INTERNATIONAL STANDARD

**ISO 14509-3**

First edition
2009-08-01

# Small craft — Airborne sound emitted by powered recreational craft —

## Part 3: Sound assessment using calculation and measurement procedures

*Petits navires — Bruit aérien émis par les bateaux de plaisance motorisés —*

*Partie 3: Évaluation du bruit à l'aide de procédures de calcul et de mesure*

Reference number
ISO 14509-3:2009(E)



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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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14509-3 was prepared by Technical Committee ISO/TC 188, *Small craft*.

ISO 14509 consists of the following parts, under the general title *Small craft — Airborne sound emitted by powered recreational craft*:

— *Part 1: Pass-by measurement procedures*

— *Part 2: Sound assessment using reference craft*

— *Part 3: Sound assessment using calculation and measurement procedures*

# Introduction

The European Union Directive 2003/44/EC (Amendment to Directive 94/25/EC) introduces limits for sound emission from recreational craft and requires conformity for certain types of craft to be shown by using the ISO 14509 series. ISO 14509-1 provides a practical measurement method, ISO 14509-2 provides an assessment method using reference craft and this part of ISO 14509 provides a predictive measurement method based on the work of the SoundBoat project. SoundBoat was funded by the European Commission and various European Marine Industry Associations and industrial partners to develop alternative methods of testing sound emission from recreational craft. Over the two years of the project, more than 65 craft have been tested according to the ISO 14509-1 pass-by test. From this an algorithm has been developed that uses a combination of hull–water sound, derived from hull parameters, and exhaust outlet sound, derived by direct measurement on board the craft under test, to predict the sound pressure level that would be observed at 25 m had the craft undergone pass-by testing according to ISO 14509-1. The method specified in this part of ISO 14509 does not require a measurement platform to be established and testing can be carried out independently of location and weather restrictions. This method does not require a list of reference craft to be established and provides a reproducible assessment procedure comparable to ISO 14509-1 pass-by testing to within 2 dB.

The SoundBoat project has concentrated on specific craft types and has only tested craft with the following characteristics:

— bottom type configuration of not more than two chines;

— square transom configuration;

— length of hull 11 m or greater.

The SoundBoat project was successfully completed in early 2005, but industry continues to gather data from on-water testing and, as the data model is refined with further validation of the concept, the parameters above will be revised appropriately. The SoundBoat project team do not believe that craft outside the above characteristics are unsuitable for assessment using this part of ISO 14509; however, where a significantly different craft is to be assessed, it might be beneficial to test according to ISO 14509-1.

# Small craft — Airborne sound emitted by powered recreational craft —

# Part 3: Sound assessment using calculation and measurement procedures

## 1 Scope

This part of ISO 14509 specifies the procedures for assessing sound emission of powered monohull recreational craft of length up to 24 m with a Froude number greater than 1,1. It is not applicable for personal watercraft (PWC).

This part of ISO 14509 specifies the determination of the A-weighted sound pressure level by combining a calculation method and a measurement method.

## 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 8665, *Small craft — Marine propulsion reciprocating internal combustion engines — Power measurements and declarations*

ISO 8666, *Small craft — Principal data*

ISO 10087, *Small craft — Craft identification — Coding system*

ISO 14509-1, *Small craft — Airborne sound emitted by powered recreational craft — Part 1: Pass-by measurement procedures*

IEC 60942, *Electroacoustics — Sound calibrators*

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

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8666 and the following apply.

**3.1**
**recreational craft**
craft of any type, regardless of the means of propulsion, intended to be used for sports and leisure purposes

**3.2**
**maximum A-frequency weighted sound pressure level for recreational craft**
maximum A-weighted sound pressure level
$L_{p\mathrm{Amax}}$
maximum sound pressure level achieved from measurement at the passage of the craft under specified operating conditions, measured with frequency weighting A according to IEC 61672-1

NOTE It is expressed in decibels (dB).

**3.3**
**Froude number**
$Fn$

$$Fn = \frac{v_{\mathrm{max}}}{\sqrt{(g \cdot L_{\mathrm{wl}})}} \tag{1}$$

where

$v_{\mathrm{max}}$ is the maximum boat speed, expressed in metres per second (m/s);

$g$ is the given gravitational constant $g$ = 9,8 m/s$^2$;

$L_{\mathrm{wl}}$ is the length of the water line, expressed in metres (m).

NOTE Adapted from EU Directive 2003/44/EC.

## 4 Symbols

$L_{\mathrm{H}}$ length of hull, as defined in ISO 8666, expressed in metres (m)

$L_{p\mathrm{Amax}}$ maximum A-frequency weighted sound pressure level of the craft, expressed in decibels (dB)

$L_{p\mathrm{ASmax}}$ maximum A-frequency weighted, S-time weighted sound pressure level of the craft as measured in ISO 14509-1, expressed in decibels (dB)

$L_{p\mathrm{HF}}$ A-weighted hull-form sound pressure level calculated according to Equation (A.1), expressed in decibels (dB)

$L_{p\mathrm{OB}}$ average A-weighted on-board sound pressure level measured according to Equation (B.1), expressed in decibels (dB)

$T_{25}$ propagation attenuation from on-board measurements to 25 m as given in Equation (B.3), expressed in decibels (dB)

## 5 Sound assessment method

The hull-form sound pressure level shall be calculated according to Annex A. The on-board sound pressure level shall be measured according to Annex B. The estimated $L_{p\mathrm{Amax}}$ for the craft under assessment is the sum of the predicted $L_{p\mathrm{HF}}$ and the propagation-corrected $L_{p\mathrm{OB}}$, and shall be calculated as follows:

$$L_{p\mathrm{Amax}} = 10 \lg \left[ 10^{\left( \frac{L_{p\mathrm{HF}}}{10} \right)} + 10^{\left( \frac{L_{p\mathrm{OB}} - T_{25}}{10} \right)} \right] \quad (2)$$

The result of this calculation will be within $\pm 2$ dB of $L_{p\mathrm{ASmax}}$, measured for the same craft according to ISO 14509-1, taking into account the stated measurement uncertainties of ISO 14509-1 and ISO 14509-3.

## 6 Test report

The assessment report shall include the following:

a) a reference to this part of ISO 14509;

b) a declaration that all of its requirements are met;

c) the name and signature of the assessor and the date of the assessment;

d) details of the measurement devices used, together with their serial numbers;

e) $L_{p\mathrm{HF}}$, calculated according to Equation (A.1);

f) the individual A-weighted on-board sound pressure levels measured according to B.2 and the resulting $L_{p\mathrm{OB}}$ calculated according to Equation (B.1);

g) $L_{p\mathrm{Amax}}$, calculated according to Clause 5;

h) details of the manufacturer and boat model (if available), according to ISO 10087;

i) details of the engine manufacturer, engine and drive type.

# Annex A
(normative)

# Hull-form sound pressure level calculation

$L_{p\mathrm{HF}}$ shall be calculated using Equation (A.1) or Equation (A.2).

NOTE The calculated result is the predicted sound pressure level generated by the hull–water interaction of a passing craft at a distance of 25 m perpendicular to the side of the craft.

$$L_{p\mathrm{HF}} = 30 \lg\left(\frac{v}{1\,\mathrm{m/s}}\right) + 5 \lg\left(\frac{L_{\mathrm{H}}}{1\,\mathrm{m}}\right) + 28{,}7 \tag{A.1}$$

where

$v$ is the speed of the craft, expressed in metres per second (m/s);

or

$$L_{p\mathrm{HF}} = 30 \lg(v_{\mathrm{kn}}) + 5 \lg(L_{\mathrm{H}}) + 20 \tag{A.2}$$

where

$v_{\mathrm{kn}}$ is the speed of the craft, expressed in knots (kn).

# Annex B
(normative)

# On-board sound pressure level measurement method

## B.1 General

### B.1.1 Equipment specifications

The sound measurement equipment including the sound level meter, associated low-pass filter and windshield recommended by the manufacturer shall meet the requirements for a class 2 instrument according to IEC 61672-1. A sound calibrator that meets the requirements for a class 1 instrument according to IEC 60942 shall be used.

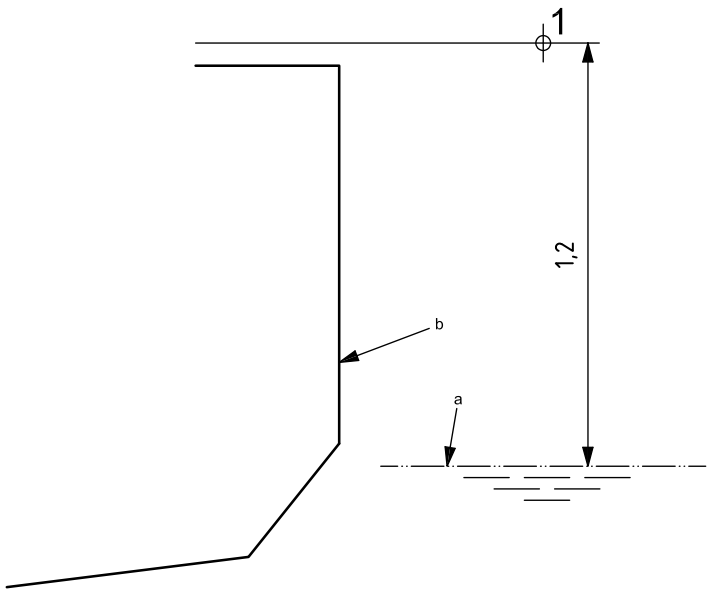
The overall acoustic performance of the measurement equipment shall be checked with the sound calibrator according to the instructions of its manufacturer at the beginning and end of each individual craft test (which comprises seven nominal measurements), and at least at the beginning and end of each measurement day.

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

### B.1.2 Microphone positions

Measurements shall be made at the seven microphone positions given in Figure B.1.

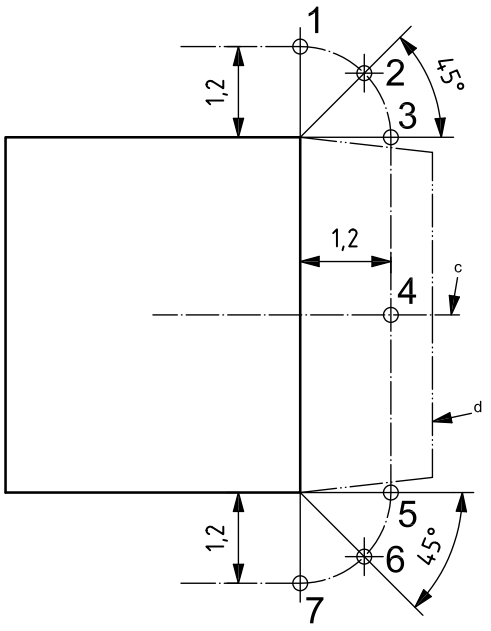
Dimensions in metres




**a) Microphone over side deck or transom (profile view)**

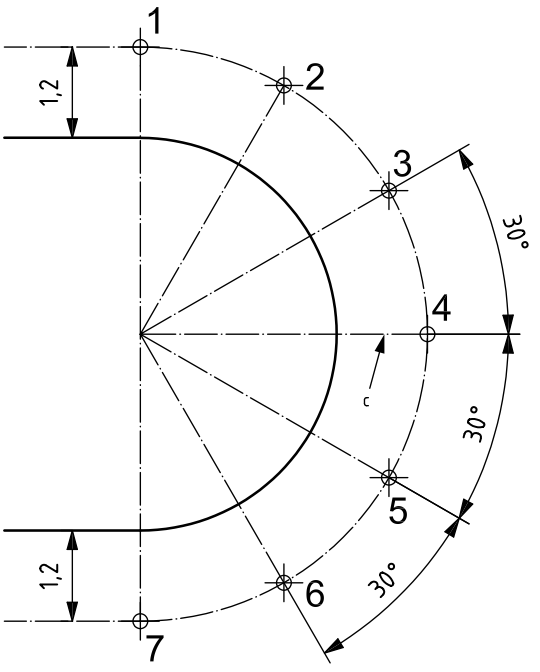
**Figure B.1** (*continued*)

Dimensions in metres




**b) Square transom (top view)**

Dimensions in metres




**c) Round transom (top view)**

**Key**

1 to 7 microphone positions

a Water line.

b Hull.

c Centre line of craft.

d Swim platform.

**Figure B.1— Microphone positions**

Microphones shall be located as close as practically possible to the dimensions indicated in Figure B.1.

The microphone shall have omnidirectional directivity characteristics and shall be generally oriented horizontally away from the craft.

### B.1.3 Operating conditions

**IMPORTANT — These measurements may be carried out without regard to wind velocity, rain or other precipitation, or wave height. However, the measurements should not be carried out in conditions beyond the design category of the boat.**

**B.1.3.1** Craft shall be operated with an equivalent two-person load except for craft intended for one person which shall have an equivalent one-person load. An equivalent one-person load is defined as 75 kg ± 20 kg.

**B.1.3.2** The engine of the craft shall be raised to operating temperature before the measurement starts. All the other operating conditions (fuel used, run-up time, etc.) shall comply with the manufacturer's instructions.

**B.1.3.3** The engine shall be operated at full throttle for all tests. If the craft speed exceeds 70 km/h (37,8 kn), the engine throttle shall be adjusted to maintain a maximum speed of 70 km/h ± 2 km/h (37,8 kn ± 1,08 kn).

**B.1.3.4** For propulsion systems equipped with adjustable trim, the trim angle shall be adjusted so that the propeller/impeller thrust is parallel to the bottom/keel-line of the craft to within ± 2°, hereafter referred to as level trim for all test conditions.

**B.1.3.5** The craft shall be trimmed for zero heel for all tests.

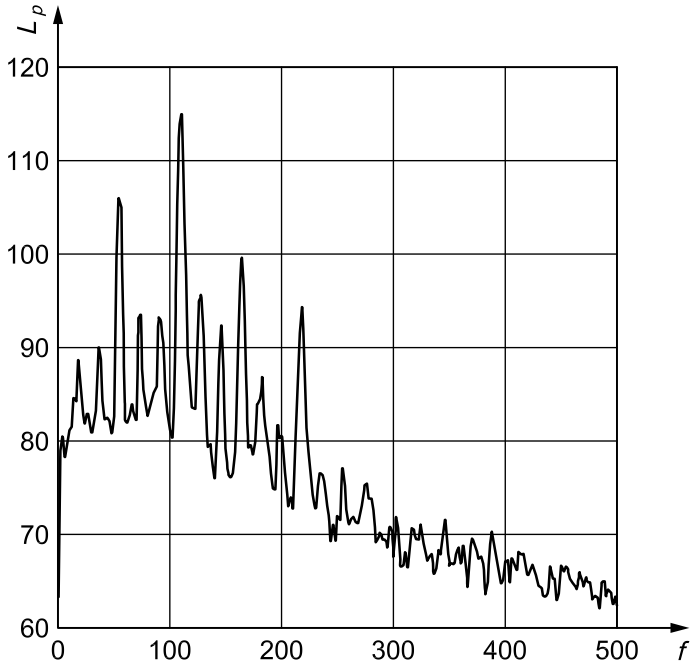
**B.1.3.6** The propeller/impeller shall be selected such that, at full throttle, the engine speed falls within ± 4 % of the declared engine speed at level trim, in accordance with ISO 8665. In the case of spark-ignition engines without speed governor, the declared engine speed shall be the mid-point of the full throttle speed range recommended by the manufacturer for propeller selection. In the case of engines with speed governors, the declared engine speed shall be the governed speed specified by the manufacturer. For controllable pitch propellers, the pitch shall be fixed in the position required to obtain the declared engine speed at full throttle, or as near to full throttle as possible, to achieve the maximum boat speed or 70 km/h, whichever is the lesser.

## B.2 Measurement of on-board sound

The A-weighted equivalent continuous sound pressure level below and including the 500 Hz third octave band (i.e. below 562 Hz) shall be measured over a 10 s period at each of the seven microphone positions in Figure B.1.

During the measurement, the recorded sound spectra shall be dominated by clear orders of exhaust sound. In this regard, acceptable and unacceptable measurements are shown in Figures B.2 and B.3, respectively.

NOTE In order to provide frequency spectra as shown in Figures B.2 and B.3, a frequency analysis might have to be performed.

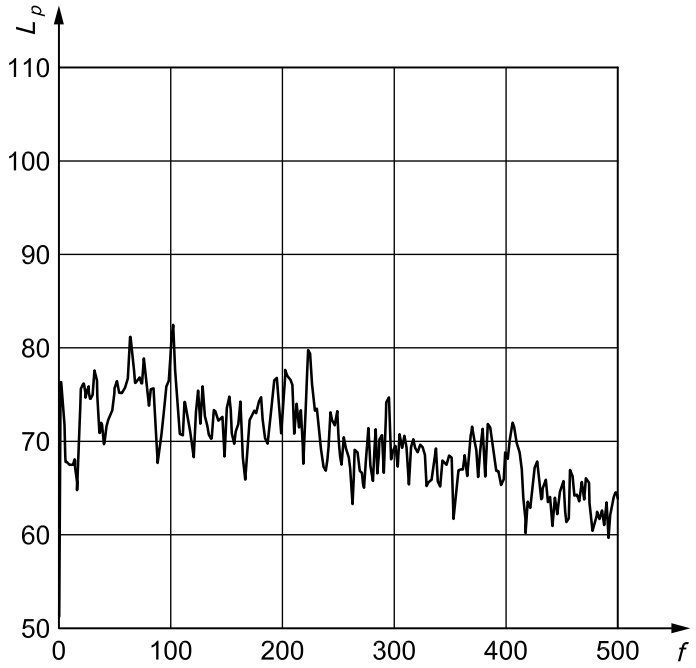



**Key**

$f$ frequency (Hz)

$L_p$ sound pressure level (dB)

**Figure B.2 — Example of a sound spectrum showing clear orders of exhaust sound**




**Key**

$f$ frequency (Hz)

$L_p$ sound pressure level (dB)

**Figure B.3 — Example of a more random sound spectrum without dominating exhaust sound showing no clear harmonics**

The average of these seven sound pressure level measurements shall be recorded. $L_{p\mathrm{OB}}$ shall be the logarithmic average of the seven values measured for the seven microphone locations and shall be derived using the following relationship:

$$L_{p\mathrm{OB}} = 10 \lg \left( \frac{10^{\frac{L_{p\mathrm{Aeq},1}}{10}} + 10^{\frac{L_{p\mathrm{Aeq},2}}{10}} + \ldots\ldots + 10^{\frac{L_{p\mathrm{Aeq},7}}{10}}}{7} \right) \quad \text{(B.1)}$$

where

$L_{p\mathrm{Aeq},1}$ is the A-weighted equivalent continuous sound pressure level below and including the 500 Hz third octave band, measured over a 10 s period at microphone position 1;

$L_{p\mathrm{Aeq},2}$ is the A-weighted equivalent continuous sound pressure level below and including the 500 Hz third octave band, measured over a 10 s period at microphone position 2;

$L_{p\mathrm{Aeq},7}$ is the A-weighted equivalent continuous sound pressure level below and including the 500 Hz third octave band, measured over a 10 s period at microphone position 7.

This average sound pressure level will be deemed to be the on-board exhaust outlet sound.

## B.3 Correction to sound pressure level over the stern

$L_{p\mathrm{OB}}$ over the stern, as measured according to Equation (B.1), shall be corrected by subtracting one of the following propagation attenuation values, $T_{25}$, to derive the craft's exhaust sound contribution at 25 m.

— Underwater exhaust outlet(s): $T_{25}$ = 16 dB (B.2)

— Above-water exhaust outlet(s): $T_{25}$ = 22 dB (B.3)

If there is any doubt regarding the exhaust outlet position (i.e. above or below the water), it shall be assumed that the outlet is below the water.

NOTE This uncertainty can provide an artificially high prediction of craft sound.

# Annex C
(informative)

# Example of test report form

This form may be copied and used to report test results.

## Test report

**Results of sound emission measurements of small craft carried out according to ISO 14509-3**

All requirements of ISO 14509-3, *Small craft — Airborne sound emitted by powered recreational crafts — Part 3: Sound assessment using calculation and measurement procedures*, have been fulfilled when carrying out the tests.

### General information

Testing institution ..... Test number .....

Test site location ..... Date of test .....

Environmental conditions: Wave height ..... mm Wind speed ..... m/s

Sound level meter manufacturer ..... Model No. ..... Serial No. .....

Sound calibrator manufacturer ..... Model No. ..... Serial No. .....

Last calibration dates: Sound level meter ..... Sound calibrator .....

### Data of the propulsion unit

Propulsion unit manufacturer ..... Motor type (IB, SD, Jet, etc.) .....

Model ..... Model year ..... Serial No. .....

Declared propeller shaft power according to ISO 8665: ..... kW Combustion process (SI, CI) .....

Declared engine speed ..... $min^{-1}$

Engine speed during the measurements ..... $min^{-1}$

## Data of the craft

Craft manufacturer ..... Model .....

Craft identification number (CIN) according to ISO 10087 .....

Speed of the craft during the measurements ..... m/s or kn

Exhaust outlet location during the measurements (above water/under water) .....

## On-board measurements

| **Microphone position** No. | $L_{p\mathrm{Aeq}}$ dB |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |

Average on-board sound pressure level, $L_{p\mathrm{OB}}$, as given in Equation (B.2) ..... dB

Calculated hull-form sound pressure level, $L_{p\mathrm{HF}}$, as given in Equation (A.1) ..... dB

Propagation attenuation, $T_{25}$, as given in Equation (B.3) ..... dB

## Test result

Maximum A-weighted sound pressure level of the craft, $L_{p\mathrm{Amax}}$ ..... dB

Person responsible for the test (name and title) .....

Date ..... Signature .....

**ICS 17.140.30; 47.080**

Price based on 11 pages