INTERNATIONAL STANDARD

ISO 14509-1

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Small craft — Airborne sound emitted by powered recreational craft —

Part 1: Pass-by measurement procedures

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

Partie 1: Méthodes de mesure pour l'essai de passage

Reference number
ISO 14509-1:2008(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 14509-1 was prepared by Technical Committee ISO/TC 188, *Small craft*.

This first edition of ISO 14509-1 cancels and replaces ISO 14509:2000, which has been technically revised. It also incorporates the Amendment ISO 14509:2000/Amd.1:2004.

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*

Small craft — Airborne sound emitted by powered recreational craft —

Part 1: Pass-by measurement procedures

1 Scope

This part of ISO 14509 specifies the conditions for obtaining reproducible and comparable measurement results of the maximum sound pressure level of airborne sound generated during the passage of powered recreational craft of up to 24 m length of hull, including inboards, stern drives, personal watercraft (PWC) and outboard motors. It also specifies standard craft based type tests for stern drives with integral exhaust systems and for outboard motors. It also specifies the procedure to be followed if, in addition to the maximum sound pressure level, the determination of the sound exposure level is desired.

NOTE For craft other than those specified above, ISO 2922 is applicable for sound emission measurements.

The accuracy grade of the acoustical test procedures specified in this part of ISO 14509 is engineering grade (grade 2).

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 8666:2002, *Small craft — Principal data*

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

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 following terms and definitions apply.

3.1
type test for recreational craft
type test
measurement performed to prove that the sound of the craft in motion, or of the outboard motor when using a standard craft, or of the stern drive with integral exhaust system when using a standard craft, complies with sound specifications or prescribed limits

NOTE See also definition of “acceptance test” in ISO 2922.

3.2
monitoring test for recreational craft
monitoring test
measurement performed in order to check that the sound of the craft in motion, or of the outboard motor when using any craft, or of the stern drive with integral exhaust system when using any craft, is still within prescribed limits and that no noticeable changes have occurred since the acceptance on initial delivery or after modification, as applicable

NOTE 1 Subsequent type testing can also be required in the case of a significant change.

NOTE 2 See also definition of “monitoring test” in ISO 2922.

3.3
maximum A-frequency weighted sound pressure level with time weighting S for recreational craft
maximum AS-weighted sound pressure level
$L_{p\mathrm{ASmax}}$
maximum sound pressure level achieved from measurement of the passage of the craft under specified operating conditions measured with frequency weighting A and with time weighting S (slow) according to IEC 61672-1

NOTE It is expressed in decibels (dB).

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

$$E_{\mathrm{A},T} = \int_{t_1}^{t_2} p_{\mathrm{A}}^2(t)\,\mathrm{d}t \tag{1}$$

NOTE 1 Unit: pascal squared second, $\mathrm{Pa}^2\,\mathrm{s}$.

NOTE 2 By 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. The application of a specific frequency weighting as specified in IEC 61672-1 is indicated by an appropriate subscript, e.g. $E_{\mathrm{A,1h}}$ denotes the A-weighted sound exposure over one hour.

NOTE 3 When applied to a single event of impulsive or intermittent sound, the quantity is called “single event sound exposure” and the symbol E is used without subscript.

NOTE 4 This definition applies only for the optional measurement of sound exposure levels according to Annex A.

NOTE 5 Adapted from ISO/TR 25417:2007, 2.6.

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, expressed in decibels

$$L_{E,\mathrm{A},T} = 10\,\lg\left(\frac{E_{\mathrm{A},T}}{E_0}\right)\mathrm{dB} \tag{2}$$

NOTE 1 The reference value, E_0, is $(20\ \mu\mathrm{Pa})^2\,\mathrm{s} = 4 \times 10^{-10}\ \mathrm{Pa\,s}$.

NOTE 2 The application of a specified frequency weighting as specified in IEC 61672-1 is indicated by an appropriate subscript, e.g. $L_{E,\mathrm{A},T,\mathrm{1h}}$ denotes the A-weighted sound exposure level over one hour.

NOTE 3 When applied to a single event of impulsive or intermittent sound, the quantity is called “single event sound exposure level” and the symbol L_E is used without further subscript.

NOTE 4 In this part of ISO 14509, the sound exposure level is to characterize the emission of the source and not the noise impact on people exposed to the sound.

NOTE 5 This definition applies only for the optional measurement of sound exposure level according to Annex A.

NOTE 6 Adapted from ISO/TR 25417:2007, 2.6.

3.6
background noise for recreational craft
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
stern-drive
propulsion unit with the engine inboard and the transmission/drive located external to the hull

3.8
stern-drive with integral exhaust systems
stern-drive where the exhaust gases are expelled through the transmission/drive

4 Symbols

$L'_{p\mathrm{ASmax}}$ maximum AS-weighted sound pressure level during the passage, expressed in decibels (dB);

$L''_{p\mathrm{AS}}$ AS-weighted background sound pressure level, expressed in decibels (dB);

$L_{p\mathrm{ASmax}}$ $L'_{p\mathrm{ASmax}}$ after applying background noise correction according to 8.3 and distance correction according to 9.2, expressed in decibels (dB);

$L'_{\mathrm{A}E}$ A-weighted sound exposure level during the passage, expressed in decibels (dB);

$L''_{\mathrm{A}E}$ A-weighted background sound exposure level, expressed in decibels (dB);

$L_{\mathrm{A}E}$ $L'_{\mathrm{A}E}$ after applying background noise correction according to A.5 and distance correction according to A.6, expressed in decibels (dB).

5 Measurement quantity

The quantity to be measured during the passage of the craft is the maximum AS-weighted sound pressure level, $L'_{p\mathrm{ASmax}}$.

From this quantity, the maximum AS-weighted sound pressure level, $L_{p\mathrm{ASmax}}$, is determined by applying the background noise correction and distance correction, if applicable.

6 Measurement uncertainty

The measurement procedure specified in the following clauses is affected by several parameters (e.g. measurement system uncertainty, environmental conditions, craft course uncertainty) that can lead to variation in the level recorded for a given craft.

In the absence of sufficient experimental data on the overall uncertainty, the uncertainty associated with this part of ISO 14509 has been evaluated by the procedure given in the *Guide to the expression of uncertainty in measurement (GUM)* (see Bibliography), where each individual source of uncertainty is identified and quantified based upon existing statistical data or engineering judgment.

The individual sources of uncertainty identified, with their standard deviations, are given in Table 1.

Table 1 — Standard deviation of reproducibility of individual sources of measurement

Individual sources of uncertainty	Individual standard deviations of the maximum AS-weighted sound pressure level, L_{ASmax} dB
Distance effects	0,3
Measuring equipment	1,0
Environmental conditions	1,5
Operator effects	0,2
Test site variations	1,0

These individual sources of uncertainty are grouped as follows.

a) Run-to-run: the variations expected within a single test series.

b) Day-to-day: the variations expected within the same test site, but over more than a single test series and including a) above.

c) Site-to-site: the variation expected across different test sites and test personnel and including a) and b) above.

The expanded uncertainty for the combined standard uncertainties for these three groups, for a coverage probability of 90 %, is given in Table 2.

Table 2 — Variability for a coverage probability of 90 %

Variability case	Expanded uncertainty dB
Run-to-run	0,3
Day-to-day	1,8
Site-to-site	2,1

NOTE In addition to the above uncertainties, a further uncertainty needs to be considered in the case of multi-engined craft. If the sound of a specific multi-engined craft is dominated by exhaust noise, the phasing of its engines, when running at nominally the same engine speed, can have a significant effect upon the vessel's pass by noise. Extreme examples of maximum AS-weighted sound pressure levels of up to 6 dB of the variability have been recorded.

The uncertainties considered in this part of ISO 14509 do not cover the uncertainties associated with the variation in the production process for a specific craft.

7 Measuring equipment

7.1 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 class 1 instrument specified in IEC 61672-1.

NOTE Sound level meters with "maximum hold" capabilities are preferred.

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

A wind speed anemometer which has an uncertainty of less than $\pm$ 10 % shall be used.

An engine speed tachometer which has an uncertainty of less than $\pm$ 2 % shall be used.

7.2 Equipment calibration

A class 1 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 instructions of its manufacturer at the beginning and at the end of each series of measurements, at least every four hours during testing and at the beginning and end of each measurement day.

At intervals of no longer than two years, the sound level meter shall undergo laboratory verification for compliance with IEC 61672-1. The date of the last verification of 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 laboratory, using national standards.

8 Test site specifications and environmental conditions

8.1 Test site specifications

Within 30 m around the craft 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 craft under test and the measurement microphone shall be open water and free from any sound absorbing or sound reflecting objects that can affect the measurement.

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

NOTE Shallow water can increase the reading of the pass-by sound pressure level.

8.2 Environmental conditions

8.2.1 The wind velocity in the test area during the pass-by shall not exceed 7 m/s.

8.2.2 Tests shall not be carried out in conditions of rain or other precipitation.

8.2.3 The wave height in the test area during the pass-by shall not exceed H according to Equation (3) or 0,1 m, whichever is the greater.

$$H = L_{wl}/50 \quad (3)$$

where L_{wl} is the length of the waterline according to ISO 8666.

NOTE The sound of any wave impact (slamming) could lead to a considerable increase of the measured sound pressure level.

8.3 Background noise

8.3.1 General

A measurement shall be invalid if changes in the background noise affect the applicable reading.

8.3.2 Type tests

For type tests, the AS-weighted background sound pressure level, L''_{pAS}, shall be at least 10 dB below the maximum AS-weighted sound pressure level, L'_{pASmax}, obtained during the passage of the craft.

8.3.3 Monitoring tests

For monitoring tests, the AS-weighted background sound pressure level, L''_{pAS}, shall be at least 6 dB below the maximum AS-weighted sound pressure level, L'_{pASmax}, obtained during the passage of the craft. The reading shall then be corrected as shown in Table 3.

Table 3 — Correction for background sound pressure level, L''_{pAS}, for monitoring tests

Values in decibels

Increase in the indication of the AS-weighted sound pressure level obtained during the passage of the craft, $L'_{pASmax} - L''_{pAS}$	Correction to be applied to the reading of the AS-weighted sound pressure level, L'_{pASmax}, obtained during the passage of the craft
$\geqslant$ 10	0
6 to 9	−1

9 Test course, microphone positions and measurement distance

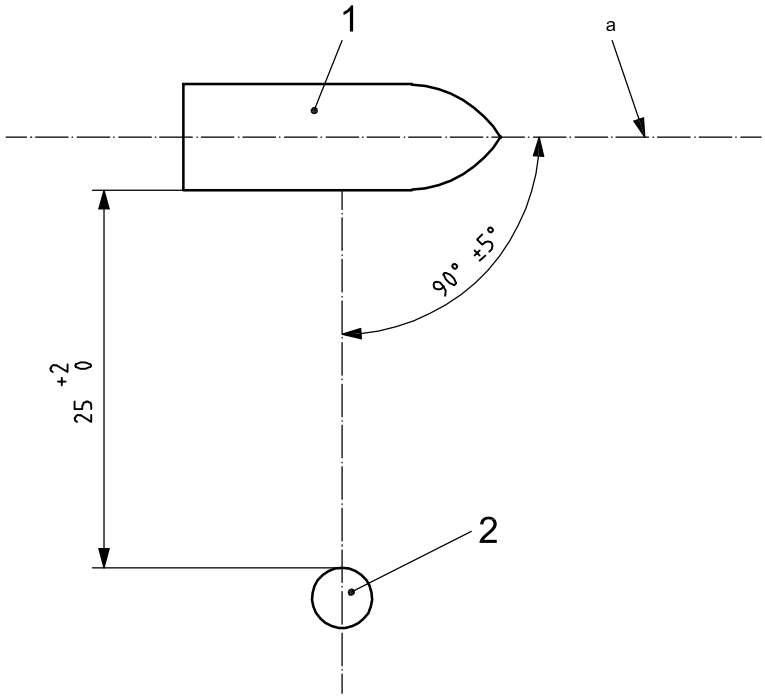
9.1 General

9.1.1 The test course to be followed shall be a straight line such that the distance between the microphone and the side of the craft nearest to the microphone when passing it shall be $\left(25^{+2}_{0}\right)$ m.

The microphone shall be orientated to the path of the craft in accordance with the manufacturer's recommendation for the microphone and associated equipment type.

NOTE Figure 1 gives information on the test site dimensions.

Dimensions in metres



Key

1 craft

2 microphone

a Craft course line.

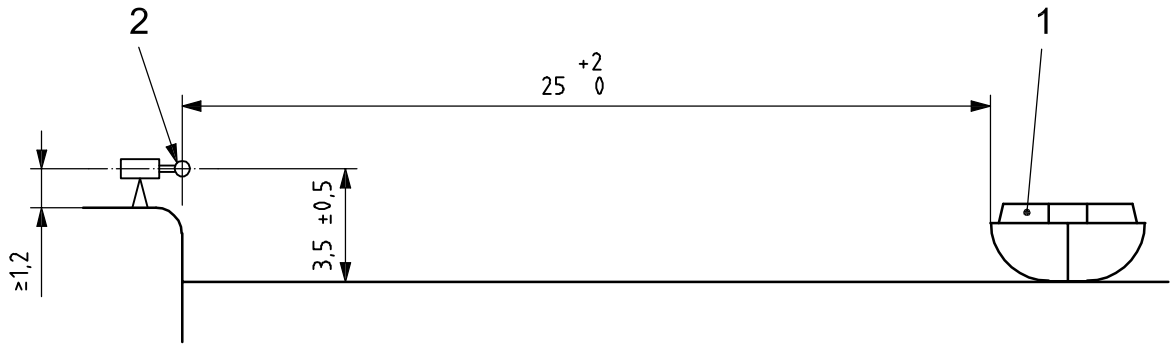
Figure 1 — Position of the microphone and test course

9.1.2 The microphone shall be positioned 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.

The microphone may be placed on the shore, on a boat, on a remote buoy or other suitable platform.

Figure 2 shows the heights of the microphone position (example for shore position).

Dimensions in metres



Key

1 craft

2 microphone

Figure 2 — Microphone position and heights

9.1.3 The intended course line should be indicated with markers, if possible.

9.1.4 For craft less than 6 m in length, the microphone may be placed $\left(12{,}5^{+1}_{0}\right)$ m from the test source if the background noise requirements according to 8.3 cannot be met when measuring at the distance of 25 m from the test source.

NOTE The reason is that it can be necessary to compensate for the low sound pressure levels by moving the microphone to a position which is closer to the craft without venturing into the acoustic near field.

9.2 Distance correction

If the distance between the microphone and the course line is set at 12,5 m, the measured maximum AS-weighted sound pressure level for each passage, $L'_{p\mathrm{ASmax}}$, shall be normalised to 25 m by subtracting 5 dB to obtain the 25 m value for $L_{p\mathrm{ASmax}}$.

NOTE The value of 5 dB has been found appropriate from the results of many tests under similar conditions (e.g. IMEC 17 F/01 and IMEC 17 F/02; see Bibliography).

10 Operating conditions

10.1 As with all waterborne testing, an appropriate risk assessment should be carried out with particular note of proximity to persons, other craft, fixed objects and the shore.

10.2 Craft shall be operated with an equivalent two-person load, except for craft intended for one person as well as all PWC which shall have an equivalent one-person load. An equivalent one-person load is defined as 75 kg ± 20 kg.

10.3 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.

10.4 For type tests, craft with the power units installed inboard (e.g. inboards, stern drives, PWC and sailboats) shall be tested as sold.

10.5 For type tests, outboard motors shall be tested on standard craft as specified in Clause 13. For type tests, stern drives with integral exhaust systems shall be tested on standard craft as specified in Clause 14.

10.6 For monitoring tests, all craft shall be tested with motors as installed.

10.7 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).

10.8 For propulsion systems which are 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.

10.9 For type tests, 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 a position required to obtain the declared engine speed at full throttle or as near full throttle as possible to achieve the lesser of maximum boat speed or 70 km/h.

11 Test procedure

11.1 During the measurement the craft shall pass through the test course as specified in Clause 9 and its direction shall be recorded.

11.2 The maximum AS-weighted sound pressure level, $L'_{p\mathrm{ASmax}}$, during the passage shall be measured.

11.3 The AS-weighted background sound pressure level, $L''_{p\mathrm{AS}}$, shall be measured according to 8.3 immediately before and immediately after the passage of the craft.

11.4 For monitoring tests, the correction for background noise according to 8.3.3 shall be applied on the measured $L'_{p\mathrm{ASmax}}$ value to obtain the applicable measurement value, the maximum AS-weighted sound pressure level, $L_{p\mathrm{ASmax}}$ (but see also 11.5).

11.5 In the case of a reduced measurement distance according to 9.1.4 for type tests and for monitoring tests, the distance correction according to 9.2 shall, in addition to that stated in 11.4, be applied on $L'_{p\mathrm{ASmax}}$ to obtain $L_{p\mathrm{ASmax}}$.

11.6 At least two measurements shall be made for each side of the craft. The sound pressure level for each side of the craft shall be the average of the first two determined values of $L_{p\mathrm{ASmax}}$ for each side which are within 1 dB of each other. The maximum AS-weighted sound pressure level, $L_{p\mathrm{ASmax}}$, to be recorded shall be that of the louder side of the craft.

11.7 The values of the following quantities shall be recorded: $L'_{p\mathrm{ASmax}}$, $L''_{p\mathrm{AS}}$, the corrections for background noise (if any), the distance corrections (if any), and $L_{p\mathrm{ASmax}}$.

12 Test report

The test report shall include the following:

a) reference to this part of ISO 14509;

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

c) the testing institution, the date of the test, the signature of the responsible person;

d) the nature of the test; i.e. type test or monitoring test;

e) the test site specification (see 8.1, including course direction) and environmental conditions, including but not limited to the water surface conditions (including wave height), water depth, the wind direction and speed (see 8.2), microphone position with respect to the course line and/or wind direction;

f) the measurement equipment;

g) the measured maximum AS-weighted sound pressure levels, $L'_{p\mathrm{ASmax}}$, and the AS-weighted background sound pressure levels, $L''_{p\mathrm{AS}}$, the corrections for background noise (if any) and the distance corrections (if any);

h) data for the propulsion unit:

   1) manufacturer,

   2) motor type and serial number,

   3) declared propeller shaft power according to ISO 8665,

   4) declared engine speed,

5) combustion process: compression-ignition engine or spark-ignition engine,

6) propeller/impeller specification (such as pitch, diameter, number of blades);

i) data for the craft or the standard craft according to Clause 13 or Clause 14:

1) manufacturer,

2) craft type and, if available, craft identification number (CIN) according to ISO 10087;

j) the engine speed at which measurements were performed;

k) fuel load as a percentage of tank capacity;

l) the speed of the craft during the measurements;

m) the microphone position;

n) the maximum AS-weighted sound pressure level, $L_{p\mathrm{ASmax}}$, according to Clause 11.

The form given in Annex B may be used for the test report.

13 Standard craft specifications for outboard motor type tests according to Clause 10

Any series production craft with a V-hull shape meeting the dimensional, mass and operating characteristics given in Table 4 may be used as standard craft.

Table 4 — Standard craft specifications

Declared propeller shaft power of outboard motor under test (according to ISO 8665) kW	**Length of hull (according to ISO 8666)** m	**Mass without engine (m_{LCC} according to ISO 8666:2002, 6.3, minus mass of heaviest engine)** kg
$P < 6$	3,8	135
$6 \leqslant P < 25$	4,2	220
$25 \leqslant P < 55$	4,7	400
$55 \leqslant P < 115$	5,5	800
$115 \leqslant P < 150$	6,2	1 100
$P \geqslant 150$	7,5	1 650

A variation of $\pm$ 20 % is allowed in the length (as given in Table 4) and $\pm$ 25 % for the mass of the craft (as given in Table 4). In addition, the craft shall have no covers over the outboard motor or unusual extensions behind the transom which could affect the sound level.

Outboard motors shall be fitted to the boat according to the manufacturer's instructions. No modifications on series production craft, such as applying additional absorbing components or trim tabs, are permitted.

14 Standard craft specifications for type tests for stern drives with integral exhaust systems according to Clause 10

Any series production craft with a V-hull shape meeting the dimensional, mass and operating characteristics given in Table 5 may be used as a standard craft.

Table 5 — Standard craft specifications for petrol engines

Declared propeller shaft power (according to ISO 8665) of the stern drive with integral exhaust system under test kW	Length of hull (according to ISO 8666) m	Mass with engine [a] (m_{LCC} according to ISO 8666:2002, 6.3) kg
$P < 78$	5,0	700
$78 \leqslant P < 115$	5,8	1 600
$115 \leqslant P < 159$	7,0	1 900
$159 \leqslant P < 226$	7,7	2 200
$P \geqslant 226$	8,7	2 600
[a] As recommended by the engine manufacturer.		

Table 6 — Standard craft specifications for diesel engines

Declared propeller shaft power (according to ISO 8665) of the stern drive with integral exhaust system under test kW	Length of hull (according to ISO 8666) m	Mass with engine [a] (m_{LCC} according to ISO 8666:2002, 6.3) kg
$P < 78$	6,0	1 200
$78 \leqslant P < 115$	7,0	1 950
$115 \leqslant P < 159$	7,5	2 500
$159 \leqslant P < 226$	8,5	2 800
$P \geqslant 226$	9,5	3 800
[a] As recommended by the engine manufacturer.		

A variation of $\pm$ 20 % is allowed in the length (as given in Tables 5 and 6) and $\pm$ 25 % for the mass of the craft (as given in Tables 5 and 6). In addition, the craft shall have no unusual covers or extensions behind the transom which could affect the sound level.

Stern drives with integral exhaust systems shall be fitted in the boat according to the manufacturer's specifications. No modifications on series production craft such as applying additional absorbing components or trim tabs are permitted.

NOTE For further information regarding this standard craft concept for stern drives with integral exhaust systems refer to IMEC 17 F/05; see Bibliography.

Annex A
(normative)

Measurement of the sound exposure level

A.1 General

The measurement of the maximum sound pressure level during the passage of the craft shall be carried out as specified in this part of ISO 14509.

However, it is optional to measure additionally the sound exposure level during the passage of the craft. This measurement shall be carried out according to this Annex. (See also Clause 1.)

Where not otherwise stated in this Annex, the specifications of this part of ISO 14509 apply accordingly.

A.2 Measurement quantity

The quantity to be measured is the A-weighted sound exposure level during the passage of the craft, $L'_{\mathrm{A}E}$.

From this quantity the A-weighted sound exposure level, $L_{\mathrm{A}E}$, is determined by applying the background noise correction and distance correction, if applicable.

A.3 Measurement uncertainty

The measurement procedure described in the following sub-clauses is affected by several parameters (e.g. measurement system uncertainty, environmental conditions, craft course uncertainty) that can lead to variation in the level recorded for a given craft.

In the absence of sufficient experimental data on the overall uncertainty, the uncertainty associated with this part of ISO 14509 has been evaluated by the procedure given in the *Guide to the expression of uncertainty in measurement (GUM)*, where each individual source of uncertainty is identified and quantified based upon existing statistical data or engineering judgment.

The individual sources of uncertainty identified, with their standard deviations, are given in Table A.1.

Table A.1 — Standard deviation of reproducibility of individual sources of measurement

Individual sources of uncertainty	Individual standard deviations of the A-weighted sound pressure level, $L_{\mathrm{A}E}$ dB
Distance effects	0,2
Measuring equipment	0,7
Environmental conditions	1,2
Operator effects	0,2
Test site variations	1,0

These individual sources of uncertainty are grouped as follows.

a) Run-to-run: the variations expected within a single test series.

b) Day-to-day: the variations expected within the same test site, but over more than a single test series and including a) above.

c) Site-to-site: the variation expected across different test sites and test personnel and including a) and b) above.

The expanded uncertainty for the combined standard uncertainties for these three groups, for a coverage probability of 90 %, is given in Table A.2.

Table A.2 — Variability for a coverage probability of 90 %

Variability case	Expanded uncertainty dB
Run-to-run	0,3
Day-to-day	1,8
Site-to-site	2,1

The uncertainties considered in this part of ISO 14509 do not cover the uncertainties associated with the variation in the production process for a specific craft.

A.4 Measuring equipment

A.4.1 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 class 1 instrument specified in IEC 61672-1.

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

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

An engine speed tachometer which is accurate to within $\pm$ 2 % shall be used.

A.4.2 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 instructions of its manufacturer 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 two years, the integrating-averaging 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 with traceability to a primary standards laboratory every year.

A.5 Background sound exposure level, L''_{AE}

A.5.1 Type tests

For type tests, the A-weighted background sound exposure level, L''_{AE}, measured with the same duration $T = t_2 - t_1$ (within ± 0,2 s) as used to measure L'_{AE}, for the passage of the craft, shall be at least 10 dB below L'_{AE}.

A.5.2 Monitoring tests

For monitoring tests, the A-weighted background sound exposure level, L''_{AE}, measured with the same duration $T = t_2 - t_1$ (within ± 0,2 s) as used to measure L'_{AE}, for the passage of the craft, shall be at least 6 dB below L'_{AE}. The reading shall then be corrected as shown in Table A.3.

Table A.3 — Correction for background sound exposure level, L''_{AE}, for monitoring tests

Values in decibels

Difference between the A-weighted sound exposure level obtained during the passage of the craft and the A-weighted background sound exposure level $L'_{AE} - L''_{AE}$	Correction to be applied to the A-weighted sound exposure level, L'_{AE}, obtained during the passage of the craft
⩾ 10	0
6 to 9	−1

A.6 Distance correction

If the distance between the microphone and the course line is set at 12,5 m following 9.1.4, the measured A-weighted sound exposure level, L'_{AE}, shall be normalized to 25 m by subtracting 3 dB to obtain the 25 m value for L_{AE}.

A.7 Test procedure

A.7.1 The test procedure according to Clause 11 shall be followed with the following modifications.

A.7.2 The A-weighted sound exposure level during passage of the craft, L'_{AE} shall be measured. The measurement time, $T = t_2 - t_1$, shall be the time at which the sound of the approaching craft is first heard above the background noise until the time that the sound from the departing craft fades into the background noise.

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

A.7.3 The A-weighted background sound exposure level, L''_{AE} shall be measured according to A.5 immediately before and immediately after the passage of the craft.

A.7.4 For monitoring tests, the corrections for background noise according to A.5.2 shall be applied on the measured L'_{AE} value to obtain the applicable measurement value, the A-weighted sound exposure level, L'_{AE} (but see also A.7.5).

A.7.5 In the case of a reduced measurement distance following 9.1.4 for type tests and for monitoring tests, the distance corrections according to A.6 shall in addition to A.7.4 be applied on L'_{AE} to obtain L_{AE}.

A.7.6 At least two measurements shall be made for each side of the craft. The sound exposure level for each side of the craft shall be the average of the first two determined values of L_{AE} for each side which are within 1 dB of each other. The A-weighted sound exposure level, L_{AE}, to be recorded shall be that of the louder side of the craft.

A.7.7 The values of the following quantities shall be recorded: L'_{AE}, L''_{AE}, the corrections for background noise (if any), the distance corrections (if any) and L_{AE}.

A.8 Test report

The test report shall be drawn up as specified in Clause 12, with g) and n) modified as follows:

g) the measured A-weighted sound exposure level, L'_{AE}, together with the measurement time, T, and the A-weighted background sound exposure level, L''_{AE}, the corrections for background noise (if any) and the distance corrections (if any);

n) the A-weighted sound exposure level, L_{AE}, according to A.7.

Annex B
(informative)

Example of test report form

The user of this form may copy this present form.

NOTE For additional measurements according to Annex A (measurement of sound exposure level), a modified form may be used to report the results.

Test report

Results of sound emission measurements of small craft according to ISO 14509-1

All requirements of ISO 14509-1, *Small craft — Airborne sound emitted by powered recreational craft — Part 1: Pass-by measurement procedures*, have been fulfilled when carrying out the tests.

General information

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

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

Test site specification: ..... Course direction (headings) .....

Environmental conditions Water surface conditions ..... Wave height ..... mm

Water depth.....m.....Wind speed .....m/s ..... Wind direction .....

Nature of test (Type/Monitoring) ..... Measurement distance ..... m

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

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

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

Microphone position .....

Propulsion unit data

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 ..... r/min

Engine speed during the measurements ..... .r/min

Propeller/Impeller specifications

Pitch: ..... Diameter: ..... No. of blades: ..... Others: .....

Data of the craft / Data of the standard craft for type tests

Craft manufacturer..... Location .....

Craft type ..... Model..... Date of manufacture.....

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

Speed of the craft during the measurements .....

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

Fuel load as percentage of tank capacity .....

Pass-by measurements

No.	Side	Craft speed	Engine speed r/min	Measurement distance m	L'_{pASmax} dB	L''_{pAS} dB	Background noise correction dB	Distance correction dB	L_{pASmax} dB
1	Port								
2	Star								
3	Port								
4	Star								
5	Port								
6	Star								
7	Port								
8	Star								
9	Port								
10	Star								
11	Port								
12	Star								
13	Port								
14	Star								

L'_{pASmax}	is the measured maximum AS-weighted sound pressure level during the passage of the craft;
L''_{pAS}	is the AS-weighted background sound pressure level measured immediately before and immediately after the passage of the craft;
L_{pASmax}	is the maximum AS-weighted sound pressure level after applying background noise correction and distance correction, if applicable.

Port side average L_{pASmax}.....dB Starboard side average L_{pASmax} .....dB

Test result:

Maximum AS-weighted sound pressure level, L_{pASmax}.....dB

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

Date Signature

Bibliography

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1) ISO/IEC Guide 98-3 will be published as a reissue of the *Guide to the expression of uncertainty in measurement (GUM)*, 1995.

2) Available from:

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