INTERNATIONAL STANDARD

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Acoustics — Methods for the description and physical measurement of single impulses or series of impulses

Acoustique — Métrique et techniques pour le mesurage physique de bruits impulsionnels isolés ou en courtes rafales

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10843 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Annexes A to E of this International Standard are for information only.

Introduction

0.1 Purpose

The purpose of this International Standard is to describe and specify the physical measurement of single impulsive sounds or short series of impulsive sounds. The actual measurement performed will change according to both the measurement situation and the physical quantities required. Detailed characterization of source emissions is beyond the scope of this standard.

0.2 Physical measurement alternatives

Physical measurement alternatives will change according to the purpose of the measurements and the measurement situation. First, measurements may be made of phase-sensitive quantities such as peak-level, rise-time, or duration, or measurements may be made of time-integrated quantities such as frequency-filtered or frequency-weighted sound exposure level (e.g. A-weighted sound exposure level). Secondly, measurements may be made on a continuous sound source or a transient sound source. This International Standard deals only with transients (single impulsive sounds or short series of impulsive sounds); therefore time-integrated descriptors such as sound exposure or sound energy, rather than time-averaged descriptors, are applicable.

0.3 Measurement situation

Noise measurement situations will change according to the purpose of the measurement. There are three alternative pairs of measurement situations which may require the measurement of single impulsive sounds or series of impulsive sounds. First, measurements may be for workplace-related purposes, such as hearing conservation or employee efficiency, or measurements may be for community environmental purposes. Secondly, measurements may be indoors or outdoors. Thirdly, measurements may be for the purpose of gathering source-emission data, or of describing immission levels in the community. Other International Standards provide guidance for specific measurement situations. ISO 11200 should be used for measurements of emission sound pressure levels at the work station and at other specified positions; the ISO 3740 or ISO 9614 series should be used for determination of sound power levels of noise sources; the ISO 1996 series should be used for description and measurement of environmental sound.

Acoustics — Methods for the description and physical measurement of single impulses or series of impulses

1 Scope

This International Standard describes preferred methods for the description and the physical measurement of single impulsive sounds or short series of impulsive sounds and for the presentation of the data. It does not provide methods for interpreting the potential effects of series of impulses of noise on hearing, community response or structures.

This International Standard applies to single impulsive sounds or short series of impulsive sounds such as those produced by explosions, artillery fire, bombing and similar activities, sonic booms, pistol and rifle fire, and cartridge-operated tools or machines.

Two different kinds of measurements are considered:

a) measurements of phase-sensitive parameters, such as peak sound pressure level and duration, that directly characterize the variation of sound pressure with time; and

b) measurements of time-integrated quantities such as frequency-weighted sound exposure level or sound energy level.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50-801:1994, *International electrotechnical vocabulary — Chapter 801: Acoustics and electroacoustics*

IEC 651:1979, *Sound level meters,* and its Amendment 1:1993.

IEC 804:1985, *Integrating-averaging sound level meters*, and its Amendment 1:1989 and Amendment 2:1993.

IEC 942:1988, *Sound calibrators.*

IEC 1260:1995, *Electroacoustics — Octave-band and fractional-octave-band filters.*

3 Definitions

For the purpose of this International Standard, the definitions given in IEC 50-801 and the following definitions apply.

NOTE — The prefix "un" is used to denote what is also termed "lin-" or "flat-" weighted sound. Unweighted is perhaps most descriptive.

3.1 Characteristics of an impulse noise

3.1.1 A-duration: Time, in seconds, required for the main or principal wave to reach its unweighted peak sound pressure and return momentarily to zero.

NOTES

1 See figure 1 a) and annex E, reference [25].

2 In practice, the A-duration is the total time between the onset of a signal level 20 dB below the peak level and the first crossing of the signal 20 dB below peak level.

3 The notation used for duration in this definition and in 3.1.2 and 3.1.3 should not be confused with the A-, B- and C-frequency weightings.

3.1.2 B-duration: Total time, in seconds, that the envelope of unweighted sound pressure fluctuations (both positive and negative) exceeds one tenth of the unweighted peak sound pressure, including the duration of that part of any reflection pattern that exceeds one tenth of the unweighted peak sound pressure.

NOTE — See figure 1 b) and annex E, reference [25].

3.1.3 C-duration: Total time, in seconds, that the main or principal wave and the following oscillations, both negative and positive, are within 10 dB of the unweighted peak sound pressure level.

NOTE — See figure 1 c) and annex E, reference [34].

3.1.4 envelope: Two idealized smooth lines which effectively join the successive positive or negative peaks of the instantaneous sound pressure.

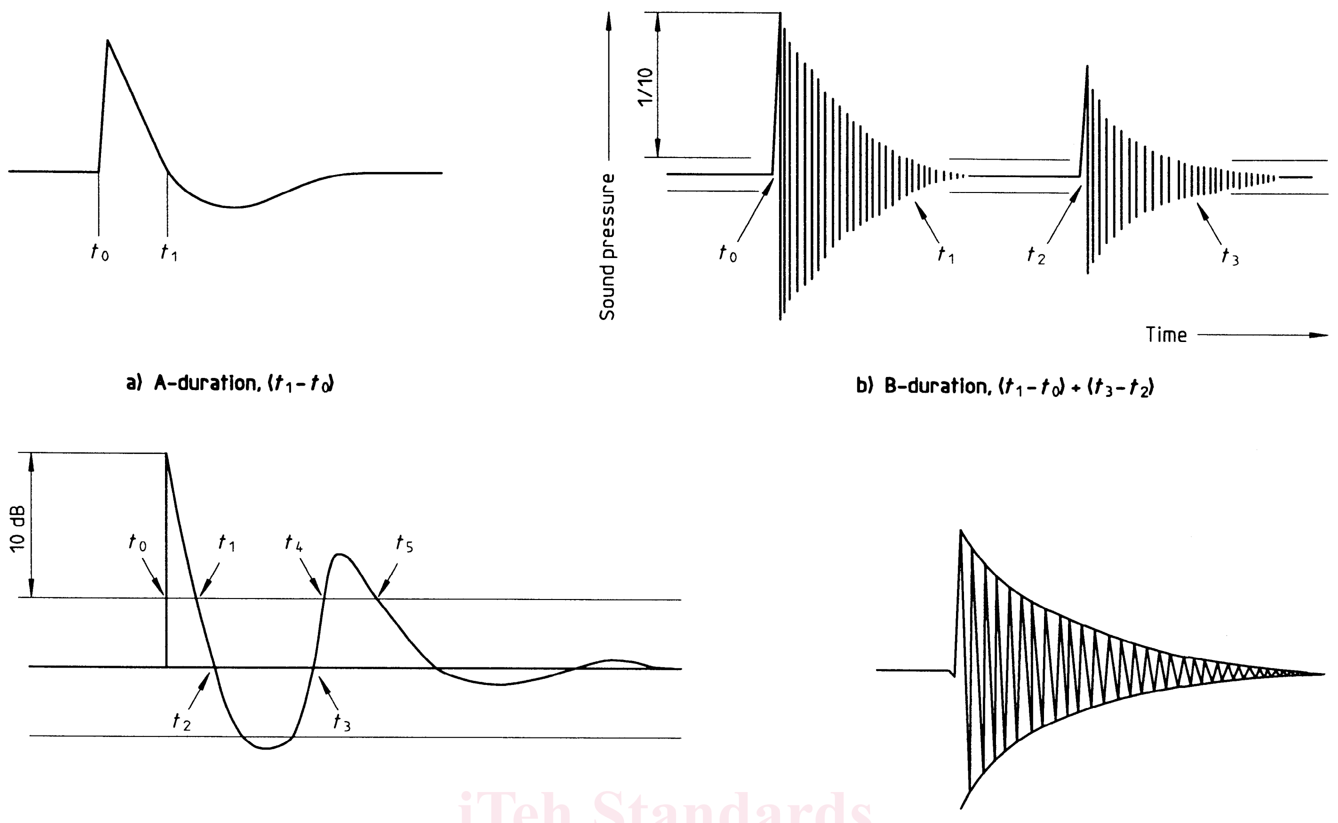
NOTE — See figure 1 d).

3.1.5 impulse noise: A single short burst or series of short bursts of sound pressure.

NOTE — The pressure-time history of a single burst of impulsive noise includes a rise to a peak pressure, followed by a decay of the pressure envelope.

3.1.6 instantaneous sound pressure: Total instantaneous pressure, in pascals, at a point in the presence of a sound wave minus the atmospheric pressure at that point.

NOTE — Instantaneous pressure relates to the pressure as measured by the microphone prior to any signal processing.



a) A-duration, $(t_1 - t_0)$

b) B-duration, $(t_1 - t_0) + (t_3 - t_2)$

c) C-duration, $(t_1 - t_0) + (t_3 - t_2) + (t_5 - t_4)$

d) Impulse wave envelope

Figure 1 — Impulse noise characteristics

3.1.7 instantaneous sound pressure level: Ten times the common logarithm of the square of the ratio of the frequency-weighted instantaneous sound pressure to the reference sound pressure, expressed in decibels.

NOTES

1 In air the reference sound pressure is 20 µPa.

2 The frequency weighting is to be specified.

3.1.8 peak sound pressure: For any specified time interval, the maximum absolute value of the instantaneous sound pressure, in pascals, that occurs during a specified time interval.

3.1.9 peak sound pressure level: Ten times the common logarithm of the square of the ratio of peak frequency-weighted sound pressure to the reference sound pressure, expressed in decibels.

NOTES

1 In air, the reference pressure is 20 µPa.

2 The frequency weighting is to be specified.

3.1.10 signal rise time: Time, in seconds, a signal takes to rise from 10 % to 90 % of its maximum absolute value of the sound pressure.

3.1.11 sound energy: Time and spatial integral of the sound intensity normal to an imaginary closed surface, where sound intensity is the real part of the product of instantaneous sound pressure and particle velocity (at the same point in space), expressed in joules.

3.1.12 sound energy level: Ten times the common logarithm of the ratio of sound energy to the reference sound energy of 1 pW·s, expressed in decibels.

3.1.13 sound exposure: Time integral of frequency-weighted squared instantaneous sound pressure, expressed in pascal-squared seconds.

$$E = \int_0^T p^2 \, dt \qquad \text{...(1)}$$

NOTE — The frequency weighting is to be specified.

3.1.14 sound exposure level: Ten times the common logarithm of the ratio of sound exposure, E, to the reference sound exposure, expressed in decibels.

$$L_E = 10 \lg \left(\frac{E}{E_0} \right) \text{dB} \qquad \text{...(2)}$$

NOTES

1 In air, the reference sound exposure, E_0, is 20 $\mu Pa^2 \cdot s$.

2 The frequency weighting is to be specified.

3 In order to avoid confusion between the noise exposure of workers and the noise emission from machinery, in the ISO 3740 series and ISO 11200, which are specific to machinery noise emission, this quantity is called "single-event emission sound pressure level."

3.2 Characteristics of the measurement system

3.2.1 bandwidth: Frequency range, in hertz, over which the response of a system to a sinusoidal input signal is within zero to –3 dB of an ideal flat response.

NOTE — This definition is specific to the purposes of this International Standard and not necessarily in accordance with more general definitions given in other International Standards.

3.2.2 droop: Amount by which the linear system output drops below the ideal final output in response to a step-function input when measured at a time which equals or exceeds the duration of the signal of interest, divided by the ideal final output and expressed as a percentage,.

3.2.3 dynamic range: Difference, in decibels, between the peak signal level (unweighted), expressed as the sound pressure level for which the measurement system operates within the instrument manufacturers' stated specifications, and the measurement system background noise level (unweighted), expressed as the sound pressure level.

NOTES

1 At low sound pressure levels the useful dynamic range is limited by acoustic noise or by electric circuit noise.

2 At high sound pressure levels the useful dynamic range is limited by overloading of the microphone or the electronic instrumentation.

3.2.4 overshoot: Amount by which the maximum of the linear system output exceeds the idealized final output in response to a step-function input, divided by the ideal final output and expressed as a percentage.

3.2.5 slew-rate: Rate of change of the measurement system output per unit time, expressed in volts per second.

3.2.6 slew-rate limit: Maximum rate of change of the measurement system output in response to a step-function input, expressed in volts per second.

3.2.7 system rise time: Time, in seconds, required for the linear system output to rise from 10 % to 90 % of its final amplitude in response to a step-function input.

4 Measurement system characteristics and requirements

4.1 General

This section does not specify general instruments for measuring impulsive sound. The purpose of this section is to specify the system characteristics required to accurately measure impulsive sound for any particular purpose.

The measurement system characteristics and requirements change according to the purpose of the measurement. For example, a type 1 integrating-averaging sound level meter, fitted with a microphone of type WS2 according to IEC 1094-4, might be used to measure the A-weighted sound exposure level from a short burst of pneumatic-hammer sound. The same sound level meter, fitted with a sealed microphone of type WS1, might be used to measure the unweighted peak sound pressure level of a mining explosion. This section describes the characteristics and accuracy required for measuring the time-varying and time-integrated characteristics of impulsive sound. These requirements permit the user to select and tailor a measurement system to the measurement purpose. See also annexes A and C.

The measurement system includes all equipment from the microphone and its windscreen, if used, to the instrument that indicates the results of the measurement. If tape-recording is employed, the system includes the recording and playback equipment as well as the tape itself.

The accuracy attained in the measurement of impulsive sound depends upon the instruments used, the measurement procedure, and the characteristics of the particular impulse sound. Information on measurement procedures is given in clause 5.

4.2 Requirements for measurement of phase-sensitive quantities

Five characteristics are important for describing an impulsive sound in the time domain: system rise time, overshoot, droop, dynamic range and bandwidth. Depending on the type of impulsive sounds being measured, some instrument characteristics may be more important than others. For example, an impulsive sound having a long A-duration need not be measured with instruments which meet the rise time requirement of 4.2.1 if only the A-duration is to be measured.

4.2.1 System rise time

The system rise time should be less than one-tenth of the rise time of the impulsive sound. For sounds having extremely short rise times (e.g. shock waves), it may not be possible to meet this recommendation.

NOTE — For shock waves which have near-zero rise time, the systematic error in the measurement of the peak pressure may be estimated by multiplying the indicated peak pressure by

$$K = 1 + \frac{T_r}{T_a}$$

where

T_r = system rise time, in seconds;
T_a = A-duration, in seconds.

That is, the estimated actual peak sound pressure equals K times the indicated pressure.

4.2.2 Overshoot

The overshoot in response to a step-function input should be less than 5 %.

NOTE — Overshoot is really an instrument requirement which is independent of the waveform being measured. It is included here for completeness.

4.2.3 Droop

The system droop in response to a step-function input shall be less than 5 % during a time period equal to the A-duration of the signal.

4.2.4 Dynamic range

The system dynamic range shall include at least the interval from 1 dB above the peak sound pressure level of the signal to 5 dB below the minimum sound pressure level of interest.

4.2.5 Phase distortion and bandwidth

The phase distortion of the measurement system in the frequency range of interest shall be limited to ± 10°. This requirement is normally fulfilled when the bandwidth includes the frequency range from one decade below the lowest frequency of interest to one decade above the highest frequency of interest. Otherwise the phase distortion for the highest frequency of interest shall be reported.

NOTES

1 Phase response is directly related to the complexity of the frequency limiting mechanisms (electrical, mechanical and acoustical) and, in complicated situations, a much greater bandwidth may be required.

2 To measure peak values and other phase-sensitive quantities, filters should be operating in "real time". Filters should be linear and the group delay should be constant. FFT analysis and the "reconstitution" of filters is inappropriate.

4.3 Requirements for measurement of time-integrated quantities

This subclause gives requirements for the measurement of the sound exposure level or sound energy level.

4.3.1 Dynamic range

The system dynamic range is specified in 4.2.4.

4.3.2 Time-integration

4.3.2.1 Single time periods

For measurements of sound exposure level, the analogue of the squared (frequency-weighted) instantaneous sound pressure shall be integrated over the duration of the impulse or series of impulses of sound. The integration period shall be selected such that the background noise influences the measured sound exposure level by less than 0,5 dB. The duration of the integration period shall be measured to within an uncertainty of ± 5 %.

4.3.2.2 Multiple time periods

For a series of separate impulsive sounds, where a series of short integration periods are used to build up a longer period or where short duration sound exposure values are used to generate other metrics, each integration period shall effectively include its corresponding single impulse or series of impulses of sound. Collectively, integration periods shall be selected such that the background noise influences the total measured sound exposure level by less than 0,5 dB. Each integration period shall be determined to an uncertainty of ± 0,01 %.

NOTE — The uncertainty of time measurement in 4.3.2 is really an instrument requirement which is independent of the waveform being measured. It is included here for completeness.

4.3.3 Digital integration

If digital integration is used, the sampling rate should be at least three times the highest frequency of interest.

NOTE — It is possible that the frequency of interest does not include the highest frequencies in the signal. If frequencies exist which are above the Nyquist frequency, then filtering should be used to prevent an aliased signal.