TECHNICAL SPECIFICATION

# ISO/TS 13474

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# Acoustics — Impulse sound propagation for environmental noise assessment

*Acoustique — Propagation des sons impulsionnels et évaluation du bruit environnemental*



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# Foreword

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An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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.

ISO/TS 13474 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

 

## Introduction

The aim of this Technical Specification is to specify engineering methods to calculate sound levels from impulse sound sources at distant locations. Its specific purpose is environmental noise assessment, and not assessment of damage risk to buildings, or injury risk to animals or people.

This procedure includes the use of both measured and calculated quantities, and offers empirical relationships and analytical methods for use when measurements are unavailable or impractical. In each case where alternative methods are given, they are presented in decreasing order of preference and accuracy.

Measured immission levels only pertain to prevailing meteorological and ground surface conditions during the measurements. Such sound levels can vary significantly as conditions change, and therefore, obtaining an accurate *averaged* level demands the averaging of measured data for different conditions.

The working method is comparable to that of ISO 9613-2. In the working method of ISO 9613-2, the immission level is calculated for a so-called *down-wind* condition and the long-term average level is estimated using a correction factor, $C_{met}$. For impulse sound events, however, higher pressure levels and lower frequencies are involved. Lower frequency sounds are generally less attenuated over a given distance in the atmosphere than higher frequencies. Provided that the background sound is unchanged, it follows that impulse sounds can be heard over greater distances and will be more affected by weather and other environmental influences.



In this method the long-term averaged immission level is calculated as a weighted average for a number of weather conditions. The weighting factors are given by the probability of occurrence of each weather condition during the relevant time period for the location of interest. To conduct calculations using the procedure, it is necessary to have a database of sound transfer functions and the statistical distribution parameters pertaining to the relevant meteorological and ground surface conditions.

# Acoustics — Impulse sound propagation for environmental noise assessment

## 1 Scope

This Technical Specification specifies engineering methods to calculate the average sound immission for a distribution of impulse sound events for the purposes of environmental noise assessment. It is applicable to impulse sounds propagating long distances (e.g. 0,5 km to 30 km) from sources such as mining blasting, artillery firing and bomb explosions using conventional explosives of moderate size (e.g. 0,05 kg to 1 000 kg of TNT equivalent mass). Prevailing meteorological conditions and terrain are considered wherever possible.

## 2 Normative references

The following referenced documents are indispensable for the application 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 9613-1, *Acoustics — Attenuation of sound during propagation outdoors — Part 1: Calculation of the absorption of sound by the atmosphere*



ISO 9613-2, *Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation*

ISO 10843, *Acoustics — Methods for the description and physical measurement of single impulses or series of impulses*

## 3 Terms and definitions

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

**3.1**
**instantaneous sound pressure**
total instantaneous pressure at a location in the presence of a sound wave minus the static pressure at that location

NOTE 1 It is expressed in pascals.

NOTE 2 Adapted from ISO 10843.

**3.2**
**impulse sound**
single short burst or series of short bursts of sound pressure

NOTE 1 The pressure-time history of a single burst includes a rise to peak sound pressure, followed by a decay of the pressure envelope.

NOTE 2 Adapted from ISO 10843.

**3.3**
**impulse event**
occurrence of an impulse sound

**3.4**
**unconfined explosion**
burst taking place in air in which no part of the bursting material or gaseous products is limited to a container or any other obstructing surface

**3.5**
**sound exposure**
time integral of frequency-weighted squared instantaneous sound pressure

NOTE 1 It is expressed in pascal-squared seconds.

NOTE 2 The type of frequency weighting is to be specified.

NOTE 3 Adapted from ISO 10843.

**3.6**
**band**
frequency range (band) of interest

**3.7**
**band sound exposure**
time integral of the band-filtered frequency-weighted squared instantaneous sound pressure



NOTE 1 It is expressed in pascal-squared seconds.

NOTE 2 The frequency band and type of frequency weighting is to be specified.



**3.8**
**band sound exposure level**
ten times the common logarithm of the ratio of the band sound exposure to the reference sound exposure

NOTE 1 It is expressed in decibels.

NOTE 2 In air, the reference sound exposure is $4 \times 10^{-10}$ $Pa^2 \cdot s$.

**3.9**
**peak sound pressure**
maximum absolute value of the frequency-weighted instantaneous sound pressure that occurs during a specified time interval

NOTE It is expressed in pascals.

**3.10**
**peak sound pressure level**
ten times the common logarithm of the square of the ratio of the peak sound pressure to the standard reference sound pressure

NOTE 1 It is expressed in decibels.

NOTE 2 In air, the reference sound pressure is 20 μPa.

NOTE 3 The type of frequency weighting is to be specified.

NOTE 4 Adapted from ISO 10843.

**3.11**
**directed sound speed**
speed of sound waves travelling in a specified direction

NOTE It is expressed in metres per second.

**3.12**
**directed sound speed profile**
directed sound speed expressed as a function of height

**3.13**
**ground condition**
sound reflection and sound absorption properties, taken collectively, of outdoor surface(s) between the source and the receiver

**3.14**
**excess attenuation**
attenuation, in excess of that due to geometric divergence and molecular absorption of sound waves, including propagation effects of reflection from presumed flat open ground at the local ground height near to the receiver

NOTE It is expressed in decibels.

**3.15**
**source height**
distance between the sound source and the local ground surface



NOTE It is expressed in metres.

**3.16**
**receiver height**
distance between the sound receiver and the local ground surface



NOTE It is expressed in metres.

**3.17**
**excess attenuation class**
one of a set of combined directed sound speed profiles, ground conditions, source heights and receiver heights, which together represent the excess attenuation conditions of the situation of interest

# 4 Basic method

## 4.1 General

The aim of this method is to provide a quantity for use in performing environmental noise assessment. ISO 1996-1 suggests a number of descriptors for environmental noise, many of which can be calculated from a summation over the frequency-weighted (and rating level adjusted) single-event sound exposures. The method of this Technical Specification focuses on calculating a representative value of a single-event sound exposure as it applies to the sound exposure over a long-term interval.

 

### 4.2 Single-event sound exposure level

The single-event sound exposure level is influenced by a number of parameters, which make various contributions. Some of the contributions may be known accurately from measurements, some may be measured or estimated within a range of values, and some may be known only through a statistical distribution. In sound propagation measurements, it has been observed, for example, that the received sound level of a steady source can vary by several decibels from moment to moment, as well as from day to day, or from season to season.

### 4.3 Probability of occurrence

To satisfy observation, the frequency-weighted single-event sound exposure level $L_{\mathrm{w}E}$, in decibels, shall be considered to be a statistical random variable with support $U$ and probability of occurrence $P(L_{\mathrm{w}E} = x)$, with $x \in U$. The probability of occurrence has the usual statistical properties: it is positive [$P(x) > 0,\ x \in U$], and it sums to one $\sum_{x \in U} P(x) = 1$.

### 4.4 Expected level

The expected frequency-weighted single-event (adjusted) sound exposure level, in decibels, shall be calculated from the mean antilog of the single-event exposure level:

$$\langle L_{\mathrm{wR}E} \rangle = 10 \lg \left[ \sum_{x \in U} P(L_{\mathrm{w}E} = x) 10^{0,1(x+\bar{K})} \right] \mathrm{dB} \tag{1}$$



where

$P$ is the probability of occurrence;

$x$ is a summation parameter, in decibels;



$U$ is the statistical support for the single-event sound exposure level $L_{\mathrm{w}E}$, i.e. the set of all values that can be equal to $L_{\mathrm{w}E}$;

w is the type of frequency weighting, such as A-weighting or C-weighting;

$\bar{K}$ designates a rating level adjustment, if applicable, for highly impulsive sounds (see ISO 1996-1).

NOTE The quantity $\langle L_{\mathrm{wR}E} \rangle$ is suitable for use in ISO 1996-1 as a frequency-weighted single-event (adjusted) sound exposure level.

### 4.5 Frequency weighting

The frequency-weighted sound exposure level $L_{\mathrm{w}E}$ shall be calculated by summation over bands, according to:

$$L_{\mathrm{w}E} = 10 \lg \left[ \sum_{j=1}^{N_{\mathrm{band}}} 10^{0,1[L_E(j) + \mathrm{w}(j)]} \right] \mathrm{dB} \tag{2}$$

where

$L_E(j)$ is the unweighted band sound exposure level, in decibels, for the $j$th frequency band;

$\mathrm{w}(j)$ is the frequency weighting, in decibels, for the $j$th frequency band;

$N_{\mathrm{band}}$ is the number of frequency bands.

Bandwidths of one-third-octave bands are preferred.

Contributions to the summation above from bands having values of $L_E(j)$ + w($j$) more than 20 dB below the maximum value shall be considered insignificant and shall not be required in the summation. Conversely, impulse sound sources produce strong low frequency components and special care shall be taken to ensure that below 200 Hz, frequency bands within 20 dB of the maximum band level are retained in the computation.

### 4.6 Band sound exposure level, $L_E(j)$

The angle-dependent band sound exposure level $L_E(j)$, in decibels, at a long distance (approximately 0,5 km to 30 km) from an impulse sound source shall be calculated by:

$$L_E(j) = S_\phi(j) - A_{\text{tot}}(j) \tag{3}$$

where

- $j$ denotes the $j$th frequency band;
- $S_\phi$ is the angle-dependent band source sound exposure level, in decibels, at a reference distance of 1 km (see 6.3);
- $\phi$ is the direction of the receiver location with respect to the location of the sound source;
- $A_{\text{tot}}$ is the band attenuation, in decibels, experienced by impulse sounds propagating from the sound source to the receiver.



NOTE 1 The direction $\phi$ may include the receiver azimuth and elevation angles in situations where the elevation angle is not zero, and may also include the source orientation angles for directional sources that can be redirected for each event.



NOTE 2 For complex cases, the source sound exposure may include the combined effects of the source and sound absorbing or reflecting screens or barriers nearby to the source that affect propagation. The diffraction insertion loss of barriers or screens can be affected by meteorological conditions which need to be taken into account.

## 5 Calculation of attenuation

### 5.1 Total band attenuation, $A_{\text{tot}}(j)$

The total band attenuation $A_{\text{tot}}$, in decibels, shall be calculated by:

$$A_{\text{tot}}(j) = A_{\text{div}} + A_{\text{atm},k}(j) + A_{\text{rec}}(j) + A_{\text{ex},\,l}(j) \tag{4}$$

where

- $A_{\text{div}}$ is the attenuation, in decibels, due to geometric divergence (see 5.2);
- $A_{\text{atm},k}(j)$ is the attenuation, in decibels, due to atmospheric absorption for the $k$th atmospheric absorption class (see 5.3);
- $A_{\text{rec}}(j)$ is the attenuation, in decibels, due to the presence of any surfaces other than flat ground (e.g. hills, walls, berms or sound-attenuating screens and barriers) near to the receiver that affect propagation (see 5.4);
- $A_{\text{ax},l}(j)$ is the excess attenuation, in decibels, for the $l$th excess attenuation class due to all other propagation effects, including only flat ground beneath and near to the receiver (see 5.5).