भारतीय मानक

Indian Standard

IS 14546 : 2024
ISO 2922 : 2020

ध्वनिकी — अंतर्देशीय जलमार्गों और बंदरगाहों पर जहाजों द्वारा उत्सर्जित वायुजनित ध्वनि का मापन

(दूसरा पुनरीक्षण)

Acoustics — Measurement of Airborne Sound Emitted by Vessels on Inland Waterways and Harbours

(Second Revision)

ICS 17.140.30

भारतीय मानक ब्यूरो
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www.bis.gov.in www.standardsbis.in

August 2024

Price Group 8

Inland, Harbour Crafts and Fishing Vessels Sectional Committee, TED 18

NATIONAL FOREWORD

This Indian Standard (*Second Revision*) which is identical to ISO 2922 : 2020 'Acoustics — Measurement of airborne sound emitted by vessels on inland waterways and harbours' issued by International Organization for Standardization (ISO), was adopted by the Bureau of Indian Standards on the recommendations of the Inland, Harbour Crafts and Fishing Vessels Sectional Committee and approval of the Transport Engineering Division Council.

This standard was first published in 1988 and revised in 1998. In this revision, conditions for obtaining measurement results of the airborne sound emitted by vessels, was made exhaustive and elaborative. This revision was undertaken to harmonize it with ISO 2922 : 2020.

The main changes incorporated in this revision are as follows:

a) Clarification in the scope that the document is applicable to vessels of all speeds and lengths has been given;

b) Specification of: sound pressure level measurement response (slow), in **4.1**; integration time for background noise (5 min), in **6.4**; and the surf/ weather limitation (sea state 1), in **6.3.2**, during the survey period; and

c) Addition of a formula to compute the sound pressure level at 25 m in **10.1.4** has been added.

The text of ISO standard may be approved for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'; and

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories	IS/ISO/IEC 17025 : 2017 General requirements for the competence of testing and calibration laboratories	Identical
IEC 60942 : 2017 Electroacoustics — Sound calibrators	IS 15059 : 2023/IEC 60942 : 2017 Electroacoustics — Sound calibrators (*second revision*)	Identical
IEC 61260-1 Electroacoustics — Octave-band and fractional-octave-band filters — Part 1: Specifications	IS 6964 : 2018 Electroacoustics — Octave-band and fractional octave band filters — Specifications (*second revision*)	Identical
IEC 61672-1 Electroacoustics — Sound level meters — Part 1: Specifications	IS 15575 (Part 1) : 2016 Electroacoustics — Sound level meters: Part 1 Specifications (*first revision*)	Identical

(*Continued on third cover*)

Contents

Page

Indian Standard

ACOUSTICS — MEASUREMENT OF AIRBORNE SOUND EMITTED BY VESSELS ON INLAND WATERWAYS AND HARBOURS

(Second Revision)

1 Scope

This document 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 the ISO 14509 series. This document is applicable to 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. There are no limitations to the application of this document with regard to speed, length and height of vessels, as long as the ship is determined to act like a point source at the reference distance of 25 m.

All noise data obtained in accordance with this document are referred to a reference distance of 25 m.

2 Normative references

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

ISO 1996-2:2017, *Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

IEC 60942:2017, *Electroacoustics — Sound calibrators*

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

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

IEC 61260-3, *Electroacoustics — Octave-band and fractional-octave-band-filters — Part 3: Periodic tests*

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

IEC 61672-3, *Electroacoustics — Sound level meters — Part 3: Periodic tests*

3 Terms and definitions

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

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

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

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

3.1
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 specified limits

3.2
monitoring test for vessels
monitoring test
measurement performed to check that the sound emitted by the vessel, stationary or in motion, is still within specified limits and that no noticeable changes have occurred since the acceptance on initial delivery or after modification, as applicable

3.3
maximum AS-weighted sound pressure level for vessels
maximum AS-weighted sound pressure level
$L_{p\mathrm{ASmax}}$
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 slow (S)

Note 1 to entry: Sound pressure level is expressed in decibels (dB).

Note 2 to entry: Other weightings such as C or unweighted can be needed.

3.4
A-weighted sound exposure
$E_{\mathrm{A},T}$
integral of the square of the sound pressure, p, over a stated time interval or event of duration T (starting at t_1 and ending at t_2), measured with frequency weighting A

$$E_{\mathrm{A},T} = \int_{t_1}^{t_2} p_{\mathrm{A}}^2(t)\,\mathrm{d}t$$

Note 1 to entry: Sound exposure is expressed in pascal-squared seconds ($\mathrm{Pa}^2\times\mathrm{s}$).

[SOURCE: ISO/TR 25417:2007, 2.6, modified – Former Notes 2 to 4 deleted.]

3.5
A-weighted sound exposure level
$L_{E,\mathrm{A},T}$
ten times the logarithm to the base 10 of the ratio of the A-weighted sound exposure, $E_{\mathrm{A},T}$, to a reference value, E_0, which is given by the product of the square of the reference sound pressure of $p_0 = 20$ µPa and the sound exposure reference duration of $T_0 = 1$ s, ($E_0 = {p_0}^2 \times T_0 = 4 \times 10^{-10}$ Pa^2 s)

Note 1 to entry: Sound exposure level is expressed in decibels (dB).

Note 2 to entry: In symbols, the A-weighted sound exposure level, $L_{E,\mathrm{A},T}$, 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, $L_{p\mathrm{Aeq},T}$, by

$$L_{E,\mathrm{A},T} = 10\lg\left\{\frac{\int_{t_1}^{t_2} p_{\mathrm{A}}^2(t)\,\mathrm{d}t}{p_0^2 T_0}\right\}\mathrm{dB} = 10\lg\left(\frac{E_{\mathrm{A},T}}{E_0}\right)\mathrm{dB} = L_{p\mathrm{Aeq},T} + 10\lg\left(\frac{T}{T_0}\right)\mathrm{dB}$$

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

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

Note 4 to entry: The abbreviation "SEL" is sometimes used for the single-event sound pressure level, $L_{p,1\mathrm{s}}$.

Note 5 to entry: In this document, the sound exposure level characterizes 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.

3.7
time-averaged sound pressure level
$L_{p,T}$
equivalent continuous sound pressure level
$L_{p,\mathrm{eq}T}$
ten times the logarithm to the base 10 of the ratio of the time average of the square of the sound pressure, p, during a stated time interval of duration, T (starting at t_1 and ending at t_2), to the square of a reference value, p_0, expressed in decibels

$$L_{p,T} = L_{p,\mathrm{eq}T} = 10\lg\left\{\frac{\frac{1}{T}\int_{t_1}^{t_2} p^2(t)\,\mathrm{d}t}{p_0^2}\right\}\mathrm{dB}$$

where the reference value, p_0, is 20 μPa

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

[SOURCE: ISO/TR 25417:2007, 2.3]

4 Measurement quantities

4.1 Frequency weighting A shall be used for all measurements. The time weighting shall be set to slow (S) for all measurements.

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

4.3 The quantities that shall be determined at all microphone positions in acceptance and monitoring tests are the A-weighted sound exposure level, $L_{E,\mathrm{A},T}$, received from the operation of the vessel, and the maximum AS-weighted sound pressure level, $L_{p\mathrm{ASmax}}$.

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 that shall 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 (dB).

4.5 When measurements are made at some distance from the source, the levels observed can 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 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 that shall be measured is the time-averaged A-weighted sound pressure level, $L_{p\mathrm{Aeq}}$.

5 Measuring equipment

5.1 Equipment specifications

The instruments for measuring sound pressure levels, including microphone(s) as well as cable(s), recording devices and other accessories, if used, shall meet the requirements for a class 1 instrument according to IEC 61672-1 for free field or random incidence application, as appropriate. Filters shall meet the requirements for a class 1 instrument according to IEC 61260-1.

A wind speed anemometer with a maximum permissible error of ±10 % shall be used.

An engine speed tachometer with a maximum permissible error of ±50 r/min shall be used.

5.2 Windscreen

A suitable windscreen shall be used to reduce the influence of the 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 a class 1 instrument according to IEC 61672-1.

5.3 Operational check/Calibration

At the beginning and at the end of every measurement session, the entire sound pressure level measuring system shall be checked at one or more frequencies by means of a sound calibrator meeting the requirements for a class 1 instrument according to IEC 60942. Without any further adjustment, the difference between the readings of two consecutive checks shall be less than or equal to 0,5 dB. If this value is exceeded, the results of measurements obtained after the previous satisfactory check shall be discarded.

In connection with each measurement session and at least at the beginning and the end of each measurement day, where possible, the impact of residual sound levels on measured results shall be checked to determine their potential impact on the measurement results.

5.4 Verification

Conformance of the sound pressure level measuring instrument, including the microphone, the filters and the sound calibrator, with the relevant requirements of IEC 61672-1, IEC 61260-1 and IEC 60942, respectively, shall be verified by the existence of a valid certificate of conformance from the manufacturer. Conformance testing in accordance with IEC 61672-3, IEC 61260-3 and ISO 60942:2017, Annex B, respectively, is required for verification. If applicable, random incidence response of the microphone shall be verified by a procedure from IEC 61183.

All conformance testing shall be conducted by a laboratory operating in accordance with ISO/IEC 17025 and meeting the maximum-permitted uncertainty defined in IEC 61672-1, IEC 61260-1 and IEC 60942 respectively.

It is recommended that the sound calibrator be calibrated at intervals not exceeding 1 year, that the conformance of the instrumentation system with the requirements of IEC 61672-1 be verified at intervals not exceeding 2 years, and that the conformance of analog filters with the requirements of IEC 61260-1 be verified at intervals not exceeding 2 years. National regulations can require otherwise.

NOTE Testing in accordance with IEC 61672-3 does not fully verify conformance with the requirements of IEC 61672-1, unless it has been pattern approved in accordance with IEC 61672-2.

6 Test site specifications and environmental conditions

6.1 Test conditions

Two classes of test conditions are considered, namely:

— moving vessels - when the vessel is under way, the requirements of 6.2.1, 6.3 and 6.4 shall apply;

— stationary vessels - when the vessel is alongside a wharf or at anchor, the requirements of 6.2.2, 6.3, 6.4 and 6.5 shall apply.

6.2 Test site specifications

6.2.1 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 can 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.

6.2.2 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.

6.3 Environmental conditions

6.3.1 At wind velocities above 7 m/s, the sound propagation can be disturbed and measurements shall not be performed unless the user has a method for adjusting the measurements for high wind.

6.3.2 Tests shall be avoided in conditions of rain or other precipitation, and/or when the wave heights are greater than 0,1 m (World Meteorological Organization (WMO) Sea State 1).

6.4 Background noise

6.4.1 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. The background noise shall be measured for a period of 5 min.

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

6.4.2 Monitoring tests

6.4.2.1 Correction for L_{pASmax} and for L_{pAeq}

The L_{pASmax} and/or the L_{pAeq} of the background noise shall be at least 6 dB below the corresponding reading obtained during the passage of the vessel (for L_{pASmax}) and/or during the measurement period (for L_{pAeq}). The readings shall then be corrected according to Table 1 or by use of an appropriate decibel subtraction method.

6.4.2.2 Correction for $L_{E,A,T}$

The $L_{E,A,T}$ of the background noise (back) is given in terms of the background L_{pAeq} by Formula (1):

$$L_{E,A,T\,(back)} = L_{pAeq\,(back)} + 10\ \lg\ (T/1s)\ dB \quad (1)$$

where T is the integration time (5 min) used to calculate for $L_{E,A,T}$.

The $L_{E,A,T}$ of the background noise shall be at least 6 dB below the corresponding reading obtained during the passage of the vessel. The reading shall then be corrected according to Table 1.

Table 1 — Correction for background sound pressure level, L''_{pAS}, for monitoring tests

Values in decibels

Difference between the maximum AS-weighted sound pressure level, the A-weighted sound exposure level[a] and/or the A-weighted time-averaged sound pressure level[b] and the corresponding quantities for the background noise	Correction to be applied to the reading of the maximum AS-weighted sound pressure level, the A-weighted sound exposure level[a] and/or the A-weighted time-averaged sound pressure level[b]
≥11	0
10	-0,5
9	-0,6
8	-0,7
7	-1,0
6	-1,3

[a] Both obtained during the passage of the vessel.

[b] Obtained during the measurement period.

6.5 Measurements on stationary vessels

For tests taken when the vessel is moored or alongside a wharf or fitting-out basin, etc., it can be impossible to obtain a distance of 30 m from large reflecting surfaces. Where this occurs, details on the test location shall be included in the report.

Measurements taken at a specific location in such conditions will refer only to that particular location and no correlation should necessarily be inferred for noise measurement taken at another berth.

NOTE The sound from moored vessels measured on land can be significantly affected by the form of the wharf to which the vessel is moored. High, solid wharves can provide considerable shielding to an extent governed by, e.g., the state of the tide.

7 Test course and measurement of distance

7.1 At the test course, the depth of water shall be sufficient for normal operation of the vessel.

7.2 During the test, the course of the vessel shall be as straight as possible at the distance from the microphone specified in Clause 9.

7.3 Vessels tested on inland waterways shall run either against the current or tide, or be in slack water. However, as specified in 10.1.2, the noisier side shall be measured.

NOTE This requirement can necessitate waiting for a suitable tide.

7.4 The distance between the microphone and the side of the vessel shall be measured with an uncertainty of ±1 m by optical means, for example by range-finders or photographic techniques, unless this distance is measured by running the vessel on a specified course past a microphone placed in a specified position. In this latter case, permanent test sites with appropriate direction markers are recommended.

8 Operating conditions

8.1 Distance from the microphone

The test run shall start at a sufficient distance from the microphone to obtain stabilized engine conditions when passing the microphone, with the vessel proceeding against any current or tide.

8.2 Loading condition

The loading condition of the vessel, the quantity, type and stowage of cargo, as well as the draught of the vessel, shall be stated in the test report. For small craft, the disposition of masses, including the number and seating of persons, shall be recorded. For acceptance tests, the vessel shall be at minimum loading.

8.3 Main engines

8.3.1 During the tests, the main engines shall run at 95 % or more of their rated speed (or 95 % of rated power) or at a nominal number of revolutions of the propellers (or nominal power) according to the specifications in the contract clauses for the vessel's acceptance or, in the case of a commissioned vessel, at the maximum continuous rate of engine revolutions (or maximum continuous power).

8.3.2 For a stationary vessel, with measurements at selected places, the propulsion machinery shall be stopped if this is normal for harbour conditions.

8.4 Auxiliary engines

All auxiliary engines and equipment necessary for continuous service and normal operation shall run at their normal speed and normal load.

8.5 Doors and windows

During the acceptance tests, measurements shall first be performed with the windows and doors of the engine rooms shut. The sound pressure level with the windows and doors of the engine rooms open shall be stated separately.

8.6 Monitoring tests

During the monitoring tests, the vessel shall run under normal sailing conditions. Windows and doors of the engine rooms shall be open if this is usual during normal operating conditions. Any vessel conditions or configurations which would impact the results of this survey shall be reported.

9 Microphone position

9.1 The microphone shall be positioned at 3,5 m ± 0,5 m above the water surface and, if mounted on a solid surface, shall be positioned at least 1,2 m above that surface. The microphone shall be positioned within ±0,5 m of the edge of the surface above which it is mounted. It is generally accepted to use a tripod to fix the microphone or the entire sound level meter.

9.2 When the vessel passes the microphone, the distance between the side of the vessel and the microphone shall be 25 m ± 5 m.

NOTE Depending on the directivity of sound radiation, the highest indication of the sound level meter might not occur when the vessel is at its closest point. For this reading, the distance can be more than 25 m.

9.3 If the point of closest approach between the microphone and the vessel deviates from the reference distance of 25 m, the results shall be corrected according to 10.1.4.

9.4 For the measurement of sound emitted by vessels at anchor, such as dredgers, salvage vessels and diving vessels, the microphones shall be placed 25 m ± 2 m from the side and at several points around the vessel, as possible. Machinery on board the vessel shall be run at the normal speed used when the vessel is at anchor or working and with normal load. If the point of closest approach between the microphone and the vessel deviates from the reference distance of 25 m, the results shall be corrected according to 10.1.4.

10 Test procedure

10.1 Moving vessels

10.1.1 Measure the sound exposure level of each individual pass-by from the time at which the sound of the approaching vessel is first heard above the background noise until the time that the sound from the departing vessel fades into the background noise. The maximum AS-weighted sound pressure level indicated during the passage of the vessel shall also be measured. For this latter measurement, ignore any maximum level which is obviously out of character with the general sound pressure level being read.

NOTE In practice, the exact start and finish of the sound exposure level measurement is not critical provided that the measurement period covers the highest 10 dB of the sound from the passage of the vessel.

10.1.2 For the acceptance tests, make at least two passages. Round the sound exposure levels and the arithmetic mean value of the sound pressure level to the nearest integral decibel.

If the sound radiation of the vessel is obviously asymmetrical with respect to the longitudinal axis of the vessel, then the measurement shall be performed at the side with the higher sound pressure level.

The spread between the results of sound exposure measurements made during the two passages shall not be larger than 3 dB, otherwise a new series of measurements shall be made.

10.1.3 For the monitoring tests, slight deviation from the test conditions specified for acceptance tests may be tolerated with respect to the test site, the background noise, the distance between the microphone and the vessel, and the operating conditions. For example, the number of measurement positions and the number of engine operating conditions may be reduced.

10.1.4 If the distance d between the microphone and the side of the vessel at its closest approach deviates from the reference value of 25 m, the A-weighted sound exposure level, $L_{E,\mathrm{A},T,d}$, measured at a distance d, and the maximum AS-weighted sound pressure level, $L_{p\mathrm{ASmax},d}$, measured at a distance d, shall be corrected to obtain the A-weighted sound exposure level, $L_{E,\mathrm{A},T,25}$, for the reference distance 25 m and

the maximum AS-weighted sound pressure level, $L_{\mathrm{ASmax},25}$, for the reference distance 25 m, according to Formulae (2) and (3):

$$L_{p\mathrm{ASmax},25} = L_{p\mathrm{ASmax},d} + k_{\mathrm{d}} \lg [d/(25\ \mathrm{m})]\ \mathrm{dB} \quad (2)$$

$$L_{E,\mathrm{A},T,25} = L_{E,\mathrm{A},T,d} + k_{\mathrm{d}} \lg [d/(25\ \mathrm{m})]\ \mathrm{dB} \quad (3)$$

where

$k_{\mathrm{d}} = 20$ for $L_{p\mathrm{ASmax}}$;

$k_{\mathrm{d}} = 20$ for $L_{E,\mathrm{A},T}$.

10.1.5 The presence of clearly audible tones as defined by ISO 1996-2:2017, Annex K, or noise of a distinctly impulsive character shall be stated in the test report.

10.2 Stationary vessels

The $L_{p\mathrm{Aeq}}$ of a complete vessel and/or specific component in accordance with 9.4 shall be measured for a period of at least 30 s.

The presence of clearly audible tones as defined by ISO 1996-2:2017, Annex K, or noise of a distinctly impulsive character shall be stated in the test report.

11 Measurement uncertainty

The measurement uncertainties associated with the sound levels determined in accordance with this document shall be evaluated, preferably in compliance with ISO/IEC Guide 98-3.

Uncertainties arise in part from variations, between test sites, in sound propagation conditions, in waves, currents and tides, in measuring equipment, in operating conditions, in operator effects and in the distances.

The uncertainties of the noise levels, L, determined in accordance with this document are estimated by the total standard deviation, σ_{tot}, in decibels, as given in Formula (4):

$$u(L) \approx \sigma_{\mathrm{tot}} \quad (4)$$

This total standard deviation can be obtained by using the modelling approach described in ISO/IEC Guide 98-3. This requires a mathematical model, which in case of lack of knowledge, can be replaced by results from measurements, including results from round robin tests.

In this context, the total standard deviation is expressed by the standard deviations of reproducibility of the likely individual sources of uncertainty in accordance with Formula (5) where the sources are considered to be independent from each other:

$$\sigma_{\mathrm{tot}} = \sqrt{\delta_1^2 + \delta_2^2 + \delta_3^2 + \delta_4^2 + \delta_5^2 + \delta_6^2 + \delta_7^2} \quad (5)$$

where

δ_1 is the standard deviation of the test site variations, in decibels;

δ_2 is the standard deviation of the sound propagation conditions, in decibels;

δ_3 is the standard deviation of the variation of waves, currents and tides, in decibels;

δ_4 is the standard deviation of the measuring equipment, in decibels;

δ_5 is the standard deviation of the operating conditions, in decibels;

δ_6 is the standard deviation of the operator(s) effects, in decibels;

δ_7 is the standard deviation of the distance effects, in decibels.

Estimated values for the standard deviations of reproducibility of the individual sources of uncertainty based on experiences are given in Table 2.

Table 2 — Standard deviation of reproducibility

Values in decibels

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

If the uncertainty of measurement is to be reported, the expanded measurement uncertainty, U, in decibels, can be calculated from σ_{tot} according to Formula (6):

$$U = k\,\sigma_{tot} \tag{6}$$

The value of U depends on the degree of confidence that is desired. In general, it is 95 %, and the practical examples are as follows.

— For a normal distribution of measured values, there is 95 % confidence that the true value lies within the range $(L - U)$ to $(L + U)$. This corresponds to a coverage factor of $k = 2$.

— If the purpose of determining the levels is to compare the result with a limit value, it can be more appropriate to apply the coverage factor for a one-sided normal distribution. In that case, the coverage factor $k = 1{,}6$ corresponds to a 95 % confidence level.

12 Test report

The test report shall include the following:

a) a reference to this document, i.e. ISO 2922:2020;

b) the nature of the tests;

c) the test site, water conditions, meteorological conditions (including temperature, barometric pressure, wind direction and wind velocity); for measurements on stationary vessels, give details of the test location if it was impossible to obtain a distance of 30 m from large reflecting surfaces (see 6.5);

d) the measuring equipment used, together with the date of the last verification of the compliance with IEC 61672-1;

e) the level of the maximum AS-weighted background sound pressure level and the A-weighted background sound exposure level;

f) the vessel, its main engines, the engine and shaft speeds during the test, and the setting of controllable-pitch or Voith-Schneider propellers;

g) the auxiliary engines and equipment and their operating conditions;

h) the loading of the vessel, the quantity, type and stowage of cargo, as well as the draught of the vessel; for small craft, the disposition of masses, including the number and seating of persons;

i) the microphone position;

j) the A-weighted sound exposure levels $L_{E,\mathrm{A},T,25}$ and $L_{E,\mathrm{A},T,d}$, and the maximum AS-weighted sound pressure levels $L_{p\mathrm{ASmax},25}$ and $L_{p\mathrm{ASmax},d}$ and, for measurements on stationary vessels, the time-averaged A-weighted sound pressure level, $L_{p\mathrm{Aeq}}$, together with the expanded measurement uncertainty (see Clause 11), and, optionally, the sound spectrum; 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 (see 4.5); the distance d whether different from 25 m or not;

k) the presence of clearly audible tones or noise of a distinctly impulsive character;

l) whether the windows and doors of the engine room were open or shut;

m) special details on test location and engine operation according to 6.5 and 8.3.2;

n) vessel name and IMO number (if applicable);

o) name of company and individuals performing the survey.

Bibliography

[1] ISO 14509 (all parts), *Small craft —Airborne sound emitted by powered recreational craft*

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

[3] ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

[4] IEC 61672-2, *Electroacoustics – Sound level meters – Part 2: Pattern Evaluation Tests*

[5] ISO/TR 25417:2007, *Acoustics — Definitions of basic quantities and terms*

(*Continued from second cover*)

The Committee has reviewed the provisions of the following International Standard referred in this adopted standard and has decided that it is acceptable for use in conjunction with this standard:

International Standard	*Title*
ISO 1996-2 : 2017	Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels
IEC 61183	Electroacoustics — Random-incidence and diffuse-field calibration of sound level meters
IEC 61260-3	Electroacoustics — Octave-band and fractional-octave-band filters — Part 3: Periodic tests
IEC 61672-3	Electroacoustics — Sound level meters — Part 3: Periodic tests

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Bureau of Indian Standards shall not be held responsible for identifying any or all such patent rights.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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This Indian Standard has been developed from Doc No.: TED 18 (19336).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi