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Acoustics — Measurement of sound pressure level from service equipment or activities in buildings — Engineering method

Acoustique — Mesurage du niveau de pression acoustique des équipements techniques ou activités dans les bâtiments — Méthode d'expertise

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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 document 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).

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For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 126, *Acoustic properties of building elements and of buildings,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 16032:2004), which has been technically revised.

The main changes are as follows:

— terms and definitions have been revised;

— procedure to detect and average spatial and temporal variations of the sound has been revised;

— measurements can be performed to verify sound levels either from a specific service equipment or an activity in the building, with operating conditions described in Annex B or by national guidelines if such exist for a specific type of service equipment, e.g. lifts;

— title is updated to reflect that also sound from activities in the building can be measured according to this document, e.g. music sound from a restaurant or sports premises in the same building;

— measurements are performed in one–third–octave–bands;

— octave–band levels, without corrections for reverberation times or background noise may be measured or estimated from the one–third–octave–band levels and reported optionally, but they are not used to calculate the *A*-weighted and *C*-weighted sound pressure levels;

— standardization with respect to reverberation times applies to the 50 Hz to 5 000 Hz one–third–octave–bands;

— frequency range used to calculate the *A*-weighted and *C*-weighted sound pressure levels can include one–third–octave bands from 25 Hz to 10 000 Hz but shall always include the bands 50 Hz to 5 000 Hz;

— Annex C added providing an example form for the expression of results.

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

Many countries have building regulations intended to protect people from noise in their homes or workplaces. For the purpose of verification of compliance with such regulations, there is a need for a standardized method for the measurement of sound pressure levels from service equipment or activities in this building. This document specifies a procedure for such measurements, under specific operating conditions and operating cycles.

Acoustics — Measurement of sound pressure level from service equipment or activities in buildings — Engineering method

1 Scope

This document specifies an engineering method for the measurement of sound pressure levels in rooms from service equipment installed in the building.

This document covers specifically measurements of sound from sanitary installations, mechanical ventilation, heating and cooling service equipment, lifts, rubbish chutes, heating devices, blowers, pumps and other auxiliary service equipment, and motor driven car park doors. It can also be applied to measurements of sounds from other types of equipment or activities within the building, e.g. noise from sport facilities or restaurants.

The measurement of noise from external sound sources generating air-borne or ground-borne noise in the building are not included in this document.

The methods are suitable for rooms with volumes of approximately 300 m^3 or less for instance, in dwellings, hotels, schools, offices and hospitals.

The methods are not intended for measurements in large auditoria or concert halls.

2 Normative references

The following documents are referred to in the text in such a way that some or all 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 3382-2, *Acoustics — Measurement of room acoustic parameters — Part 2: Reverberation time in ordinary rooms*

IEC 60942, *Electroacoustics — Sound calibrators*

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

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
sound pressure level
L_i
ten times the logarithm to the base 10 of the ratio of the square of the sound pressure p^2(t), to the square of the reference sound pressure $p_0{}^2$, measured in a position *i* with a particular time weighting and a particular frequency weighting, selected from those defined in IEC 61672-1

Note 1 to entry: L_i is expressed in decibels.

Note 2 to entry: The reference sound pressure is 20 µPa.

3.2
maximum sound pressure level with time weighting "*S*"
L_{Smax}
maximum sound pressure level measured in one–third–octave–bands determined with time weighting "*S*"

3.3
maximum sound pressure level with time weighting "*F*"
L_{Fmax}
maximum sound pressure level measured in one–third–octave–bands determined with time weighting "*F*"

3.4
equivalent continuous sound pressure level
L_{eq}
sound pressure level measured in one–third–octave–bands determined as a time average of the squared sound pressure during a stated integration time

Note 1 to entry: The integration time, can be indicated with additional subscripts for the stated time interval or a stated duration, e.g. $L_{22\text{-}06}$ or L_{30s} or L_{1h}.

3.5
average sound pressure level
L
ten times the logarithm to the base 10 of the ratio of the space and time average of the square of the sound pressure p^2(t), to the square of the reference sound pressure $p_0{}^2$, the space average being taken over the entire room with the exception of those parts where the direct radiation of a sound source or the near field of the boundaries (walls, etc.) is of significant influence

Note 1 to entry: L is expressed in decibels.

Note 2 to entry: The space average can be calculated from measurements of the sound pressure level L_i taken in n positions, including repetitions in one position, according to the Formula:

$$L = 10 \lg \left[\frac{1}{n} \sum_{i=1}^{n} 10^{0.1 L_i} \right] \text{dB}$$

Note 3 to entry: The measured sound pressure levels can be maximum time weighted levels L_{Smax} or L_{Fmax}, or equivalent continuous sound pressure levels L_{eq}.

3.6
reverberation time
T
duration required for the space-averaged sound energy density in an enclosure to decrease by 60 dB after the source emission has stopped

Note 1 to entry: The reverberation time is expressed in seconds.

Note 2 to entry: T can be evaluated based on a smaller dynamic range than 60 dB and extrapolated to a decay time of 60 dB. It is then labelled accordingly. Thus, if T is derived from the time at which the decay curve first reaches 5 dB and 25 dB below the initial level, it is labelled T_{20}. If decay values of 5 dB and 35 dB below the initial level are used, it is labelled T_{30}.

Note 3 to entry: T is measured in one–third–octave–bands from 50 Hz to 5 000 Hz.

3.7
standardized average sound pressure level
L_{nT}
average sound pressure level standardized to a reference reverberation time in one–third–octave–bands.

Note 1 to entry: To calculate the standardized quantity, the following formula applies:

$$L_{nT} = L - 10 \lg\left[\frac{T}{T_0}\right] \text{dB}$$

where

T is the measured reverberation time in seconds;

T_0 reference reverberation time 0,5 seconds.

3.8
normalized average sound pressure level
L_n
average sound pressure level normalized to an equivalent sound absorption area of 10 m^2 in one–third–octave–bands.

Note 1 to entry: To calculate the normalized quantity, the following formula applies:

$$L_n = L - 10 \lg\left[\frac{A_0\, T}{0{,}16\, V}\right] \text{dB}$$

where

A_0 is the reference equivalent sound absorption area in square meters; A_0 = 10 m^2;

T is the measured reverberation time in seconds;

V is the room volume in cubic meters;

0,16 has the unit (s/m).

3.9
***A*- weighted average sound pressure level**
L_A

$$L_A = 10 \lg\left[\sum_{k=1}^{m} 10^{0{,}1(L_k + A_k)}\right] \text{dB}$$

where

L_k is the average sound pressure level in each one–third–octave–band k;

A_k is the A-weighting correction of the one–third–octave–band k according to Annex A.

3.10
***C*- weighted average sound pressure level**
L_C

$$L_C = 10 \lg\left[\sum_{k=1}^{m} 10^{0{,}1(L_k + C_k)}\right] \text{dB}$$

where

L_k is the average sound pressure level in each one–third–octave–band k;

C_k is the C-weighting correction of the one–third–octave–band k according to Annex A.

4 Measurement equipment

Measurement of sound pressure levels according to this document shall be made with a one–third–octave–band analyser that registers all sound pressure levels simultaneously.

The instrumentation system, including the microphone and cable, shall meet the requirements for a class 1 instrument specified in IEC 61672-1. The one–third–octave–band filters shall meet the requirements for class 1 filters specified in IEC 61260-1.

The residual noise of the used instrumentation shall be assessed, to be compared with the background levels according to Clause 8.

At the beginning and at the end of the measurements, the sensitivity of the instrumentation shall be verified with a sound calibrator class 1 according to IEC 60942. If the calibration measurement deviates from previous calibrations by more than 0,5 dB, do not use this equipment until the reason for this deviation has been clarified and appropriate actions have been taken to ensure a correct sensitivity within its dynamic range and frequency range.

It is recommended the microphone is mounted on a stable stand, e.g. a tripod, with an adjustable height.

NOTE The stand can be equipped with a resilient mount for the microphone to reduce background noise from vibrations of the floor.

5 Test method — General

The sound pressure level, L_i, from a service equipment or an activity in a building shall be measured in a fixed position i as the linear (unweighted) spectrum in one–third–octave–bands during a specified time period or operating cycle of the service equipment under test.

For the evaluation of a maximum sound pressure level with a time weighting "*S*" or "*F*", register the one–third–octave–band sound pressure levels at that time when the maximum *A*-weighted or *C*-weighted sound pressure level indicated by the instrument occurs in this microphone position.

The equivalent continuous sound pressure level, L_{eq}, shall be determined with an integration time determined according to the guidelines in Annex B, unless there are guidelines in national requirements and regulations which shall then be applied instead of the guidelines in Annex B.

The sound pressure levels taken in different positions are then used to calculate the average sound pressure levels in one–third–octave–bands.

These average sound pressure levels shall be corrected for background noise measured according to 6.6.

The background noise corrected average sound pressure levels in one–third–octave–bands shall be used to calculate the standardized average sound pressure levels or the normalized average sound pressure levels, unless national requirements only require uncorrected levels to be reported.

Finally, the *A*-weighted average sound pressure level and *C*-weighted average sound pressure level are calculated from the background noise corrected and standardized or normalized or uncorrected one–third–octave–band results.

The average sound pressure levels which can be reported according to this document are given in Table 1.

Table 1 — *A*- and *C*-weighted average sound pressure levels

	***A*-weighted average sound pressure level** (calculated from one–third octave band sound pressure levels)	***C*-weighted average sound pressure level** (calculated from one–third octave band sound pressure levels)
Maximum sound pressure level with time weighting "*S*"	L_{ASmax} $L_{ASmax,nT}$ $L_{ASmax,n}$	L_{CSmax} $L_{CSmax,nT}$ $L_{CSmax,n}$
Maximum sound pressure level with time weighting "*F*"	L_{AFmax} $L_{AFmax,nT}$ $L_{AFmax,n}$	L_{CFmax} $L_{CFmax,nT}$ $L_{CFmax,n}$
Equivalent continuous sound pressure level "eq"	L_{Aeq} $L_{Aeq,nT}$ $L_{Aeq,n}$	L_{Ceq} $L_{Ceq,nT}$ $L_{Ceq,n}$

The different weighted average sound pressure levels given in Table 1 are not comparable. Only measurement results obtained with the same time and frequency weightings shall be compared. When measurement results are compared with legal requirements it shall be ensured that both refer to the same quantity. Thus, the notation in Table 1 shall be used when reporting measurement results.

Octave–bands sound pressure levels, directly measured or estimated from the one–third–octave–band results, can be presented optionally, without correction for background noise and without standardization or normalization.

6 Measurement procedure

6.1 General

The sound pressure level shall be determined for a specified operating condition and operating cycle of a service equipment or a given time frame for an activity in the same building.

NOTE 1 Sounds in a room from external sources of noise can be measured according to ISO 1996–2.

NOTE 2 Background sounds in large spaces or in rooms with highly sound absorbing surfaces, e.g. an office landscape, can be measured according to ISO 3382–3.

Operating conditions and operating cycles are determined according to Clause 5.

Special care shall be taken to ensure that operating conditions of automated service equipment are fulfilled, either by supervised operation of the source or by some kind of additional measurement of the source itself, e.g. with an accelerometer.

Windows and doors shall be closed during the measurements, but air inlets shall be in their normal position.

It is recommended the operator performing the test stays outside the room during the measurement to ensure the background noise is unaffected by the operator. A microphone stand can then be used according to Clause 4.

NOTE 3 It is often efficient to listen to the microphone signal in headphones to ensure no background sound affects the measurement, or to record and playback this signal after the measurement. See Clause 8.

NOTE 4 In some situations, it can be advantageous that the operator is present in the room to listen for intermittent background noise.

If one or several persons are present in the room during the measurements, this measurement condition shall be stated in the test report.

If the sound contains clearly audible tonal components or time variations, this shall be stated in the test report.

According to this document, sound pressure levels are first measured in three microphone positions, one position in a selected corner of the room and two positions in the reverberant sound field. The measurements are repeated in the selected corner and two or four new room positions in case the results differ from each other by more than limits according to 6.4.

The sound pressure level is measured and corrected according to 6.2 to 6.9.

6.2 Selection of the corner position for the microphone

To select the corner position (number 1), search for the corner of the room with the highest *C*-weighted equivalent continuous sound pressure level. Use the chosen operating condition and operating cycle or any stable condition suitable for the finding of the location with the highest sound level.

For the selection of the corner position, the *C*-weighted equivalent continuous sound pressure level can be measured directly e.g. by the use of an integrating sound level meter. Hence, calculation from one–third–octave–bands and corrections for reverberation times or background noise shall not be applied for this purpose. The selection procedure for the corner position stated above shall be used prior to all measurements according to this document.

The corner microphone position shall, preferably, be located at each corner 0,5 m from the walls and the floor. If this position is not feasible due to protruding furniture, obstacles etc., increase the height to 1,0 m or if necessary to 1,5 m above the floor.

The microphone position shall be at least 0,2 m away from any obstacle. Move away small protruding items close to the microphone that do not affect the sound field, if necessary. If the sound pressure level in a corner is dominated by direct sound from a source in the room – e.g. a ventilation outlet – this corner shall be left out when choosing the corner position.

6.3 Selection of the reverberant field positions of the microphone

Choose two additional positions (number 2 and 3) somewhere in the reverberant field of the room. Whenever practical, the minimum distance between each of the positions 1 (the corner position), 2 and 3 shall preferably be 1,5 m but at least 1,0 m. The distance to any sound source in the room shall be at least 1,5 m. The distance between positions 2 and 3 and any room surface shall be at least 0,50 m. In small rooms where one or several positions cannot fulfil this requirement, the distance to a room surface may be decreased to 0,30 m. The height above floor level shall be at least 0,5 m and not more than 2,0 m. The microphone shall be placed at different heights as well as moved to different positions on the floor.

6.4 Measurement of sound pressure levels

6.4.1 Measurement of the equivalent continuous sound pressure level

Carry out the measurements of the equivalent continuous sound pressure level in positions 1, 2 and 3 during the chosen operating conditions and operating cycles according to 6.1.

If the difference between the highest and the lowest *A*-weighted equivalent continuous sound pressure levels at these three measurement positions, as indicated directly by the instrument without any corrections for reverberation times nor background noise, is equal to or less than 3,0 dB, then proceed to carry out corrections and calculations according to 6.5 to 6.7.

If the difference exceeds 3,0 dB, carry out additional measurements with the microphone at the same corner position and at two new room positions (number 4 and 5), observing the distances described in 6.3. If the difference between the highest and the lowest of the six *A*-weighted equivalent continuous sound pressure levels, without any corrections, is less than 6,0 dB, then carry out corrections and calculations according to 6.5 to 6.7.

If the difference exceeds 6,0 dB, carry out additional measurements at the same corner microphone position and a two new room positions (number 6 and 7), observing the distances described in 6.3. If the difference

between the highest and the lowest of the nine *A*-weighted sound pressure levels is less than 9,0 dB, then carry out corrections and calculations according to 6.5 to 6.7.

If the difference is larger than 9,0 dB and the three readings in the corner position indicate the sound source is not stable, then the measurement session shall be interrupted and the reasons for the large differences should be investigated before a new series of measurement are carried out. No data from the interrupted series of measurement shall be used to calculate weighted single number values.

If a statistical estimate of the time variation of the sound shall be derived (optionally), this can be done in addition to the ordinary measurements. Take a new sequence of corner measurements and calculate the standard deviation, based on the squared sound pressures. It can then be assumed this standard deviation is representative also for the average sound pressure level in the room.

6.4.2 Measurement of the maximum sound pressure level

If the maximum sound pressure levels are measured, use the highest *C*-weighted maximum sound pressure level in each position with a similar procedure to 6.4.1 to determine the number of measurements to be made and to calculate the average sound pressure level. However, in the case of sound events of short duration, an equivalent sound pressure level measured during a fixed integration time that comprises each sound event can be used instead of the maximum sound pressure level to determine the required number of measurements.

The chosen operating conditions and operating cycles shall be used.

NOTE The measurement uncertainty can be high when maximum sound pressure levels are measured in the lower one–third–octave–bands because of time delays caused by the sound level meter filtering circuits and hence the level can depend on the equipment.

6.5 Averaging the sound pressure level

Calculate for each one–third–octave–band the average sound pressure level of all the measurements made according to 6.4.1 or 6.4.2 with the chosen time and frequency weightings respectively. The levels shall be rounded to one decimal place.

NOTE Maximum sound pressure levels with time weightings "*S*" or "*F*" are determined as time and spatial averages of measurements in several positions. This procedure is considered necessary to reach an acceptable reproducibility. Since the averaging is made from several squared sound pressure signals, it follows that the highest sound pressure levels will to some extent determine the averaged maximum sound pressure level. This average will be close to the highest level registered in any of the positions chosen, but not identical to this. Hence, it can be useful to explain this specific meaning of an average maximum sound pressure level in the test report.

6.6 Determination of the background sound pressure level

The background sound pressure level shall be determined in one–third–octave–bands as the equivalent continuous sound pressure levels over a period of approximately 30 s just before or after each set of measurements. The same microphone positions shall be used as for the service equipment sound pressure level measurements. Corrections for background sounds are applied according to Clause 8.

6.7 Standardization or normalization of one–third–octave–band results

The one–third–octave–band results corrected for background noise shall be standardized or normalized to reference absorption properties of the room, unless uncorrected values are requested in a national regulation or guideline that refers to measurements according to this document.

Measure the reverberation time according to Clause 7 and make the standardization by use of formula in 3.7, or the normalization according to the formula in 3.8.

Because of severe problems with determining reverberation times in the 25 Hz, 31,5 Hz, 40 Hz, 6 300 Hz, 8 000 Hz and 10 000 Hz one–third–octave–bands, the measured sound pressure levels in these bands shall

not be standardized nor normalized. If any of these bands contribute to the *A*- or *C*-weighted sound pressure level, this shall be mentioned in the test report.

NOTE Standardization or normalization based on measured reverberation times may lead to a bias error in rooms without sound diffusing objects in case one or several surfaces are highly sound absorbing, e.g. a room with an acoustical ceiling. This error is caused by late and rather weak reflections between acoustically reflecting parallel surfaces, e.g. the walls, that result in a prolonged reverberation time. However, the sound pressure level can still be reduced by absorption of the early and strong reflections from the absorbing surface. Hence, the correction based on reverberation times may then be overestimated. In this kind of room, it may be useful to compare the earliest part of the reverberation decay with the late part in the evaluation of the reverberation time, e.g. comparing a T_{10} value with a a T_{30} value. If the difference is notable, this can be mentioned in the test report.

6.8 Calculation of *A*- and *C*-weighted values

Determine the *A*-weighted level from the one–third–octave–band levels according to the formula in 3.7 with frequency weights given in Annex A, either within a restricted frequency range 50 Hz to 5 000 Hz or within an extended range 25 Hz to 10 000 Hz. For the extended frequency range, the measured sound pressure levels in the 25 Hz, 31,5 Hz, 40 Hz, 6 300 Hz, 8 000 Hz and 10 000 Hz one–third–octave–bands are included with 0 dB correction terms for the reverberation times according to 6.7. Indicate the frequency range applied in the test report.

Determine the *C*-weighted level from the one–third–octave–band levels according to the formula in 3.10 with frequency weights given in Annex A within the extended frequency range 25 Hz to 10 000 Hz.

The *A*-weighted and *C*-weighted results shall be rounded to integer numbers.

NOTE It can be useful to compare the calculated *A*– and *C*–weighted results corrected for background noise with the values indicated directly by the instrument. If the difference is more than 2 dB, the calculations can be checked for possible explanations.

6.9 Sound sources present in the room (additional measurements)

In situations where sound sources are present in the room – e.g. a ventilation outlet in the wall or in the ceiling – a separate measurement position shall be used for each source. For noise sources in the wall a position is chosen 1 m in front of the source and 1,5 m above floor level. For a noise source in the ceiling, the position shall be 1,5 m above floor level, directly below the source. Additional measurement result(s) shall not be standardized or normalized. They shall be reported separately and shall not be included in the average of the levels measured in microphone positions according to 6.4.

7 Measurement of reverberation time

The reverberation time shall be measured in the 50 Hz to 5 000 Hz one–third–octave–bands–according to ISO 3382-2, preferably using the impulse response method at least in the lower one–third–octave–bands 50 Hz to 315 Hz.

8 Correction for background noise

This method is only suitable provided that the background noise is approximately constant in time. If the background noise level is 10 dB or more below the sound pressure level of the service equipment, no correction shall be made.

The residual noise of the used instrumentation shall be compared to the measured background noise levels. If the residual noise has had an influence on the background levels, this shall be stated in the test report.

If the background noise level is 4 dB to 10 dB below the sound pressure level of the service equipment, the measured sound pressure level shall be corrected using the following Formulae (1) to (3):

$$L = L_1 - K \tag{1}$$

$$K = -10\lg\left[1-10^{(-0,1\Delta L)}\right] \quad (2)$$

$$\Delta L = L_1 - L_2 \quad (3)$$

where

L is the corrected sound pressure level, in decibels;

L_1 is the measured one–third–octave–band sound pressure level from the service equipment including background noise, in decibels;

L_2 is the one–third–octave–band background sound pressure level, in decibels;

K is the one–third–octave–band correction value, in decibels.

A difference of 4 dB corresponds to a correction value of 2,2 dB. If the difference is less than 4 dB the correction value shall be limited to 2,2 dB, and in the test report, it shall be stated that the measurement result is influenced by background noise. For comparison with noise limits, the measuring result can be considered as the upper limit of the service equipment sound pressure level. It shall be stated whether the background noise is influencing the *A*-weighted and *C*-weighted average sound pressure levels.

NOTE 1 If the background noise is varying with time – e.g. caused by road traffic – a reliable correction cannot be made. However, the maximum sound pressure levels of the background noise can be determined over a period of 10 min to 15 min in the corner microphone position. If the maximum level is 10 dB or more below the service equipment sound pressure level the result can be regarded valid without correction. It can also be helpful to monitor the time signal to select the appropriate time slot for measurements and check the validity in all relevant one–third–octave–bands.

NOTE 2 A simple check on–site is to compare the maximum level to the equivalent level in the middle of the frequency range during one or several measurement period. For many stable sources this difference can be in the order of 5 dB. If this difference is maintained during the remaining measurements, it is likely that these measurements have not been disturbed by background sounds from closing doors, footfall noise etc.

9 Precision

Table 2 shows estimates of the standard deviation associated with reproducibility of average sound pressure levels. The values are estimated based on a limited number of measurements on sound sources constant in time[3]. Fluctuations of the sound pressure level of the source will increase the measurement uncertainty, particularly for maximum sound pressure levels.

Table 2 — Estimated standard deviation of average levels, associated with reproducibility

One–third–octave–band centre frequencies Hz	Octave–band centre frequencies Hz	Standard deviation of reproducibility dB
25, 31,5 and 40	31,5	1,9
50, 63 and 80	63	1,9
100, 125 and 160	125	1,9
200, 250 and 315	250	1,5
400, 500 and 630	500	1,2
800 to 10 000	1 000 to 8 000	1,0
A-weighted		0,8[a]
C-weighted		1,2[a]

[a] Valid for a constant sound with a relatively flat sound spectrum in the frequency range 25 Hz to 10 000 Hz and with a difference between service equipment sound pressure level and background noise level of at least 10 dB.

10 Test report

The test report shall include at least the following information:

a) reference to this international standard, i.e. ISO 16032:2024;

b) name of the organization and person(s) that has performed the measurements;

c) name and address of the client, i.e. the organization or the person who ordered the test;

d) date of the test;

e) identification of the room where the sound pressure level has been measured;

f) description of relevant building constructions, furniture and absorption treatment of surfaces;

g) detailed description of any particular service equipment or activity in the building;

h) detailed information about measurement duration, operating conditions, operating cycles (e.g. period of a cycle) and the number of persons present in the room during the measurement (including the operator);

i) for water installations:

   1) mandatory:

      i) the position of stop cocks;

      ii) a description of all relevant aspects of the water installation and the operating conditions;

   2) optional:

      i) the flow pressure (cold and warm water system);

      ii) the flow rate/refilling time for cisterns;

      iii) the manufacture and destination of the valve or device;

      iv) the sound class and flow rate for valves or devices classified according to ISO 3822-1;

      v) the flow rate, static pressure, and flow pressure of the valves during the test;

      vi) the volume and filling time of the flush tank (if possible);

j) positions of the microphones;

k) time constant (X=*S* or X=*F*) for L_{Xmax};

l) test result (the notation stated in Table 1 shall be used). For *A*-weighted and/or *C*-weighted values the corresponding weighted one–third–octave–band spectrum shall be reported, optionally the octave–band spectrum may be given (uncorrected values). If the sound contains clearly audible tonal components, this shall be stated in the test report;

m) reverberation times, in one–third–octave–bands, if they were determined;

n) background noise in one–third–octave–bands;

o) instrumentation used, with the date of the latest verification by a certified laboratory;

p) any deviation from the test method;

q) date of the last verification of the compliance of the equipment with the relevant European Standards shall be recorded;

r) form with a diagram according to Annex C can be used to present the results.

Annex A
(normative)

A-weighting and *C*-weighting correction values

Table A.1 — *A*-weighting and *C*-weighting correction values

One-third-octave-band, Hz	*A*-weighting, dB	*C*-weighting, dB		Octave-band, Hz	*A*-weighting, dB	*C*-weighting, dB
25	-44,7	-4,4				
31,5	-39,4	-3,0		31,5	-39,4	-3,0
40	-34,6	-2,0				
50	-30,2	-1,3				
63	-26,2	-0,8		63	-26,2	-0,8
80	-22,5	-0,5				
100	-19,1	-0,3				
125	-16,1	-0,2		125	-16,1	-0,2
160	-13,4	-0,1				
200	-10,9	0				
250	-8,6	0		250	-8,6	0
315	-6,6	0				
400	-4,8	0				
500	-3,2	0		500	-3,2	0
630	-1,9	0				
800	-0,8	0				
1 000	0	0		1 000	0	0
1 250	+0,6	0				
1 600	+1,0	-0,1				
2 000	+1,2	-0,2		2 000	+1,2	-0,2
2 500	+1,3	-0,3				
3 150	+1,2	-0,5				
4 000	+1,0	-0,8		4 000	+1,0	-0,8
5 000	+0,5	-1,3				
6 300	-0,1	-2,0				
8 000	-1,1	-3,0		8 000	-1,1	-3,0
10 000	-2,5	-4,4				

Annex B
(normative)

Operating conditions and operating cycles for measuring the maximum sound pressure level and the equivalent continuous sound pressure level

B.1 General principles

B.1.1 Overview

In the following, operating conditions and operating cycles are given for the most common service equipment and activities in buildings.

The operating conditions and operating cycles given in this Annex shall be used unless there are guidelines in national requirements and regulations that refer to this document, which shall then be used instead of the guidelines in this Annex.

However, service equipment and activities not mentioned in the following can be measured according to the principles stated in this document. The chosen operating conditions and operating cycle shall then be reported in detail.

All sources related to a special activity or premise in a building shall be running in their normal operating conditions during the measurement. This requirement applies also to parts of the equipment placed on the outside of a building, e.g. an air outlet or a cooler connected to other equipment in a restaurant in a building.

In the case of equipment that operates depending on input from external sensors, it can be necessary to switch to manual operation prior to measuring the sound levels. B.10 gives additional guidelines to be used in case the equipment cannot be monitored or controlled, or the sound of interest appears unpredictably or irregularly.

NOTE It can be useful to ask the manufacturer or installer for advice or assistance for this purpose since such operation can cause damage to the service equipment if handled improperly.

B.1.2 Maximum sound pressure level, L_{max}

In this Annex B, L_{max} is used as a general symbol for the respective quantities given in Table 1. The basic principle for measuring the maximum sound pressure level is that the service equipment under test during the measurement is operated - automatically or manually - within the limits of normal practical use. For service equipment with a constant sound level, the maximum sound pressure level is determined during a measurement period of approximately 30 s. For service equipment with sound varying with time, the maximum sound pressure level is determined for a typical operation, e.g. during the period of opening and closing a water tap.

B.1.3 Equivalent continuous sound pressure level, L_{eq}

In this Annex B, L_{eq} is used as a general symbol for the respective quantities given in Table 1. The basic principle for measuring the equivalent continuous sound pressure level is that the integration time corresponds to a typical operating cycle of the service equipment under test. If no operating cycle can be defined, apply an averaging time long enough to stabilize the $L_{A,eq}$ value indicated directly by the instrument, but not shorter than 30 seconds.

B.2 Water installations

B.2.1 General operating conditions

For sound measurements on water taps, the water can be drained off the sink, shower cabin or tub during the measurement.

It shall be ensured that all functions are in normal operation (water pressure, flow rate etc.). For water installations, the stop cocks shall be completely open, or when this is not the case the position shall be reported. Measurement and reporting of the flow pressure and the flow rate of the valve are optional.

Normally the sound pressure level from sanitary installations is not measured in the room where the installation is mounted, but exclusively in surrounding rooms (e.g. neighbouring dwellings).

L_{max}:

The maximum sound pressure level at each microphone position is determined for a specified operating condition and operating cycle of the installation under test as described in B.2.2 to B.2.6.

Measurement on water installations starts before the installation is operated and stops after the operating cycle has ended.

L_{eq}:

Concerning water taps the measurement is carried out with the tap fixed in the position causing the highest sound pressure level (see B.2.2, operating cycle for the equivalent continuous sound pressure level).

B.2.2 Water tap

a) Operating conditions:

L_{max} and L_{eq}:

If the outlet of the tap or valve is movable, it shall be placed in the position closest to the middle of the sink (for further operating conditions, see B.2.1).

b) Operating cycles:

L_{max}:

— Taps with one inlet: open the tap completely, wait a few seconds and then turn off the tap.

— Mixing valves with similar independent controls for hot and cold water: open the hot tap completely, open the cold tap, wait a few seconds, close the hot tap and then close the cold tap.

— Mixing valves with one dual function control for flow and temperature: open the control completely at average temperature setting, decrease the temperature to the minimum, and then increase the temperature to the maximum, wait until the maximum temperature has been reached and close the control.

— Mixing valves with independent controls for flow and temperature: open the flow control completely at average temperature setting, decrease the temperature to the minimum and then increase the temperature to the maximum, wait until the maximum temperature has been reached and close the control.

— Thermostatic mixing valves: open the tap completely at average temperature setting, decrease the temperature to the minimum and then increase the temperature to the maximum and close the tap.

L_{eq}:

The integration time is approximately 30 s.

— Taps with one inlet: open the tap and find the position causing the highest sound pressure level. The taps shall be fixed in this position during the measurement.

— Mixing valves with similar independent controls for hot and cold water: open both the hot tap and the cold tap and find the position causing the highest sound pressure level. The taps shall be fixed in this position during the measurement.

— Mixing valves with one dual function control for flow and temperature: open the tap and find the position causing the highest sound pressure level at average temperature setting. The taps shall be fixed in this position during the measurement. The sound pressure level with the taps in hot-water position and cold-water position, respectively, shall be checked. The highest of the three levels is the measurement result.

— Mixing valves with independent controls for flow and temperature, and thermostatic valves: open the tap and find the position causing the highest sound pressure level at average temperature setting. The taps shall be fixed in this position during the measurement. The sound pressure level with the tap in hot-water position and cold-water position respectively, shall be checked. The highest of the three levels is the measurement result.

B.2.3 Shower cabin

a) Operating conditions

L_{max} and L_{eq}:

The shower shall be placed in the wall fixture at its highest position above floor level and the shower shall be directed towards the floor of the cabin (for further operation conditions, see B.2.1).

b) Operating cycle

The measurement is performed according to B.2.2.

If a distinction is needed between the sound pressure level originating by the impact sound excitation from the water bouncing on the floor of the cabin and the sound pressure level originating by using the valves, the water shall be drained off soundlessly (measurement of the valves alone).

B.2.4 Bath (tub)

a) Operating conditions

L_{max} and L_{eq}:

If the tap of the bath is a combination of a nozzle exclusively for filling the bath and a separate shower, the two functions shall be regarded separately. If there is no fixture on the wall, the shower shall be held at a height above the bottom of the tub of approximately 1,5 m. Emptying the bath shall take place simultaneously with the measurement (for further operating conditions see B.2.1).

b) Operating cycle

L_{max} and L_{eq}:

The measurement is performed according to B.2.2 and, if the bath is fitted with a shower, according to B.2.3.

If a distinction is needed between the sound pressure level originating by the impact sound excitation from the water bouncing on the bottom of the tub and the sound pressure level originating by using the valves, the water shall be drained off soundlessly (measurement of the valves alone).

B.2.5 Filling and emptying sinks and baths

a) Operating conditions

L_{max} and L_{eq}:

If the sound pressure level from filling and emptying sinks and baths is measured separately, the plug is closed and the sink/bath is filled to half of the maximum level during the measurement. Hot and cold water is mixed equally with the tap(s) in fully opened position(s) (for further operating conditions see B.2.1).

The plug is opened, and a new measurement is carried out during the emptying period.

b) Operating cycle

L_{max}:

The measurement is carried out first during the filling and then during the emptying period.

L_{eq}:

Integration time is equal to the filling period and emptying period.

B.2.6 Water closet

a) Operating conditions

L_{max} and L_{eq}:

The sound from a water closet consists partly of the sound from flushing the water and partly of sound generated when the cistern is refilled. Flushing valves and flushing cisterns shall be operated to the end stop. In case of a flushing cistern the sound pressure level is measured when the supply valve is fully opened and until the supply valve has closed (for further operating conditions, see B.2.1).

b) Operating cycle

L_{max}:

The measurement is carried out during a full flushing/refilling cycle.

L_{eq}:

The integration time shall correspond to a full flushing/refilling cycle.

B.3 Mechanical ventilation

a) Operating conditions

L_{max} and L_{eq}:

The part of a ventilation system placed in a dwelling typically includes ventilation inlets or outlets in living rooms and toilets for comfort ventilation, as well as cooker hoods in kitchens.

Before the sound level is measured, it shall be checked that the system has been adjusted to the correct air-flow.

NOTE 1 In a national guideline or regulation, it can be stated that manually operated ventilation systems should be measured at a specific setting during the measurement in the dwelling to which the system belongs.

NOTE 2 Cooker hoods connected to a ventilation system common to the whole building can generate a considerable sound when the vent is fully closed. An additional measurement with the hood in this operating condition can be appropriate.

b) Operating cycle

L_{max}:

Continuous operating. The measurement time is approximately 30 s.

L_{eq}:

The integration time is approximately 30 s.

B.4 Heating and cooling service equipment

a) Operating conditions

L_{max} and L_{eq}:

For individual heating systems, the measurement shall be carried out during simultaneous working of the heating source under full load, circulation pump, fan and fuel delivery pump (maximum normal water flow; maximum normal airflow).

Cooling systems shall be set to the position with the highest sound pressure level.

b) Operating cycle

L_{max}:

For heating systems, start-up from cold conditions. Operate at full load. Open and close slowly each appliance (taps for heating elements; regulators of air devices) and stop.

For cooling systems, the measurement time shall be approximately 30 s.

L_{eq}:

The integration time is approximately 30 s.

NOTE For heating systems, the equivalent continuous sound pressure level can be supplemented by the maximum *A*- weighted sound pressure level measured when operating each appliance (taps for heating elements; regulators of air devices) according to B.4.

L_{max} and L_{eq}:

For measurements of sound pressure levels from radiators, the water flow shall be stabilized in the thermostat position for the highest possible room temperature. After that, search for the thermostat position which causes the maximum constant noise level.

B.5 Lift

a) Operating conditions

L_{max} and L_{eq}:

The lift shall be loaded with 1 or 2 persons. The load and the number of persons in the lift during the measurement shall be reported.

b) Operating cycle

L_{max} and L_{eq}:

Start the lift from the lowest possible level (or from five floors below the measurement location if the lowest level is below that). Stop at each intermediate level. Open and close the door (if by hand without force). When the lift has arrived at the top of the elevator shaft (or five floors above the measurement location, if the top of the shaft is above that), call it back directly to the initial measurement floor and then open and close the door. Measure the sound continuously while this cycle is repeated at least three times, with the microphone in positions according to 6.4.

NOTE For measurements on lifts, the equivalent continuous sound pressure level can preferably be supplemented by at least the *A*-weighted maximum sound pressure levels, including typical impulsive noise from breaks or relays during the completed operating cycle.