
**Acoustics — Measurement of airborne
sound emitted by vessels on inland
waterways and harbours**

*Acoustique — Mesurage du bruit aérien émis par les bateaux de navigation
intérieure et portuaire*

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 2922 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This second edition cancels and replaces the first edition (ISO 2922:1975), which has been technically revised.

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Acoustics — Measurement of airborne sound emitted by vessels on inland waterways and harbours

1 Scope

This International Standard specifies the conditions for obtaining reproducible and comparable measurement results of the airborne sound emitted by vessels of all kinds on inland waterways and in ports and harbours, except powered recreational craft as specified in ISO 14509. This International Standard is applicable to small sea-going vessels, harbour vessels, dredgers, and all watercraft including non-displacement craft, used or capable of being used as a means of transport on water.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60942, *Electroacoustics — Sound calibrators*, ISO 2922:2000
<https://standards.itec.ai/catalog/standards/sist/80109a28-0f76-4272-b4d5-5d6214983619/iso-2922-2000>

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

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

3 Terms and definitions

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

3.1

acceptance test for vessels

acceptance test

measurement performed to prove that the sound emitted by the vessel, stationary or in motion, as delivered by the manufacturer, complies with noise specifications or prescribed limits

3.2

monitoring test for vessels

monitoring test

measurement performed in order to check that the sound emitted by the vessel, stationary or in motion, is still within prescribed limits and that no noticeable changes have occurred since the acceptance on initial delivery or after modification, as applicable

1) To be published. (Revision of IEC 60651 and IEC 60804)

3.3
maximum AS-weighted sound pressure level for vessels
maximum AS-weighted sound pressure level

L_{pASmax}

maximum sound pressure level achieved from measurement during the passage of the vessel under specified operating conditions measured with frequency weighting A and with time weighting S according to IEC 61672-1

NOTE It is expressed in decibels (dB).

3.4
A-weighted sound exposure

E_A
 time integral of squared, instantaneous, A-weighted sound pressure over a stated time interval or event

NOTE 1 It is expressed in pascal-squared seconds (Pa²·s).

NOTE 2 In symbols, the A-weighted sound exposure, E_A , of a specified event (e.g. the passage of a craft) is represented by

$$E_A = \int_{t_1}^{t_2} p_A^2(t) dt$$

where $p_A^2(t)$ is the squared, instantaneous, A-weighted sound pressure as a function of running time t for an integration time starting at t_1 and ending at t_2 (see 11.1.1).

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3.5
A-weighted sound exposure level

L_{AE}
 ten times the logarithm to the base 10 of the ratio of an A-weighted sound exposure, E_A , to the reference sound exposure, E_0 , given by the product of the square of the reference sound pressure of $p_0 = 20 \mu\text{Pa}$ and the sound exposure reference duration of $T_0 = 1 \text{ s}$, ($E_0 = p_0^2 T_0 = 4 \times 10^{-10} \text{ Pa}^2 \cdot \text{s}$)

NOTE 1 It is expressed in decibels (dB).

NOTE 2 In symbols, the A-weighted sound exposure level, L_{AE} , of a specified event (e.g. the passage of a vessel) with the duration $T = t_2 - t_1$, is related to a corresponding measurement of the time-averaged A-weighted sound pressure level, $L_{pAeq,T}$, by

$$L_{AE} = 10 \lg \left\{ \frac{\int_{t_1}^{t_2} p_A^2(t) dt}{p_0^2 T_0} \right\} \text{ dB} = 10 \lg \left(\frac{E_A}{E_0} \right) \text{ dB} = L_{pAeq,T} + 10 \lg \left(\frac{T}{T_0} \right) \text{ dB}$$

where $p_A^2(t)$ is the squared, instantaneous, A-weighted sound pressure as a function of running time t .

NOTE 3 The A-weighted sound exposure level L_{AE} is arithmetically identical to the single-event sound pressure level $L_{p,1s}$ (reference duration $T_0 = 1 \text{ s}$) as, for example, defined in ISO 3744.

NOTE 4 The abbreviation "SEL" is sometimes used for the single-event sound pressure level, $L_{p,1s}$.

NOTE 5 In this International Standard, the sound exposure level is to characterize the emission of the source and not the noise impact on people exposed to the sound.

3.6**background noise for vessels****background noise**

noise from all sources other than the craft under test

EXAMPLE Noise from waves splashing on the measuring craft or the shore, other craft or equipment, and wind effects.

4 Measurement quantities

4.1 Frequency weighting A shall be used for all measurements.

4.2 Care should be taken to avoid any influence on the result from unwanted sound signals, for example noise from wind on the microphone of the measuring equipment, electrical interference, or extraneous sound sources not under consideration.

4.3 The quantities to be determined at all microphone positions in acceptance and monitoring tests are the A-weighted sound exposure level, L_{AE} , received from the operation of vessel and the maximum AS-weighted sound pressure level, L_{pASmax} , both expressed in decibels.

4.4 If, in addition to the sound exposure level, spectral analysis in acceptance tests or determination of some special acoustical characteristics of vessels is needed, the quantities to be measured are the unweighted or C-frequency weighted, octave-band or one-third-octave-band S-time weighted sound pressure levels in decibels at the time of maximum sound pressure, or the unweighted or C-frequency weighted, octave-band or one-third-octave-band sound exposure levels in decibels.

4.5 When measurements are made at some distance from the source, the levels observed may be considerably affected by the weather conditions. For example, the attenuation of sound due to air absorption is affected by the temperature and humidity of the air. In addition the refraction of sound waves due to wind and temperature gradients will affect the levels received at a particular position. It is recommended that measurements taken in extreme or atypical conditions be avoided. If possible, a value obtained under typical climatic conditions, and an indication of the range of values obtained under other climatic conditions, should be included in the test report.

4.6 For steady-state noise, as that from a stationary ship's engine, the quantity to be measured is the time-averaged A-weighted sound pressure level, L_{pAeq} .

5 Measurement uncertainty

Table 1 lists the likely sources of uncertainty and estimates of the standard deviation associated with each based on experience. These sources of uncertainty are considered to be independent for each measurement type. Therefore, the estimated total standard uncertainty is given by the square root of the sum of the squares of the individual standard deviations contained in Table 1.

Table 1 — Standard deviation of reproducibility

Values in decibels

Individual sources of uncertainty	Individual standard deviations			
	Maximum AS-weighted sound pressure level L_{ASmax}	A-weighted sound exposure level L_{AE}	Time-averaged A-weighted sound pressure level at 25 m L_{pAeq}	Time-averaged A-weighted sound pressure level at 1 m L_{pAeq}
Distance effects	0,25	0,15	0,0	1,0
Measuring equipment	1,0	0,7	0,7	0,7
Sound propagation conditions	1,5	1,2	1,2	0,0
Waves, currents and tides	1,5	1,5	0,0	0,0
Operator(s) effects	0,2	0,2	0,1	0,1
Test site variations	1,0	1,0	1,5	1,0
Operating conditions	0,5	0,5	0,5	0,5
Estimated total standard uncertainty	2,6	2,3	2,1	1,7

6 Measuring equipment

6.1 Equipment specifications

The instrumentation system, including microphones and cables (which shall be used according to the manufacturer's specifications), and including the windscreen recommended by the manufacturer and the overall electroacoustic performance of any additional measuring equipment, including for example a tape recorder and/or level recorder, shall meet the requirements for a type 1 instrument specified in IEC 61672-1.

NOTE Sound level meters with "maximum hold" capabilities are preferred to measure the maximum S-time weighted sound pressure level.

When a tape recorder is used for the measurements, the dynamic range of the instrumentation shall be consistent with the measured signal.

For the measurement of noise spectra the filters shall correspond to IEC 61260, class 1.

A wind speed anemometer which is accurate to within $\pm 10\%$ shall be used.

An engine speed tachometer which is accurate to within ± 50 r/min shall be used.

6.2 Windscreen

A suitable windscreen shall be used to reduce the influence of wind on the reading. When it can be expected that the wind-induced signal will be within 10 dB of the average sound level induced by the vessel under investigation, windscreens shall be used which, together with the sound level meter, meet the requirements of IEC 61672-1.

6.3 Equipment calibration

A sound calibrator which meets the requirements of IEC 60942 shall be used.

The overall acoustic performance of the measurement equipment shall be checked with the sound calibrator, according to the manufacturer's instructions, at the beginning and at the end of each series of measurements and at least at the beginning and end of each measurement day.

At intervals of no longer than 2 years, the sound level meter shall undergo laboratory verification for compliance with IEC 61672-1. The date of the last verification of the compliance with IEC 61672-1 shall be recorded.

The sound calibrator used for calibration of the sound level meter shall undergo laboratory verification every year, with traceability to a primary standards laboratory.

7 Test site specifications and environmental conditions

7.1 Test conditions

Two classes of test conditions are considered, namely

- when the vessel is under way, the requirements of 7.2.1, 7.3 and 7.4 shall apply;
- when the vessel is alongside a wharf or at anchor, the requirements of 7.2.2, 7.3, 7.4 and 7.5 shall apply.

7.2 Test site specifications

7.2.1 Moving vessels

Within 30 m around the vessel under test and the microphone, there shall be no large surfaces (e.g. retaining walls, building façades, rocks, bridges) from which sound can be reflected back to the microphone.

In the vicinity of the microphone, there shall be no obstacles which could disturb the sound field. Therefore, no person shall be between the microphone and the sound source, and any observers shall be in such a position that any influence on the meter reading is avoided.

The area between the vessel under test and the measurement microphone shall be open water, free from any sound absorbing or sound reflecting objects.

7.2.2 Stationary vessels

The surroundings of the microphone up to 30 m shall be free of large, sound-reflecting objects like barriers, hills, rocks, bridges or buildings.

7.3 Environmental conditions

7.3.1 At wind velocities above 7 m/s, the sound propagation may be disturbed and measurements shall not be performed.

7.3.2 Tests shall be avoided in conditions of rain or other precipitation and/or when wave motion or surf is too high for the size of vessel under test.

7.4 Background noise

7.4.1 Acceptance tests

The maximum AS-weighted sound pressure level, the A-weighted sound exposure level and/or the time-averaged sound pressure level due to other noise sources (e.g. waves splashing on the measuring boat or ashore, other vessels, local industry or other machinery) and due to wind shall be at least 10 dB below the maximum AS-weighted sound pressure level, the A-weighted sound exposure level and/or the time-averaged sound pressure level of the sound of the vessel.

If the noise is frequency analysed, the difference shall be at least 10 dB in the required octave or one-third-octave bands.