 9 dB for tone frequencies of 1 000 Hz and higher, and by a greater amount for tones at lower frequencies. Reference [11] provides the basis for these values.

D.3 Microphone position

If the equipment has an operator position, the measurements shall be performed at the operator position. If there is more than one operator position, the measurements described below shall be performed at the operator position with the highest A-weighted sound pressure level.

If the equipment has no operator position, the measurements shall be performed at the bystander position with the highest A-weighted sound pressure level and at all other bystander positions having A-weighted sound pressure levels within 0,5 dB of it to determine the tone-to-noise ratios or prominence ratios.

When the methods of this Annex are to be applied to sub-assemblies, the sub-assembly shall be installed as in either 5.1.7 or 8.5 and the measurements shall be performed at the bystander position with the highest A-weighted sound pressure level and at all other bystander positions having A-weighted sound pressure levels within 0,5 dB of this one.

D.4 Instrumentation

A digital Fast Fourier Transform (FFT) analyzer capable of measuring the power spectral density of the microphone signal shall be used for the measurements of this Annex.

The analyzer must have rms averaging (linear averaging, rather than exponential averaging) capabilities, a Hanning time window function, an upper frequency limit high enough to allow computing the quantities required herein for the particular tone under investigation, and a frequency bandwidth resolution less than one per cent of the frequency of the tone.

The microphone output signal fed to an FFT analyzer shall meet the requirements for class 1 sound level meters stated in IEC 61672-1. Because the procedures of this Annex include the option of working directly in terms of sound pressure levels, the FFT analyzer (or, alternatively, the software used for post-processing of the FFT data) should allow calibration directly in terms of sound pressure levels in decibels (reference 20 μ Pa).

No frequency weighting function (e.g., A-weighting) shall be applied to the analyzer input signal.

The FFT analysis shall use a sufficient number of averages to provide an analysis time satisfying 8.7.2.

D.5 Audibility requirement

Discrete tones should only be classified as prominent if they are, in fact, audible. Therefore, an initial aural examination of the noise emitted from the equipment under test shall be made at the specified microphone position, with the following cases applied.

1. If one or more discrete tones are audible, then the measurement procedures of this Annex for either the tone-to-noise ratio or prominence ratio, or both, shall be carried out for each audible tone. If the criterion for prominence in either D.7.5 or D.8.6 is met for a particular tone, the tone is classified as *prominent*.
2. If no tones are audible, the procedures of this Annex need not be carried out and a statement such as "no audible discrete tones" or "no prominent discrete tones" may be included in the report.
3. If there is doubt as to whether or not audible tones are present (e.g., if the test engineer is not a trained or experienced listener), then other, more objective evidence should be sought. It is recommended that a preliminary FFT or other narrow-band spectrum be taken of the noise. If the spectrum indicates that audible tones may be present (i.e., if it shows one or more sharp spikes), then the following audibility test should be performed for each potential tone. A sinusoidal signal corresponding to the frequency of the tone in question should be generated and listened to, and compared to the noise from the product, noting whether or not a tone at the same frequency is audible in the product noise emissions. If it is not, then the procedures of this Annex need not be carried out for the tone; it is not audible and would not be classified as "prominent." If the tone is audible, it is treated as in case 1 above.

D.6 Critical bandwidths

The width of the critical band Δf_c , centred at any frequency f_0 , can be calculated from the following equation [12]:

$$\Delta f_c = 25,0 + 75,0 \times [1,0 + 1,4 \times (f_0 / 1000)^2]^{0,69} \quad (D,1)$$

(for example, $\Delta f_c = 162,2$ Hz for $f_0 = 1\,000$ Hz and $\Delta f_c = 117,26$ Hz for $f_0 = 500$ Hz).

For the purposes of this Annex, the critical band is modelled as an ideal rectangular filter with centre frequency f_0 , lower band-edge frequency f_1 , and upper band-edge frequency f_2 , where

$$f_0 = \sqrt{f_1 \times f_2} \quad (D,2)$$

and

$$f_2 - f_1 = \Delta f_c \quad (D,3)$$

Solving (D,2) and (D,3) for the band-edge frequencies yields:

$$f_1 = -\frac{\Delta f_c}{2} + \frac{\sqrt{(\Delta f_c)^2 + 4f_0^2}}{2} \quad \text{and} \quad (D,4)$$

$$f_2 = f_1 + \Delta f_c \quad (D,5)$$

D.7 Tone-to-noise ratio method

D.7.1 FFT measurement

The operating procedures for the FFT analyzer shall be followed to acquire the power spectral density (or sound pressure level) of the signal at the measurement position, for the same mode(s) of operation and measurement conditions as used for the measurements in 8.7, employing the Hanning time window and rms averaging (linear averaging). No frequency weighting, such as A-weighting, shall be applied to the signal fed to the FFT analyzer. The FFT analysis shall use a sufficient number of averages to provide an analysis time satisfying 8.7.2. Zoom analysis should be used with the centre frequency of the zoom band corresponding, approximately, to the frequency of the discrete tone, and the width of the zoom band at least equal to, and preferably slightly greater than, the width of the critical band.

NOTE

The power spectral density of a signal is usually calculated and displayed as a mean-square value of some quantity per hertz (e.g., a mean-square voltage per hertz (V^2/Hz) or a mean-square sound pressure per hertz (Pa^2/Hz), versus frequency. For the purposes of determining the tone-to-noise ratio, ΔL_T , the units of the measured power spectral density are not important, and absolute calibration of the analyzer to some reference quantity (such as 1 V or 20 μPa) is unnecessary. However, calibration of the instrument in pascals-squared per hertz will enable sound pressure level quantities to be readily obtained. The procedures in this Annex assume this calibration and the text is written in terms of the "mean-square sound pressure," but to indicate that any quantity may be used, the symbol has been chosen as "X".

D.7.2 Determination of tone level

The mean-square sound pressure of the tone, X_t , (or the tone sound pressure level, L_t) is determined from the FFT spectrum measured above by computing the mean-square sound pressure in the narrow band that "defines" the tone. The width of this frequency band, Δf_t , in hertz, is equal to the number of discrete data points ("lines") included in the band, times the resolution bandwidth ("line spacing"). If the width of the frequency band selected for the purpose of computing X_t is greater than 15% of the width of the critical band centred at the

frequency of the tone, the FFT spectrum should be repeated with a smaller resolution bandwidth.

For the determination of the mean-square sound pressure of the tone (or tone sound pressure level) for multiple tones in a single critical band see D.7.6.

NOTE

Care should be taken when selecting the bandwidth Δf_t to delineate the discrete tone, especially when automated procedures are being used. If the band is too narrow, the mean-square sound pressure of the tone (or the tone sound pressure level) will be underestimated and the mean-square sound pressure of the noise (see D.7.3) will be overestimated. If the band is too wide, masking noise or secondary tones may be erroneously included with the tone computations and omitted from the noise computation.

D.7.3 Determination of masking noise level

For the purposes of this Annex, the mean-square sound pressure of the masking noise, X_n , (or the masking noise sound pressure level, L_n) is taken as the value determined using the following two-step procedure.

The first step is to compute the total mean-square sound pressure (or the total sound pressure level) in the critical band. The width of the critical band is determined from equation (D,1) with f_0 set equal to the frequency of the tone under investigation, f_t , and with lower band-edge frequency f_1 and upper band-edge frequency f_2 as given in equation (D,4) and equation (D,5), respectively.

From the FFT spectrum, the total mean-square sound pressure, X_{tot} , (or the total sound pressure level, L_{tot}) of the critical band is computed. Depending on the particular instrumentation used, this may be performed on the FFT analyzer itself using band cursors, on an external computer using appropriate software, or by some other means. In any event, the width of the frequency band used to compute this value, Δf_{tot} , in hertz, is equal to the number of discrete FFT data points included in the band times the resolution bandwidth.

The second step is to calculate the masking noise mean-square sound pressure, X_n , (or the masking noise sound pressure level, L_n) from the following equation:

$$X_n = (X_{tot} - X_t) \frac{\Delta f_c}{(\Delta f_{tot} - \Delta f_t)} \quad (D,6A)$$

or

$$L_n = 10 \lg(10^{0,1L_{tot}} - 10^{0,1L_t}) + 10 \lg\left(\frac{\Delta f_c}{\Delta f_{tot} - \Delta f_t}\right) \text{ dB} \quad (D,6B)$$

For the determination of the mean-square sound pressure of the masking noise (or the noise sound pressure level) for multiple tones in a critical band, see D.7.6.

NOTE

The equation (D,6A) [or equation (D,6B)] accounts for both the fact that the FFT analyzer bandwidth, Δf_{tot} , used to compute X_{tot} (or L_{tot}) may not be exactly equal to the critical bandwidth, Δf_c , and the fact that the calculated mean-square sound pressure ($X_{tot} - X_t$), [or the calculated sound pressure level, $10 \lg(10^{0,1L_{tot}} - 10^{0,1L_t})$] does not include the noise contained in the narrow band Δf_t .

D.7.4 Determination of the tone-to-noise ratio

The tone-to-noise ratio, in decibels, is calculated as follows:

$$\Delta L_T = 10 \lg(X_t / X_n) \text{ dB} \quad (D,7A)$$

or

$$\Delta L_T = L_t - L_n \text{ dB} \quad (\text{D},7\text{B})$$

For the determination of the tone-to-noise ratio for multiple tones in a critical band, see D.7.6.

D.7.5 Prominent discrete tones

A discrete tone is classified as *prominent* according to the tone-to-noise ratio method if

$$\Delta L_T \geq 8,0 \text{ dB} \quad \text{for } f_t \geq 1\,000 \text{ Hz}, \quad (\text{D},8\text{A})$$

or

$$\Delta L_T \geq 8,0 + 8,33 \times \lg(1000/f_t) \text{ dB} \quad \text{for } f_t < 1\,000 \text{ Hz}, \quad (\text{D},8\text{B})$$

and the discrete tone meets the audibility requirement of D.5. The criteria in equations (D,8A) and (D,8B) are illustrated graphically in Figure D.4.

D.7.6 Multiple tones in a critical band.

The noise emitted by a machine may contain multiple tones, and several of these may fall within a single critical band. If one or more tones are audible, the procedure above is followed for each tone, with the following differences. The tone with the highest level in the critical band is identified as the primary tone, and its frequency is denoted as f_p . For the critical band centred on this primary tone, the tone with the second highest level is identified as the secondary tone and its frequency denoted as f_s .

If the secondary tone is sufficiently close in frequency to the primary tone, then the two are considered to be perceived as a single discrete tone and the prominence is determined by combining their mean-square sound pressures (or sound pressure levels). Two tones may be considered sufficiently close or “proximate” if their spacing $\Delta f_{s,p} = |f_s - f_p|$ is less than the proximity spacing defined as follows [13]:

$$\Delta f_{\text{prox}} = 21 \times 10^{1,2 \times [\lg(f_p/212)]^{1,8}} \text{ Hz, for } 88 < f_p < 1000 \text{ Hz} \quad (\text{D},9)$$

(for example, $\Delta f_{\text{prox}} = 23 \text{ Hz}$ for $f_p = 150 \text{ Hz}$; and $\Delta f_{\text{prox}} = 64 \text{ Hz}$ for $f_p = 850 \text{ Hz}$).

If the proximity criterion $\Delta f_{s,p} < \Delta f_{\text{prox}}$ is met, then the mean-square sound pressure of the secondary tone, $X_{t,s}$, is added to the mean-square sound pressure of the primary tone, $X_{t,p}$, when calculating the mean-square sound pressure of the tone, X_t , and subtracted from the total mean-square sound pressure, X_{tot} , before calculating the tone-to-noise ratio ΔL_T . (When working with sound pressure levels for this case, the sound pressure level of the secondary tone, $L_{t,s}$, is combined on an energy basis with the sound pressure level of the primary tone, $L_{t,p}$, and subtracted on an energy basis from the total sound pressure level of the noise, L_{tot}). For tone frequencies higher than 1 kHz, the proximity spacing, Δf_{prox} exceeds half the width of the critical band, so the criterion is always met. Thus, in equation form:

$$X_t = (X_{t,p} + X_{t,s}) \quad (\text{D},10\text{A})$$

or

$$L_t = 10 \lg \left[10^{0,1L_{t,p}} + 10^{0,1L_{t,s}} \right] \quad (\text{D},10\text{B})$$

and

$$X_n = [X_{\text{tot}} - (X_{t,p} + X_{t,s})] \times \left[\frac{\Delta f_c}{\Delta f_{\text{tot}} - (\Delta f_{t,p} + \Delta f_{t,s})} \right] \quad (\text{D},11\text{A})$$

or

$$L_n = 10 \lg \left(10^{0,1L_{\text{tot}}} - (10^{0,1L_{t,p}} + 10^{0,1L_{t,s}}) \right) + 10 \lg \left(\frac{\Delta f_c}{\Delta f_{\text{tot}} - (\Delta f_{t,p} + \Delta f_{t,s})} \right). \quad (\text{D},11\text{B})$$

With the above values for X_n and X_t , (or L_n and L_t), equation (D,7) is used to compute the tone-to-noise ratio.

If the proximity criterion is not met, then the tones are considered to be perceived as separate tones and are treated individually. In this case, the mean-square sound pressure of the secondary tone is removed from the mean-square sound pressure of the masking noise (but otherwise ignored; i.e., not added to the mean-square value of the primary tone) before calculating the tone-to-noise ratio of the primary tone. [When working with sound pressure levels for this case, the sound pressure level of the secondary tone is subtracted on an energy basis from the sound pressure level of the noise (but otherwise ignored; i.e., not combined with the sound pressure level of the primary tone) before calculating the tone-to-noise ratio of the primary tone.] In this case, either equation (D,11A) [or equation (D11,B)] applies directly, but the mean-square sound pressure of the tone is taken as either $X_t = X_{t,p}$ when evaluating the primary tone or $X_t = X_{t,s}$ when evaluating the secondary tone [or, similarly, the tone sound pressure level is taken as either $L_t = 10 \lg(10^{0,1L_{t,p}})$ or $L_t = 10 \lg(10^{0,1L_{t,s}})$]. With this value for X_t , with X_n above, (or this value of L_t , with L_n above) equation (D,7) is used to compute the tone-to-noise ratio.

D.7.7 Complex tones containing harmonic components

Although laboratory-generated discrete tones may be pure sinusoids, most of the discrete tones that occur in the noise emissions from real machinery and equipment are not. As such, the FFT spectrum will generally show a series of tonal components (called harmonics, overtones, or partials) at integral multiples of some fundamental frequency. Usually the fundamental is the strongest component, but this is not always the case. For the purposes of this Annex, each tonal component in the harmonic series which meets the audibility requirement of D.5 shall be evaluated independently.

D.7.8 Example (tone-to-noise ratio method)

A sound pressure level spectrum is shown in Figure D.1. This Figure shows how a single tone in a critical band is analyzed using the tone-to-noise ratio method. Figure D.2 shows how the tone-to-noise ratio method is used when multiple tones exist in a critical band.

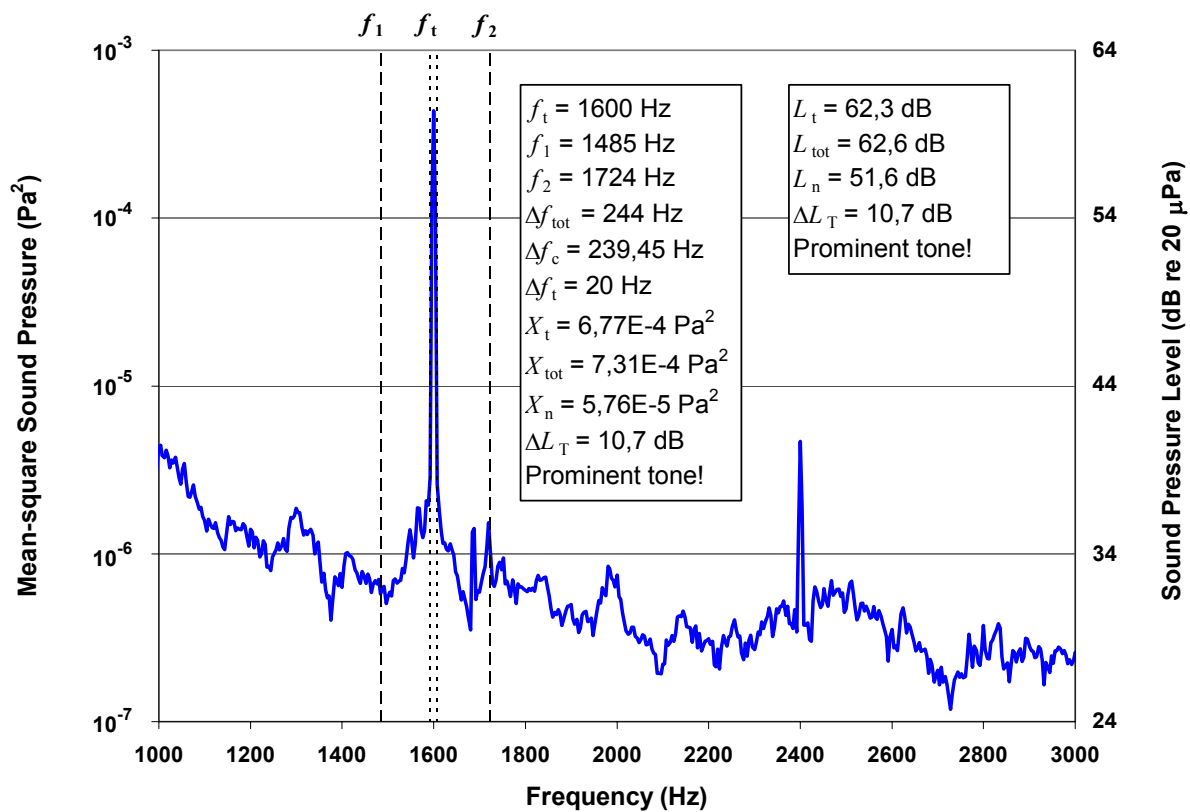


Figure D.1 — Tone-to-noise ratio method applied to a single tone in a critical band

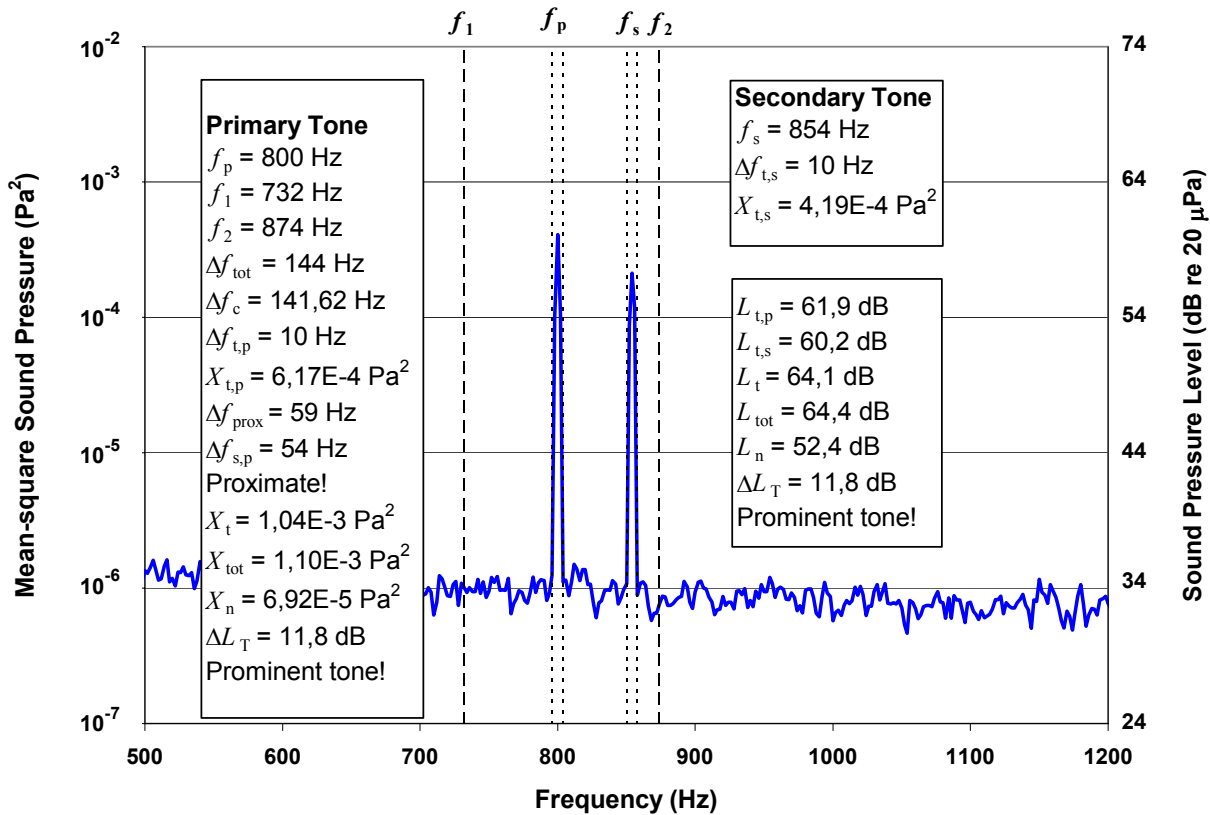


Figure D.2 — Tone-to-noise ratio method applied to multiple tones in a critical band

D.8 Prominence ratio method

D.8.1 FFT measurement

The operating procedures for the FFT analyzer shall be followed to acquire the power spectral density (or sound pressure level) of the signal at the measurement position, for the same mode(s) of operation and measurement conditions as used for the measurements in 8.7, employing the Hanning time window and rms averaging (linear averaging). No frequency weighting, such as A-weighting, shall be applied to the signal fed to the FFT analyzer. The FFT analysis shall use a sufficient number of averages to provide an analysis time satisfying 8.7.2. Zoom analysis should be used with the centre frequency of the zoom band corresponding, approximately, to the frequency of the discrete tone, and the width of the zoom band equal to about 4 times the width of the critical band.

NOTE

The power spectral density of a signal is usually calculated and displayed as a mean-square value of some quantity per hertz (e.g., a mean-square voltage per Hz (V^2/Hz) or a mean-square sound pressure per hertz (Pa^2/Hz), versus frequency. For the purposes of determining the prominence ratio, ΔL_P , the units of the measured power spectral density are not important, and absolute calibration of the analyzer to some reference quantity (such as 1 V or 20 μPa) is unnecessary. However, calibration of the instrument in pascals-squared per hertz will enable sound pressure level quantities to be readily obtained. The procedures in this Annex assume this calibration and the text is written in terms of the "mean-square sound pressure," but to indicate that any quantity may be used, the symbol has been chosen as "X".

D.8.2 Determination of the level of the middle critical band

The mean-square sound pressure of the middle critical band, X_M , is defined as the total mean-square sound pressure contained in the critical band centred on the tone under investigation. (When working with sound pressure levels, this quantity becomes the sound pressure level of the middle critical band, L_M .) The width of the middle critical band, Δf_M , as well as the lower and upper band-edge frequencies, $f_{1,M}$ and $f_{2,M}$ are determined from the relationships in D.6 with f_0 set equal to the frequency of the tone under investigation, f_t . The band-edge frequencies then become:

$$f_{1,M} = -\frac{\Delta f_M}{2} + \frac{\sqrt{(\Delta f_M)^2 + 4f_t^2}}{2} \quad (D,12)$$

and

$$f_{2,M} = f_{1,M} + \Delta f_M \quad (D,13)$$

(e.g., $f_{1,M} = 922,2\text{Hz}$ and $f_{2,M} = 1084.4\text{Hz}$ when $f_t = 1\ 000\text{Hz}$).

The value of X_M (or L_M) is determined from the FFT spectrum by bracketing the data points lying between $f_{1,M}$ and $f_{2,M}$ and computing the mean-square sound pressure of the middle critical band (or the sound pressure level of the middle critical band). Depending on the particular instrumentation used, this may be performed on the FFT analyzer itself using band cursors, on an external computer using appropriate software, or by some other means.

D.8.3 Determination of the level of the lower critical band

The mean-square sound pressure of the lower critical band, X_L , is defined as the total mean-square sound pressure contained in the critical band immediately below, and contiguous with, the middle critical band defined in D.8.2. (When working with sound pressure levels, this quantity becomes the sound pressure level of the lower critical band, L_L .) The relationships in D.6 govern this lower critical band, with centre frequency $f_{0,L}$, bandwidth Δf_L , and lower and upper band-edge frequencies $f_{1,L}$ and $f_{2,L}$, respectively. Since this lower critical band must be contiguous with the middle critical band, $f_{2,L} = f_{1,M}$. However, because $f_{0,L}$ is not known *a priori*, the equations in D.6 cannot be used directly, and the lower band-edge frequency $f_{1,L}$ must be computed by iteration. Generally, the iterative process is as follows: (i) make a guess for $f_{0,L}$; (ii) use the equations in D.6 to compute Δf_L , $f_{1,L}$, and $f_{2,L}$ for the lower band; (iii) compare the computed value of $f_{2,L}$ to $f_{1,M}$; and (iv) if necessary, make a better guess for $f_{0,L}$ and repeat the process until the computed value of $f_{2,L}$ compares to $f_{1,M}$ to within a specified precision. For the purposes of this Annex, the precision shall be set to 0,1%; i.e., $|(f_{1,M} - f_{2,L})/(f_{1,M})| \times 100 \leq 0,1$.

NOTE

An acceptable alternative method for computing $f_{1,L}$ and $f_{2,L}$ is linear interpolation between tabulated values in Tables 1 and 2 of Reference 14. However, the range of these tables is limited to tone frequencies less than or equal to 6000 Hz.

For tone frequencies below 163,5 Hz, the lower band-edge frequency for the lower critical band would compute to less than 20 Hz, the accepted lower limit of human hearing. For such cases, the lower band-edge frequency shall be set equal to 20 Hz (so that the band used for the determination of X_L extends from 20 Hz up to $f_{2,L}$). The width of this lower band, Δf_L , will now be less than the width of the true critical band, and the determination of the prominence ratio takes this into account (see D.8.5).

The value of X_L (or L_L) is determined from the FFT spectrum by bracketing the data points lying between $f_{1,L}$ and $f_{2,L}$ and computing the mean-square sound pressure (or the sound pressure level) of the lower critical band. Depending on the particular instrumentation used, this may be performed on the FFT analyzer itself using band cursors, on an external computer using appropriate software, or by some other means. Care should be taken to ensure that the lower critical band and the middle critical band do not overlap computationally; i.e., that the FFT data point(s) closest to the common band edge is (are) assigned uniquely to one band or the other, and not both.

D.8.4 Determination of the level of the upper critical band

The mean-square sound pressure of the upper critical band, X_U , is defined as the total mean-square sound pressure contained in the critical band immediately above, and contiguous with, the middle critical band defined in D.8.2. (When working with sound pressure levels, this quantity becomes the sound pressure level of the upper critical band, L_U .) The relationships in D.6 govern this upper critical band, with centre frequency $f_{0,U}$, bandwidth Δf_U , and lower and upper band-edge frequencies $f_{1,U}$ and $f_{2,U}$, respectively. Since this lower critical band must be contiguous with the middle critical band, $f_{1,U} = f_{2,M}$. However, because $f_{0,U}$ is not known *a priori*, the equations in D.6 cannot be used directly, and the upper band-edge frequency $f_{2,U}$ must be computed by iteration. Generally, the iterative process is as follows: (i) make a guess for $f_{0,U}$; (ii) use the equations in D.6 to compute Δf_U , $f_{1,U}$, and $f_{2,U}$ for the upper band; (iii) compare the computed value of $f_{1,U}$ to $f_{2,M}$; and (iv) if necessary, make a better guess for $f_{0,U}$ and repeat the process until the computed value of $f_{1,U}$ compares to $f_{2,M}$ to within a specified precision. For the purposes of this Annex, the precision shall be set to 0,1%; i.e., $|(f_{2,M} - f_{1,U})/(f_{2,M})| \times 100 \leq 0,1$.

NOTE

An acceptable alternative method for computing $f_{1,L}$ and $f_{2,L}$ is linear interpolation between tabulated values in Tables 1 and 2 of Reference 14. However, the range of these tables is limited to tone frequencies less than or equal to 6000 Hz.

The value of X_U (or L_U) is determined from the FFT spectrum by bracketing the data points lying between $f_{1,U}$ and $f_{2,U}$ and computing the mean-square sound pressure (or the sound pressure level) of the upper critical band. Depending on the particular instrumentation used, this may be performed on the FFT analyzer itself using band cursors, on an external computer using appropriate software, or by some other means. Care should be taken to ensure that the lower critical band and the middle critical band do not overlap computationally; i.e., that the FFT data point(s) closest to the common band edge is (are) assigned uniquely to one band or the other, and not both.

D.8.5 Determination of prominence ratio

The prominence ratio, in decibels, is calculated as follows (for tone frequencies greater than 163,5 Hz):

$$\Delta L_P = 10 \lg \left[\frac{X_M}{(X_L + X_U) \times 0,5} \right] \text{ dB.} \quad (\text{D},14\text{A})$$

When working with sound pressure levels, the above equation becomes:

$$\Delta L_P = 10 \lg(10^{0,1L_M}) - 10 \lg[(10^{0,1L_L} + 10^{0,1L_U}) \times 0,5] \text{ dB} \quad (\text{D},14\text{B})$$

For tone frequencies less than or equal to 163,5 Hz, the above equations are modified slightly to account for the truncation of lower critical band (see D.8.3), as follows:

$$\Delta L_P = 10 \lg \left[\frac{X_M}{(X_L + X_U) \times F} \right] \text{ dB} \quad (\text{D},15\text{A})$$

or, when working with sound pressure levels:

$$\Delta L_P = 10 \lg(10^{0,1L_M}) - 10 \lg[(10^{0,1L_L} + 10^{0,1L_U}) \times F] \text{ dB} \quad (\text{D},15\text{B})$$

where

$$F = \frac{\Delta f_M}{(\Delta f_L + \Delta f_U)} \quad (D,16)$$

D.8.6 Prominent discrete tone criterion (prominence ratio method)

A discrete tone is classified as *prominent* according to the prominence ratio method if:

$$\Delta L_P \geq 9,0 \text{ dB} \quad \text{for } f_t \geq 1\,000 \text{ Hz} \quad (D,17A)$$

or

$$\Delta L_P \geq 9,0 + 10 \times \lg(1000/f_t) \text{ dB} \quad \text{for } f_t < 1\,000 \text{ Hz}, \quad (D,17B)$$

and the discrete tone meets the audibility requirement of D.5. The criteria in equations (D,17A) and (D,17B) are illustrated graphically in Figure D.4.

D.8.7 Example (prominence ratio)

The prominence ratio method is illustrated graphically in Figure D.3. The prominence ratio was calculated according to D.8.5 and was found to be $\Delta L_P = 12,1$ dB for the 1 600 Hz tone. Because the result is more than 9,0 dB, which is the prominence ratio criterion at 1 600 Hz, the tone is classified as prominent.

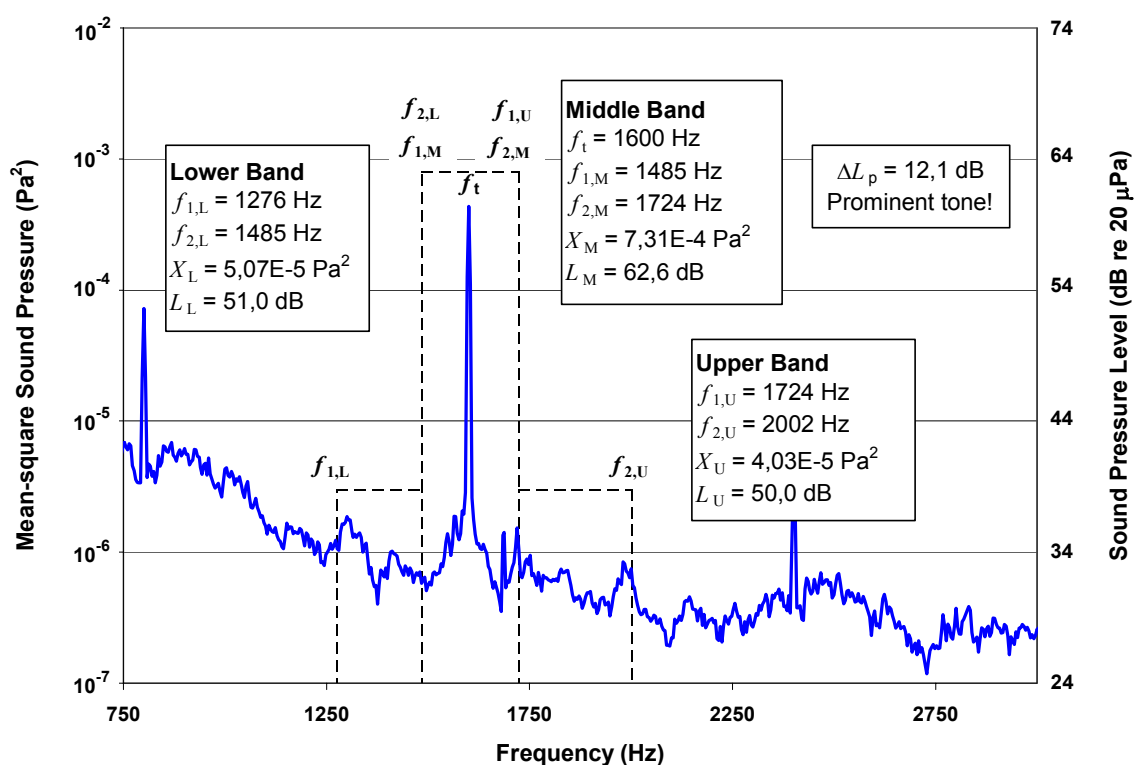


Figure D.3 — Illustration of the prominence ratio method for prominent tone identification

D.9 Information to be recorded for prominent discrete tones

For each discrete tone that has been identified as prominent according to this Annex, the following information shall be recorded:

1. The frequency of the tone, f_t , in hertz.
2. The method used to evaluate the tone (D.7 tone-to-noise ratio or D.8 prominence ratio).

3. If the tone-to-noise ratio method was used, the tone-to-noise ratio, ΔL_T in decibels. If the prominence ratio procedure was used, the prominence ratio ΔL_P in decibels.
4. If the noise emissions under investigation include more than one identified prominent tone, the frequency of each tone, and either ΔL_T or ΔL_P for each tone.

NOTE

It may be useful to record the A-weighted sound pressure level of the prominent tone, especially for low noise devices.

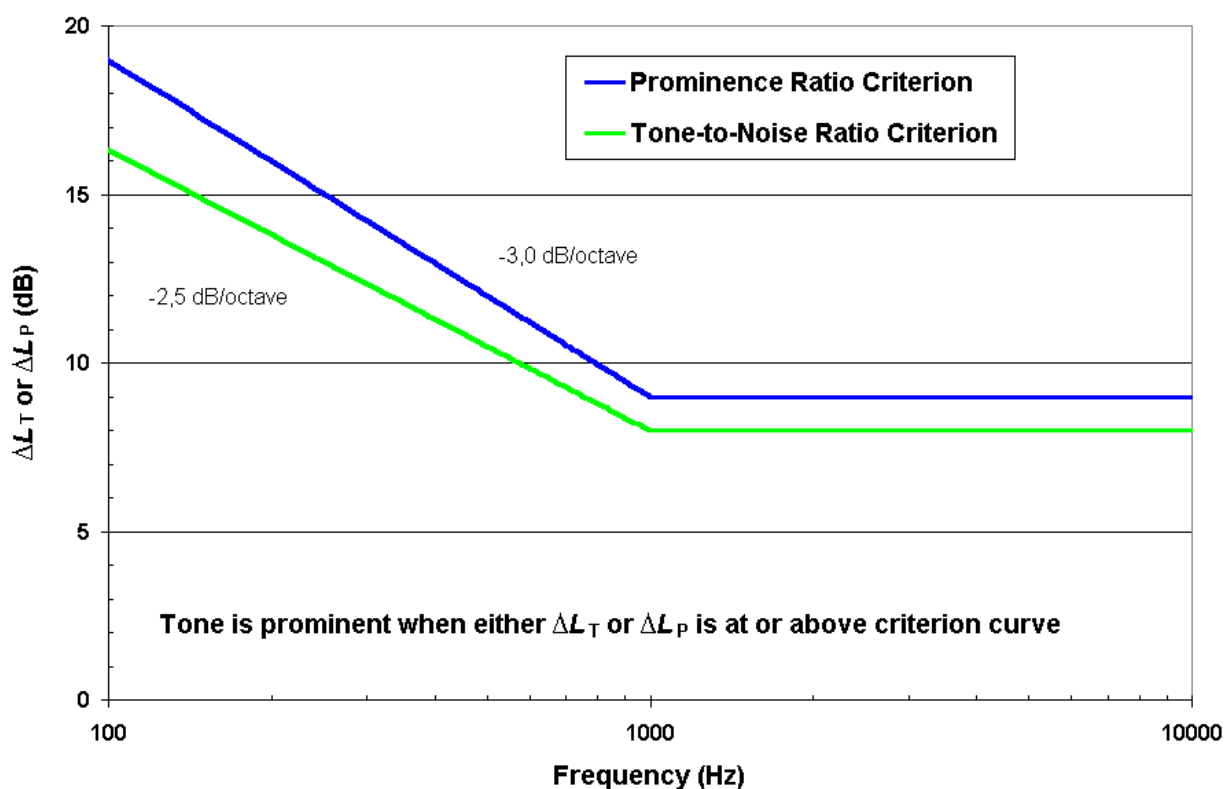


Figure D.4 — Criteria for prominence for both tone-to-noise ratio (D.7.5) and prominence ratio (D.8.6) as a function of frequency

Annex E (informative)

Detection of impulsive sound pressure levels

E.1 General

This Annex 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.

This method is based on ISO 11201, Annex A, paragraph 1, with modifications for consistency with other parts of this Standard.

E.2 Instruments

The instruments should meet the requirements of 8.4. The sound level meter should be equipped with the time weighting I.

E.3 Microphone position

If the equipment has an operator position, the measurements should be performed at the operator position. If there is more than one operator position, the measurements described below should be performed at the operator position with the highest A-weighted emission sound pressure level.

If the equipment has no operator position, the measurements should be performed at the bystander position with the highest A-weighted emission sound pressure level and at all other bystander positions having A-weighted emission sound pressure levels within 0,5 dB of it to determine the impulsive parameter ΔL_I identified below.

For sub-assemblies which will be installed in table top products, the sub-assembly should be installed in the centre of a standard test table and isolated from the surface by three or four elastomeric feet, approximately 12 mm high. For sub-assemblies which will be installed in other enclosures or racks, the sub-assembly should be installed as in 5.1.7. For sub-assemblies which will be installed in equipment with a defined operator position, this operator position should be used for the sub-assembly measurement, otherwise, the bystander position having the highest A-weighted emission sound pressure level should be used.

E.4 Measurement procedure

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

The time averaged A-weighted impulse sound pressure level, L_{pAI} , and A-weighted sound pressure level, L_{pA} , should be measured for the same mode(s) of operation, measurement conditions, time duration and time averaging as used for the measurements in 8.7. The difference in decibels between the time averaged A-weighted impulse sound pressure level, L_{pAI} , and the A-weighted sound pressure level, L_{pA} , should be obtained. The difference ($L_{pAI} - L_{pA}$) is the impulsive parameter, ΔL_I . If $\Delta L_I > 3$ dB the noise is considered to be impulsive.

The time averaged 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 d.c. level output of the impulse sound level meter should be used. The dynamic response of the recorder should 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.

E.5 Test record for impulsive sound pressure levels

If no impulsive sound pressure levels were identified, record the fact. If impulsive sound pressure levels were identified, record that fact in the test record and the value of the impulsive parameter, ΔL_I .

Annex F (informative)

Bibliography

- [1] "Geräuschemission von Geräten der Büro- und Informationstechnik",. Schriftenreihe der Bundesanstalt für Arbeitsschutz Fb 481, Bd. 1 Wirtschaftsverlag NW, Verlag für neue Wissenschaft GmbH, Germany.
- [2] Dunens, E.K., "Measurement of the sound power emitted by small sound sources with a reduced radius hemispherical surface", INTER-NOISE 2002, N374, 2002.
- [3] Xu, Y., Liu, Y., Oliver, D. and Parker, J., "Evaluation of smaller hemispheric measurement surface for sound power measurement of very quiet hard disk drives", INTER-NOISE 2002, N278, 2002.
- [4] Baugh, E. and Green, K., "Numerical and experimental investigations for hard disk drive sound power level measurements in hemi-anechoic rooms", INTER-NOISE 2002, N422, 2002.
- [5] Nobile, M.A. and Shaw, J.A., "The cylindrical microphone array for measuring sound power levels of noise sources", Proc. INTER-NOISE 99, 1535-1540, 1999.
- [6] Nobile, M.A., Donald, B. and Shaw, J.A., "The cylindrical microphone array: A proposal for use in international standards for sound power level measurements", Proceedings of NOISE-CON 2000 (CD ROM), 1PNSc2, 2000.
- [7] Nobile, M.A., Shaw, J.A., and Boyes, R.A., "The cylindrical microphone array for the measurement of sound power level: number and arrangement of microphones", INTER-NOISE 2002, N318, 2002.
- [8] Recordable Compact Disk Systems, Part III: CD-RW, Version 2.0, System Description, 1998, Sony/Philips.
- [9] Kimizuka, I., "Development of ISO 7779 Amendment 1 "Noise measurement specification for CD/DVD-ROM drives", INTER-NOISE 2002, N575, 2002.
- [10] ISO 10996, First edition, 1999-03-01, Photography — Still-picture projectors — Determination of noise emissions.
- [11] Hellweg, R. D. and Nobile, M. A., "Modification to procedures for determining prominent discrete tones", INTER-NOISE 2002, N473, 2002.
- [12] Zwicker, E. and Terhardt, E., "Analytical expression for critical-band rate and critical bandwidth as a function of frequency", Journal of Acoustical Society of America, **68**(5), 1980, pp. 1523-1525.
- [13] Plomp, R. "The ear as a frequency analyzer", Journal of Acoustical Society of America, **36** 1964, pp. 1628-1636.
- [14] Nobile, M. A., "Prominence Ratio Method for Discrete Tones in Noise: Computation of Adjacent Bands", NOISE-CON 94, 1994, p. 729 – 734.

