
**Acoustics — Measurement of airborne
noise emitted by information
technology and telecommunications
equipment**

*Acoustique — Mesurage du bruit aérien émis par les équipements liés
aux technologies de l'information et aux télécommunications*





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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This fourth edition cancels and replaces the third edition (ISO 7779:2010), which has been technically revised. The main changes compared to the previous edition are as follows:

- [Clause 3](#):
 - Updates of many items in [3.1](#) and [3.2](#) to be consistent with basic standards, such as ISO/TR 25417, ISO 3744, etc.
 - Addition of new [3.3](#) corresponding to new [Clause 9](#).
- [Clause 6](#):
 - In [6.4.6](#), the microphone calibration procedures were amended to be consistent with those of industrial counterpart, ECMA-74.
- [Clause 7](#):
 - In [7.3](#) ([7.3.1](#)), the procedure for test environment qualification was amended to clarify that any frequency bands, typically low in frequency, not significantly affecting A-weighted sound power level need not meet the hemi-anechoic room qualification criteria for the purposes of determining A-weighted sound power level.

- In [7.4.6](#), the microphone calibration procedures were amended to be consistent with those of industrial counterpart, ECMA-74.
- [Clause 8](#):
 - In [8.6](#), new [8.6.1](#) was inserted to clarify the method of defining operator position and bystander positions.
- [Clause 9](#):
 - [Clause 9](#) was newly inserted.
 - In relation to [Clause 9](#), [3.3](#) was also added, and the descriptions of [Tables 1](#), [5](#) and [6](#) (in [6.2](#), [7.2](#) and [8.2](#) respectively) were amended.
- [Annex B](#):
 - [B.2.2](#) and [B.2.3](#) were amended to clarify the section of size and microphone positions on the cylindrical measurement surface, respectively.
- [Annex D](#):
 - In [D.1](#), [D.8](#), [D.9.5](#), [D.10.3](#) and [D.10.4](#), descriptions were amended to clarify that [Annex D](#) permits to use FFT data below 89,1 Hz and above 11 200 Hz to calculate tone-to-noise ratio and prominence ratio.
 - In [D.9.7](#) and [D.10.7](#), notes were added to mention that new metrics for detecting prominent discrete tone, (1) total tone-to-noise ratio and (2) total prominence ratio are under development.
- [Annex E](#):
 - The measurement method stated in [Annex E](#) became out of date and was removed. But the annex structure is still maintained for the possible development of a new method (the title of the annex was amended accordingly).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document specifies methods for the measurement of airborne noise emitted by information technology and telecommunications (ITT) 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 document simplifies such comparisons and is the basis for the declaration of the noise emission levels of ITT equipment.

In order to ensure accuracy, validity and acceptability, this document is based on the basic International Standards for determination of the sound power level and for determination of the emission sound pressure level at the operator position and bystander positions. Furthermore, implementation is simplified by conformity with these International Standards.

In many cases, free-field conditions over a reflecting plane are realised by hemi-anechoic rooms. These rooms can be particularly useful during product design to locate and to improve individual contributing noise sources. Reverberation test rooms can 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 be the same. In [Annex C](#), these parameters are standardized for many categories of equipment.

This document is based on ECMA-74.

Acoustics — Measurement of airborne noise emitted by information technology and telecommunications equipment

1 Scope

This document specifies procedures for measuring and reporting the noise emission of information technology and telecommunications equipment.

NOTE 1 This document is considered part of a noise test code (see [3.1.2](#)) for this type of equipment and is based on basic noise emission standards (see [3.1.1](#)) ISO 3741, ISO 3744, ISO 3745, ISO 9295 and ISO 11201.

The basic emission quantity is the A-weighted sound power level, which can be used for comparing equipment of the same type but from different manufacturers, or for comparing different equipment.

Three basic noise emission standards for determination of the sound power levels are specified in this document in order to avoid undue restriction on existing facilities and experience. ISO 3741 specifies comparison measurements in a reverberation test room; ISO 3744 and ISO 3745 specify measurements in an essentially free field over a reflecting plane. Any of these three basic noise emission standards can be selected and used exclusively in accordance with this document when determining sound power levels of a machine.

The A-weighted sound power level is supplemented by the A-weighted emission sound pressure level determined at the operator position or the bystander positions, based on basic noise emission standard ISO 11201. This sound pressure level is not a level of noise immission at a work station (see [3.2.12](#)), but it can assist in identifying any potential problems that could cause annoyance, activity interference or hearing damage to operators and bystanders.

Methods for determination of whether the noise emission includes prominent discrete tones are specified in [Annex D](#).

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

The methods specified in this document allow the determination of noise emission levels for a functional unit (see [3.1.4](#)) tested individually.

The procedures apply 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 can serve noise emission declaration and comparison purposes (see ISO 9296[3]).

NOTE 2 The sound power levels and emission sound pressure levels obtained are not intended to be considered as installation noise immission levels; however, they can be used for installation planning (see ECMA TR/27[1]).

If sound power levels obtained are determined for a number of functional units of the same production series, they can be used to determine a statistical value for that production series (see ISO 9296[3]).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3741, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for reverberation test rooms*

ISO 3744, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane*

ISO 3745, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for anechoic rooms and hemi-anechoic rooms*

ISO 6926, *Acoustics — Requirements for the performance and calibration of reference sound sources used for the determination of sound power levels*

ISO 9295, *Acoustics — Determination of high-frequency sound power levels emitted by machinery and equipment*

ISO 11201, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections*

ISO 11203, *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 60942, *Electroacoustics — Sound calibrators*

IEC 61183, *Electroacoustics — Random-incidence and diffuse-field calibration of sound level meters*

IEC 61260-1, *Electroacoustics — Octave-band and fractional-octave-band filters — Part 1: Specifications*

IEC 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*

ECMA-74¹⁾, *Measurement of airborne noise emitted by information technology and telecommunications equipment*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 General definitions

3.1.1

basic noise emission standard

B-type standard

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

[SOURCE: ISO 12001:1996, 3.1]

1) Available [viewed 2017-04-07] at: <http://www.ecma-international.org/publications/files/ECMA-ST/ECMA-74.pdf>

3.1.2**noise test code****C-type standard**

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 1 to entry: This document, together with ISO 9296[3], comprises the noise test codes for ITT equipment.

[SOURCE: ISO 12001:1996, 3.2, modified — Note 1 to entry was added.]

3.1.3**information technology and telecommunications equipment****ITT equipment**

equipment for information processing, and components thereof, used in homes, offices, server installations, telecommunications installations or similar environments

3.1.4**functional unit**

unit of information technology and telecommunications equipment, either with or without its own end-use enclosure, that is tested or intended to be tested in accordance with the procedures of this document

Note 1 to entry: A functional unit can comprise more than one unit of ITT equipment when such units are to be tested together in accordance with the methods of this document. A functional unit can also comprise one or more units of ITT equipment coupled to one or more units of non-ITT equipment, such as power modules, water pumps, or refrigeration units, when such equipment is necessary for the normal operation of the ITT equipment.

Note 2 to entry: Functional units of ITT equipment can take on a wide range of forms, including commercially available products, prototype units under development or sub-assemblies and components thereof.

3.1.5**work station****operator position**

position in the vicinity of the equipment under test which is intended for the operator

Note 1 to entry: This term does not refer to a computer “workstation”, which denotes a high-performance, single-user computer.

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

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, generally without its own end-use enclosure, intended to be installed in another unit of ITT equipment or assembled together with other sub-assemblies or units of ITT equipment into a single end-use enclosure

3.1.12

rack-mountable unit

functional unit that is designed to be installed in an end-use enclosure in the form of a rack, frame, or cabinet, either fully enclosed, partially enclosed, or open frame

3.1.13

rack-enclosed system

functional unit in the form of a rack, frame, or cabinet containing one or more rack-mountable units

Note 1 to entry: Rack-enclosed systems represent a wide variety of ITT equipment, depending on the particular configuration of the rack-mountable units in the rack or enclosure. These can be server systems, storage systems, I/O systems, networking systems or “integrated” systems of these or other types of rack-mountable units.

3.1.14

hand-held equipment

functional unit, generally small and lightweight, intended to be supported in one's hand(s) during operation

3.1.15

standard test table

rigid table having a top surface of at least 0,5 m² and length of the top plane not less than 700 mm

Note 1 to entry: The design for the standard test table is shown in [A.1](#).

3.2 Acoustical definitions

3.2.1

emission

noise emission

airborne sound radiated by a well-defined noise source (e.g. the equipment under test)

Note 1 to entry: Noise emission descriptors can be incorporated into a product declaration and/or product specification. The basic noise emission descriptors are the sound power level of the source itself and the emission sound pressure levels at an operator position (work station) and/or at bystander positions (if no operator position is defined) in the vicinity of the source.

3.2.2

sound pressure

p

difference between instantaneous total pressure and static pressure

Note 1 to entry: Sound pressure is expressed in pascals.

Note 2 to entry: The symbol *p* for instantaneous sound pressure is often used without modification to represent a root-mean-square (RMS) sound pressure.

Note 3 to entry: See ISO 80000-8.

3.2.3 sound pressure level

L_p

ten times the logarithm to the base 10 of the ratio of the square of the sound pressure, p , to the square of a reference value, p_0 , expressed in decibels

$$L_p = 10 \lg \frac{p^2}{p_0^2} \text{ dB}$$

where the reference value, p_0 , is 20 μPa

[SOURCE: ISO/TR 25417:2007, 2.2, modified — Notes to entry were removed.]

3.2.4 time-averaged sound pressure level

$L_{p,T}$

ten times the logarithm to the base 10 of the ratio of the time average of the square of the sound pressure, p , during a stated time interval of duration, T (starting at t_1 and ending at t_2), to the square of a reference value, p_0 , expressed in decibels

$$L_{p,T} = 10 \lg \left[\frac{\frac{1}{T} \int_{t_1}^{t_2} p^2(t) dt}{p_0^2} \right] \text{ dB}$$

where the reference value, p_0 , is 20 μPa

Note 1 to entry: Because of practical limitations of the measuring instruments, p^2 is always understood to denote the square of a frequency-weighted and frequency-band-limited sound pressure. If a specific frequency weighting as specified in IEC 61672-1 and/or specific frequency bands are applied, this should be indicated by appropriate subscripts; e.g. $L_{p,A,10\text{ s}}$ denotes the A-weighted time-averaged sound pressure level over 10 s.

Note 2 to entry: $L_{p,T}$ can be interpreted as the sound pressure level of a stable and permanent noise that will have the same average energy as the noise under study.

3.2.5 emission sound pressure level

L_p

sound pressure level at a specified position near a machine, when the machine is in operation under specified operating and mounting conditions on a reflecting plane surface, but excluding the effects of background noise as well as the effect of reflections other than those from the plane or planes permitted for the purpose of the test

Note 1 to entry: The emission sound pressure level is expressed in decibels with a reference value, p_0 , of 20 μPa ($20 \times 10^{-6} \text{ Pa}$).

Note 2 to entry: [Clause 8](#) specifies the method for determination of emission sound pressure level.

[SOURCE: ISO 11205:2003, 3.6, modified — Note 1 to entry was elaborated and Note 2 to entry was added.]

3.2.6

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

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

Note 1 to entry: The time-averaged emission sound pressure level is expressed in decibels with a reference value, p_0 , of 20 μPa ($20 \times 10^{-6} \text{ Pa}$).

Note 2 to entry: The emission sound pressure level is determined at the specified position(s) required by the noise test code (i.e. this document, for specific families of ITT equipment).

Note 3 to entry: Clause 8 of this document specifies the method for the determination of time-averaged A-weighted emission sound pressure level, L_{pA} , for ITT equipment defined in [3.1.3](#).

Note 4 to entry: In general, the subscripts “eq” and “T” are omitted since time-averaged emission sound pressure levels are necessarily determined over a certain measurement time interval.

3.2.7

C-weighted peak emission sound pressure level

$L_{pC,peak}$

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

Note 1 to entry: The C-weighted peak emission sound pressure level is expressed in decibels with a reference value, p_0 , of 20 μPa ($20 \times 10^{-6} \text{ Pa}$).

3.2.8

sound power

P

through a surface, product of the sound pressure, p , and the component of the particle velocity, u_n , at a point on the surface in the direction normal to the surface, integrated over that surface

Note 1 to entry: Sound power is expressed in watts.

Note 2 to entry: The symbol, P , is often used without modification for the mean value (over time) of the sound power.

Note 3 to entry: The quantity relates to the rate per unit time at which airborne sound energy is radiated by a source.

[SOURCE: ISO/TR 25417:2007, 2.8]

3.2.9

sound power level

L_W

ten times the logarithm to the base 10 of the ratio of the sound power of a source, P , to a reference value, P_0 , expressed in decibels

$$L_W = 10 \lg \frac{P}{P_0} \text{ dB}$$

where the reference value, P_0 , is 1 pW

Note 1 to entry: If a specific frequency weighting as specified in IEC 61672-1 and/or specific frequency bands are applied, this is indicated by appropriate subscripts; e.g. L_{WA} denotes the A-weighted sound power level.

Note 2 to entry: [Clauses 6](#) and [7](#) of this document specify the method for the determination of the A-weighted sound power level, L_{WA} , for ITT equipment ([3.1.3](#)).

[SOURCE: ISO/TR 25417:2007, 2.9, modified — Note 2 to entry was added.]

3.2.10

reference sound source

device which is intended for use as a stable source of sound and has a known broad-band sound power spectrum determined in full conformance with ISO 6926 over the frequency range of interest.

3.2.11

frequency range of interest

range of one-third-octave bands with centre frequencies from 100 Hz to 10 000 Hz inclusive

Note 1 to entry: For equipment which emits discrete tone(s) in the 16 kHz octave band, the procedures specified in ISO 9295 are used; see [Table 4](#).

3.2.12

noise immission at a work station

any noise that arrives, whether or not a worker is present, over a specific time period T , at a measuring point (work station) in the actual situation; i.e. noise coming from the machine, noise coming from the other sound sources and noise reflected by the ceiling, the walls and any fittings

[SOURCE: ISO 11690-1:1996, 3.3.1, modified — Note 1 to entry and the reference to Figure 1b) were deleted.]

3.3 Statistical definitions

3.3.1

standard deviation of repeatability

σ_r

standard deviation of noise emission values obtained under repeatability conditions, that is the repeated application of the same noise emission measurement method on the same noise source within a short interval of time under the same conditions (same laboratory, same operator, same apparatus)

[SOURCE: ISO 7574-1:1985, 3.16]

3.3.2

standard deviation of reproducibility

σ_{R0}

standard deviation of noise emission values obtained under reproducibility conditions, that is the repeated application of the same noise emission measurement method on the same noise source at different times and under different conditions (different laboratory, different operator, different apparatus).

Note 1 to entry: The standard deviation of reproducibility, therefore, includes the standard deviation of repeatability (see [3.3.1](#)).

Note 2 to entry: An estimate of σ_{R0} to be given in the measurement test code for the family of machines should preferably be derived from an interlaboratory test. In the absence of such a test, σ_{R0} may be agreed upon provisionally.

[SOURCE: ISO 7574-1:1985, 3.17, modified — The last part of the definition was moved to a new Note 1 to entry and Note 1 to entry was renumbered as Note 2 to entry.]

4 Conformity requirements

Measurements are in conformity with this document if they meet the following requirements:

- a) the measurement procedures, the installation and the operating conditions specified in this document shall be fully taken into account;
- b) for the determination of sound power levels, one (and only one) of the methods specified in [Clause 6](#) or [7](#) shall be used;

- c) for determination of emission sound pressure level at the operator or bystander positions, the method specified in [Clause 8](#) shall be 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 ITT 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 can interfere with the measurements.

NOTE If the equipment is mounted near one or more reflecting planes, the sound power radiated by the equipment can depend upon its position and orientation. It is possible that the determination of the radiated sound power is of interest 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 test rooms

Floor-standing equipment (see [3.1.8](#)) 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 test room.

5.1.2.2 Requirements for hemi-anechoic rooms

Floor-standing equipment (see [3.1.8](#)) 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. Information on reflection is given in [7.3.1.1](#), Note 1. The plane(s) shall not contribute to the sound radiation due to its (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 can 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 (information on reflection are given in [7.3.1.1](#), Note 1). The distance from the wall shall be in accordance with the manufacturer's instructions or as specified in the relevant annex of ECMA-74 (see [Annex C](#)). If such information is not available there, the distance shall be 0,1 m.

5.1.3 Table-top equipment

5.1.3.1 Requirements for reverberation test rooms

Table-top equipment (see 3.1.9) 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 in accordance with 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 in accordance with A.1.

5.1.3.2 Requirements for hemi-anechoic rooms

Table-top equipment (see 3.1.9) shall be placed on the floor, unless a table or stand is required for operation in accordance with 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 in accordance with A.1. In any case, the measurement surface defined in 7.6 terminates on the floor.

5.1.4 Wall-mounted equipment

Wall-mounted equipment (see 3.1.10) shall be affixed to a wall of the reverberation test 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 includes both individual rack-mountable units (see 3.1.12) and rack-enclosed systems (see 3.1.13). Rack-mountable units shall either be tested outside of the rack or installed in a rack enclosure in accordance with the requirements of ECMA-74. Rack-enclosed systems shall be tested either as floor-standing equipment (see 5.1.2) or as table-top equipment (see 5.1.3) according to the type and size of system. The specific installation and operation requirements of ECMA-74 shall be followed.

For rack-enclosed systems that are available in more than one configuration of rack-mountable units, the particular configuration to be measured is usually governed by the purposes of the test and is thus not specified in this document (see ECMA-74 for more information).

5.1.6 Hand-held equipment

Hand-held equipment (see 3.1.14) shall be supported $0,25\text{ m} \pm 0,03\text{ m}$ above the reflecting plane by a vibration-isolating stand or fixture or by appropriate vibration-isolating elements. If a hemispherical measurement surface is used with any radius less than 1 m (see B.1), the hand-held equipment support height shall be reduced to $0,125\text{ m} \pm 0,015\text{ m}$. The method of supporting the hand-held equipment shall not interfere with the propagation of airborne sound from the equipment or generate any additional sound radiation.

5.1.7 Sub-assemblies

A sub-assembly (see 3.1.11) shall be supported $0,25\text{ m} \pm 0,03\text{ m}$ above the reflecting plane by a vibration-isolating stand or fixture or by appropriate vibration-isolating elements. If a hemispherical measurement surface is used with a radius less than 1 m (see B.1), the sub-assembly support height shall be reduced to $0,125\text{ m} \pm 0,015\text{ m}$. The method of supporting the sub-assembly shall not interfere with the propagation of airborne sound from the sub-assembly or generate any additional sound radiation.

If the above-specified support height is not adequate to allow the manufacturer's recommended air flow at the sub-assembly's intake port, the height may be adjusted accordingly, but shall not exceed 0,5 m. The new height shall be documented in the test report.

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 the intended use shall be defined, tested and described in the test report. Any subsequent declaration shall either:

- declare both values, indicating that one is based on [Annex C](#) and 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.

When there are multiple operating modes specified in [Annex C](#), at a minimum, the most typical operating mode shall be chosen for the measurement. This mode shall be clearly described in the test report.

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 to perform different functions, such as manual 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 operational cycle has not been defined in [Annex C](#), such a typical cycle shall be defined for the measurements. This mode shall be clearly described in the test report.

For rack-mounted equipment in which the operation of several functional units is possible, the units intended to operate together shall do so during the test; all other units shall be in idle mode. In the absence of operational specifications provided by [Annex C](#) or by the manufacturer, an operating mode that represents the most typical usage shall be defined and tested. This mode shall be clearly described in the test report.

Some equipment does not operate continuously because of its mechanical design or its mode of operation under program control. Long periods can occur during which the equipment is idle. The operating mode measurements shall not include these idle 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 defined and clearly 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 can be of interest. Such measurements can be made, but they are not part of the methods specified in this document.

6 Method for determination of sound power levels of equipment in reverberation test rooms

6.1 General

The method specified in this clause provides a comparison procedure for determination of the sound power levels of ITT equipment in a reverberation test room, in accordance with the comparison method specified in ISO 3741. It applies to equipment which radiates broad-band noise, narrow-band noise, noise which contains discrete-frequency components or impulsive noise.

It is strongly recommended that the room be qualified for discrete-frequency components in accordance with the relevant procedure specified in ISO 3741. 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 of reproducibility for the frequency range of interest of this document which are equal to, or less than, those given in [Table 1](#).

Table 1 — Typical upper bound values of the standard deviation of reproducibility in determining sound power levels in a reverberation test room in accordance with [Clause 6](#)

Octave band centre frequencies Hz	One-third-octave-band centre frequencies Hz	Standard deviation of reproducibility, σ_{R0} 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 ITT 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 can result when the sound power levels in other bands determine the A-weighted sound power level.

NOTE 2 The standard deviations of reproducibility, σ_{R0} (see [3.3.2](#)), 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 can be caused, for example, by changes in the installation or operating conditions of the equipment. In quantitative sense, the repeatability, σ_r (see [3.3.1](#)), of the test results for the same piece of equipment and the same measurement conditions can be considerably better (i.e. smaller standard deviations) than indicated by the values given in [Table 1](#).

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, 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 test 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) ambient 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 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 defined by the manufacturer, the recommended range is 40 % to 70 %.

For equipment whose noise emissions vary with ambient temperature in a prescribed manner (e.g. by varying the speeds of air-moving devices), the room temperature during the measurement shall be $23\text{ °C} \pm 2\text{ °C}$.

For equipment whose noise emissions vary with altitude in a prescribed manner (e.g. by varying the speeds of air-moving devices), either the altitude of the test room shall be less than or equal to 500 m, or the equipment shall be tested under conditions simulating its operation at an altitude less than or equal to 500 m.

NOTE This variation of speed of air-moving devices does not refer to the changing speed that is already accounted for in the correction for ambient pressure described in [6.10.1](#), Note.

6.4 Instrumentation

6.4.1 General

The requirements of this subclause ([6.4](#)), as well as the instrumentation requirements of ISO 3741, shall be followed.

Digital integration is the preferred method of averaging.

6.4.2 The microphone and its associated cable

The instrumentation system, including the microphone and its associated cable, shall meet the requirements of ISO 3741. 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 for an instrument specified in accordance with IEC 61260-1, class 1 shall be followed.

6.4.6 Calibration

The microphones shall be calibrated for random incidence as specified in IEC 61183.

Before and after each series of measurements, a sound calibrator meeting the requirements of IEC 60942, class 1 shall be applied to each microphone to verify the calibration of the entire measuring system at one or more frequencies within the frequency range of interest. Without any further adjustment, the difference between the readings made before and after each series of measurements shall be less than or equal to 0,5 dB. If this value is exceeded, the results of the series of measurements shall be discarded.

NOTE A “series” of measurements does not require that this verification be conducted “daily”. Other methods for checking the calibration of the measurement system to ensure this requirement is met can be available. For example, see JBMIA-TR-28[28].

The calibration of the sound calibrator, the conformance of the instrumentation system with the requirements of IEC 61672-1, the conformance of the filter set with the requirements of IEC 61260-1 and, if used, the conformance of the reference sound source with the requirements of ISO 6926 shall be verified at intervals in a laboratory making calibrations traceable to appropriate standards preferably by meeting the requirements of ISO/IEC 17025[9].

The sound calibrator should be calibrated at intervals not exceeding 1 year, the reference sound source should be calibrated at intervals not exceeding 2 years, the conformance of the instrumentation system with the requirements of IEC 61672-1 should be verified at intervals not exceeding 2 years and the conformance of the filter set with the requirements of IEC 61260-1 should be verified at intervals not exceeding 2 years.

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 test room is the spatial irregularity of the sound field. The extent of this irregularity and, hence, the effort required to determine the time-average sound pressure level accurately are greater for discrete-frequency sound than for broad-band sound.

It is strongly recommended that the room be qualified for the measurement of discrete-frequency components in accordance with the relevant procedures of ISO 3741. This avoids the need to determine the number of microphone positions and equipment locations each time equipment is measured.

If the room has not been qualified for the measurement of discrete-frequency components, the procedures specified in ISO 3741 shall be used to determine the minimum number of microphone positions and to evaluate the need for additional noise source locations prior to each measurement. The results of these procedures depend on the presence or absence of significant discrete-frequency components or narrow bands of noise in the sound emitted by the source. When these are present, the number of microphone positions and equipment locations may be large.

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

The requirements of ISO 3741 shall be followed.

6.6.3 Microphone arrangement

The requirements of ISO 3741 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 operational cycles (e.g. page printers), the measurement duration shall include at least three operational cycles. For equipment which performs a sequence of varying operational 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.

NOTE When the levels of the background noise in the test room are extremely low and well controlled, it is possible that the environment satisfies the absolute and/or relative criteria for background noise in accordance with ISO 3741.

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 reverberation test rooms, this document 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 mean time-averaged band sound pressure level

The requirements of ISO 3741 shall be followed.

6.10 Determination of sound power level

6.10.1 Calculation of band sound power levels

The sound power level, under reference meteorological conditions, of the equipment in each one-third-octave band within the frequency range of interest (see [3.2.11](#)) is obtained by using the comparison method of ISO 3741.

NOTE The procedures in ISO 3741 are used to determine the sound power level under reference meteorological conditions (ambient pressure $1,013\,25 \times 10^5$ Pa, temperature 23 °C, relative humidity 50 %).

The sound power level in the k th octave band, $L_{W_{\text{oct}, k}}$, in decibels, if needed, shall be based on one-third-octave-band data and calculated as per [Formula \(1\)](#):

$$L_{W_{\text{oct}, k}} = 10 \lg \sum_{j=3k-2}^{3k} 10^{0,1L_{W1/3, j}} \text{ dB} \quad (1)$$

where

k is an identification number of octave band within the frequency range of interest (see [Table 2](#));

$L_{W1/3, j}$ is the sound power level in the j th one-third-octave band, in decibels (see [Table 3](#));

j is an identification number lying within the range of $(3k-2)$ and $3k$, which identifies the three one-third-octave bands that make up the k th octave band.

6.10.2 Calculation of A-weighted sound power level

The A-weighted sound power level, L_{WA} , in decibels, shall be based on the frequency range of interest, and calculated as per [Formula \(2\)](#):

$$L_{WA} = 10 \lg \sum_{j=1}^{21} 10^{0,1(L_{W1/3, j} + A_j)} \text{ dB} \quad (2)$$

where

$L_{W1/3, j}$ is the sound power level, in decibels, in the j th one-third-octave band;

A_j is the A-weighting value corresponding to the j th one-third-octave band (see [Table 3](#));

j is an identification number of a one-third-octave band within the frequency range of interest (see [Table 3](#)).

NOTE [Formulae \(1\)](#) and [\(2\)](#), as well as [Tables 2](#) and [3](#), are intended for common use for not only [Clause 6](#), but also [Clause 7](#).

Table 2 — Identification number, k , for octave bands

k	Octave-band centre frequency
	Hz
1	125
2	250
3	500
4	1 000
5	2 000
6	4 000
7	8 000

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

j	One-third-octave-band centre frequency Hz	A-weighting 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

Some ITT equipment emits high-frequency noise in the 16 kHz octave band. Depending upon the nature of noise emissions, [Table 4](#) shows how to handle each situation.

For the determination of A-weighted sound power levels from band levels, this document does not extend the frequency range of interest to include the 16 kHz octave band.

For equipment which emits discrete tone(s) in the 16 kHz octave band, each frequency and level of the tone(s) that is (are) within 10 dB of the highest tone level in the band shall be determined in accordance with the procedures specified in ISO 9295 (see [Table 4](#)). The derived levels are not frequency weighted.

CAUTION — The 16 kHz octave-band contribution is not included in the determination of the A-weighted level.