

RULES FOR  
CLASSIFICATION OF

**SHIPS**

NEWBUILDINGS

SPECIAL EQUIPMENT AND SYSTEMS  
ADDITIONAL CLASS

PART 6 CHAPTER 24

# SILENT CLASS NOTATION

JANUARY 2010

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# INTRODUCTION

## General

The Board approved this new chapter in December 2009.

The rules come into force on 1 January 2010.

This chapter is valid until superseded by a revised chapter. Supplements will not be issued except for an updated list of corrections presented in Pt.0 Ch.1 Sec.3. Pt.0 Ch.1 is normally revised in January and July each year.

Revised chapters will be forwarded to all subscribers to the rules. Buyers of reprints are advised to check the updated list of rule chapters printed in Pt.0 Ch.1 Sec.1 to ensure that the chapter is current.

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## SECTION 1 GENERAL REQUIREMENTS

### A. Introduction

#### A 100 Application

**101** The rules in this chapter apply to underwater noise radiation from vessels to ensure a low environmental impact and/or to ensure hydro-acoustic operational capability for vessels relying on hydro-acoustic equipment as an important part of their operation.

#### A 200 Class notations

**201** Vessels fulfilling the requirements and which are classed with the Society may be given the optional class notation **SILENT**, where qualifiers for the type of requirements satisfied, will be placed after the class notation connected by a hyphen. The requirements differ depending on required operational capability and/or controlled environmental noise emission.

**Guidance note:**

Vessels fulfilling the requirements in this chapter, but is not classed with the Society may be given a Certificate of Compliance.

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**202** The requirements for underwater noise levels are specified for four types of operations; Acoustic, Seismic, Fishery, Research as well as controlled Environmental noise emission.

**203** Acoustic (A), requirements for vessels using hydro-acoustic equipment as important tools in their operation, e.g. survey vessels, ocean research vessels, pipe layers, diving vessels, various offshore support vessels, naval vessels, etc.

**204** Seismic (S), requirements for vessels carrying out seismic surveys using acoustic streamers.

**205** Fishery (F), requirements for vessels engaged in fishing.

**206** Research (R), requirements for research and particularly noise critical operations (ref. ICES 209).

**207** Environmental (E), requirements for any vessel demonstrating a controlled environmental noise emission.

**208** A vessel satisfying the requirements for several of the class notations may have a combination of qualifiers, e.g. **SILENT-AE** denotes a underwater noise class for acoustical operations as well as having a controlled environmental noise emission.

- SILENT-A** – vessel using hydro-acoustic equipment
- SILENT-S** – vessel engaged in seismic research activities
- SILENT-F** – vessel performing fishery activity
- SILENT-R** – vessel engaged in research or other noise critical operations
- SILENT-E** – any vessel wanting to demonstrate a controlled environmental noise emission.

### B. Definitions

#### B 100 Definitions

**101** *Sound Pressure Level:*

$$L_p = 10 \log_{10} \left( \frac{P_{r.m.s.}}{P_{ref}} \right)^2 = 20 \log_{10} \left( \frac{P_{r.m.s.}}{P_{ref}} \right) \text{ dB re. } 1 \mu\text{Pa}$$

where:

$P_{r.m.s.}$  = Root mean square sound pressure (Pa)  
 $P_{ref}$  = Reference r.m.s. sound pressure ( $1 \mu\text{Pa}$ )

**102** *Source Level:*  $L_{p1m} = L_p$  at 1 meter (usually back calculated from a level measured at a known distance) *dB re. 1 μPa*

**103** *Spectrum Level:*  $L_{ps} = L_p - 10 \log_{10} \Delta f$  *dB re. 1 μPa 1 Hz*

where:

$\Delta f$  = the bandwidth of the measured data in Hz

**104** *Source spectrum level:*

$$L_{ps1m} = L_{p1m} - 10 \log_{10} \Delta f \text{ dB re. } 1 \mu\text{Pa } 1 \text{ Hz } 1 \text{ m}$$

**105** *Distance Correction:* Correction added to a measured level to derive an apparent 1 m source level:

$$X \log_{10} \left( \frac{r}{r_{1m}} \right) \text{ dB}$$

where:

$X$  = is 20 for perfect spherical spreading,  
 is 10 for cylindrical spreading.  
 $R$  = distance between source and hydrophone in meters.  
 $r_{1m}$  = 1 meter reference distance.

**Guidance note:**

$X$  will in practical measurement cases attain a value depending on the actual acoustic field.

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**106** *Acoustical centre:* Position of assumed point source location. On a vessel this point is defined to be at the 0.7 propeller radius when the blade is pointing upwards.

**107** *Closest point of approach (cpa):* Shortest distance between hydrophone and vessel acoustical centre during a pass-by test.

**108** *1/3 octave bands:* The logarithmic frequency interval between a lower frequency  $f_1$  and a higher frequency  $f_2$  when  $f_1/f_2 = 2^{1/3}$ . For practical purposes the bandwidth of a 1/3 octave band is equal to  $0.23 f_c$ , where  $f_c$  is the centre frequency of the band. Preferred 1/3 octave band centre frequencies are defined in IEC 61260.

## C. Documentation Requirements

### C 100 Documentation requirements

101 Documentation shall be submitted for approval as required by Table C1:

Table C1 Documentation requirements		
Activity	Documentation type	Additional description
Underwater Noise Measurement	Z250 – Procedure	<p>A detailed plan for the measurements of the underwater noise levels prior to the execution of the measurements:</p> <ul style="list-style-type: none"> <li>— Geographical location for planned measurements (several alternatives may be presented).</li> <li>— Description of depths at measuring site and bottom condition (nautical draft/map or similar).</li> <li>— Description of planned measurement set-up. i.e. location of hydrophone(s), planned sailing path(s) for vessel and details of instrumentation to be used.</li> <li>— Description of the expected operating profile for the vessel, i.e. expected time at different operating conditions when in normal service.</li> <li>— Detailed intended operating conditions for the vessel during the measurements, i.e.: Rotational speed, pitch and load of any propeller / thruster at test condition. Rotational speed and load of any engine to be used during the test. Estimated vessel speed through water.</li> <li>— If the vessel will be towing an object, type of object, calculated towing force and method of calculation of towing force.</li> <li>— Description of method(s) to be used for monitoring operating conditions.</li> <li>— Expected loading condition during the measurements and normal range of loading conditions for the vessel.</li> <li>— Description of any intended deviations from the required measuring procedure, operating conditions or loading conditions.</li> </ul>
Underwater Noise Measurement	Z241 – Measurement report	<p>A measurement report containing:</p> <ul style="list-style-type: none"> <li>— Measured source levels plotted against the criterion in graphical form.</li> <li>— Measured source levels in numerical form for each 1/3 octave band and overall source level for the seismic Underwater Noise Class notation.</li> <li>— Detailed observed operating conditions during the tests, i.e. Rotational speed, pitch and load of any propeller / thruster in use. Rotational speed and load of any engine in use. Vessel speed over ground and through water. Depth at the measuring site. Weather conditions.</li> <li>— Graphical description of measuring site and location of hydrophone(s).</li> </ul>

### C 200 Normative references.

201 This chapter contains references to the following publications:

- IEC 6120 Electro acoustics – Octave-Band and Fractional-Octave-Band Filters, International Electrotechnical Commission.
- ICES Cooperative Research Report no. 209. Underwater

noise of research vessels, review and recommendations. ISSN 1017-6195, May 1995.

These normative references are cited at appropriate places in the text. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document including any amendments applies.

## SECTION 2 UNDERWATER NOISE

### A. General

#### A 100 Rule applications

**101** The rules specify requirements for maximum underwater noise emission for a given set of operating conditions. The rules specify different requirements for specific vessel groups as shown in Fig. 1 – 5 and also stated in numerical form below each figure and summarised in Table B1. Compliance with the rules shall be demonstrated by measurements following the procedures specified in this chapter.

**Guidance note:**

Deviations from the requirements may be accepted upon assessment by the Society. Accepted deviations will be noted in the appendix to the Class Certificate or in the Certificate of Compliance.

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The operating conditions for which the maximum noise levels apply are given in Sec.3 A300 – A700.

**102** Compliance with the rules shall be verified through measurements.

**103** The noise limits are stated in 1/3 octave bands.

**Guidance note:**

It is recommended to carry out calculations at an early project stage in order to ensure that the design includes necessary low noise features and that noise control measures are integrated in the construction if necessary.

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#### B 200 Acoustic (A) requirements

**201** Maximum allowable noise levels are specified in Fig.1 for two conditions, one thruster condition, and one light survey condition:

**Guidance note:**

Air bubbles will reduce the efficiency of acoustical equipment through added attenuation. Deteriorated performance due to air bubbles is not considered by these rules.

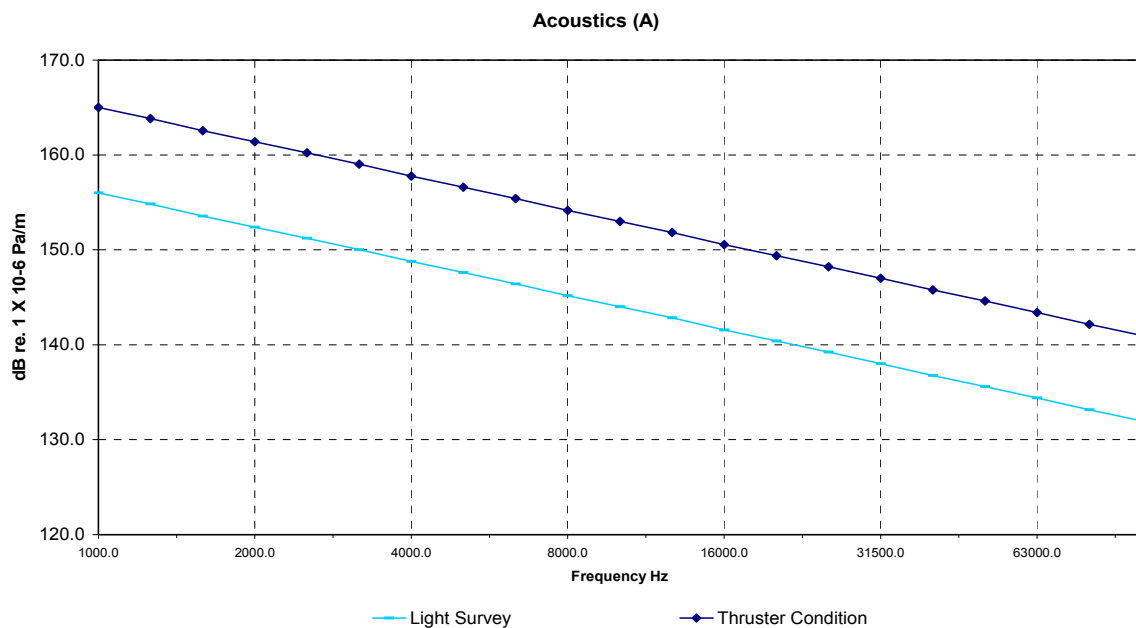
Extreme operational conditions are not covered by these rules.

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### B. Underwater Noise Requirements

#### B 100 General

**101** The maximum allowable noise levels for the various operations are shown in Fig. 1 – 5 and summarised in Table B1.



**Fig. 1**  
Maximum allowable noise levels in 1/3 octave bands for acoustic operations **SILENT-A**.  
See Table B1 for numeric specification of the criteria

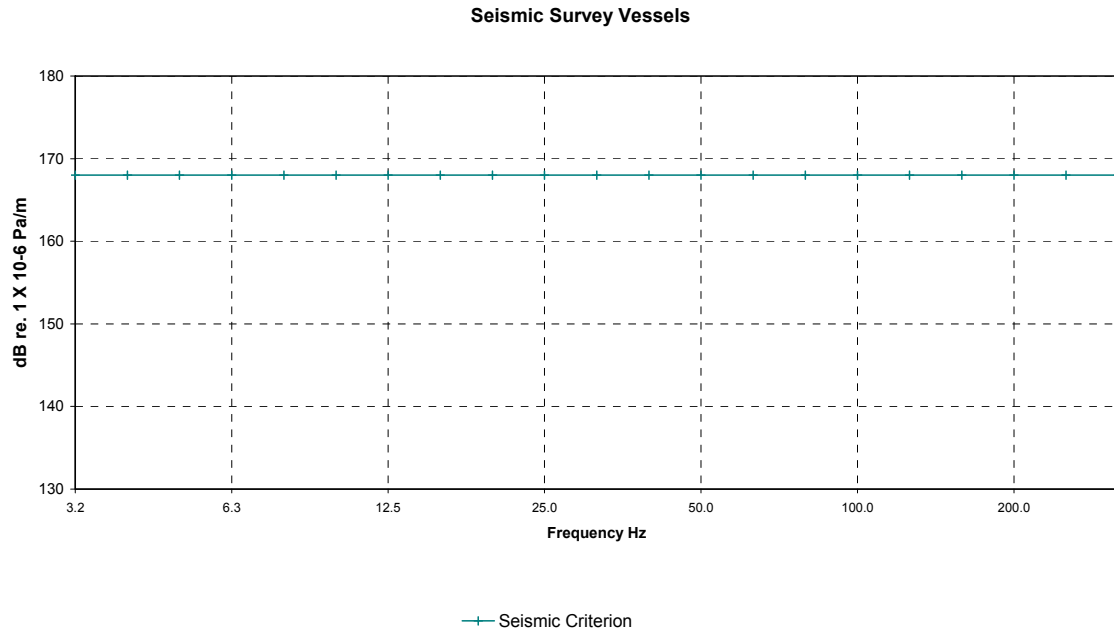
#### B 300 Seismic (S) requirements

**301** For vessels with power > 3 000 kW / shaft, the allowable noise level for class assignment shall be increased by 20 log (distance in meters to first hydrophone group/250) dB when the distance to the first hydrophone group exceeds 250 m.

**Guidance note:**

The Appendix to the class certificate will state the minimum spacing between vessel and streamer used to derive the allowance.

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**Fig. 2**  
Maximum allowable noise levels for seismic survey vessels, **SILENT-S**.  
In addition to the 1/3 octave band level of 168 dB re.1 $\mu$  Pa/m, the overall rms noise level in the frequency range 3 – 300 Hz should not exceed 175 dB re.1 $\mu$  Pa/m

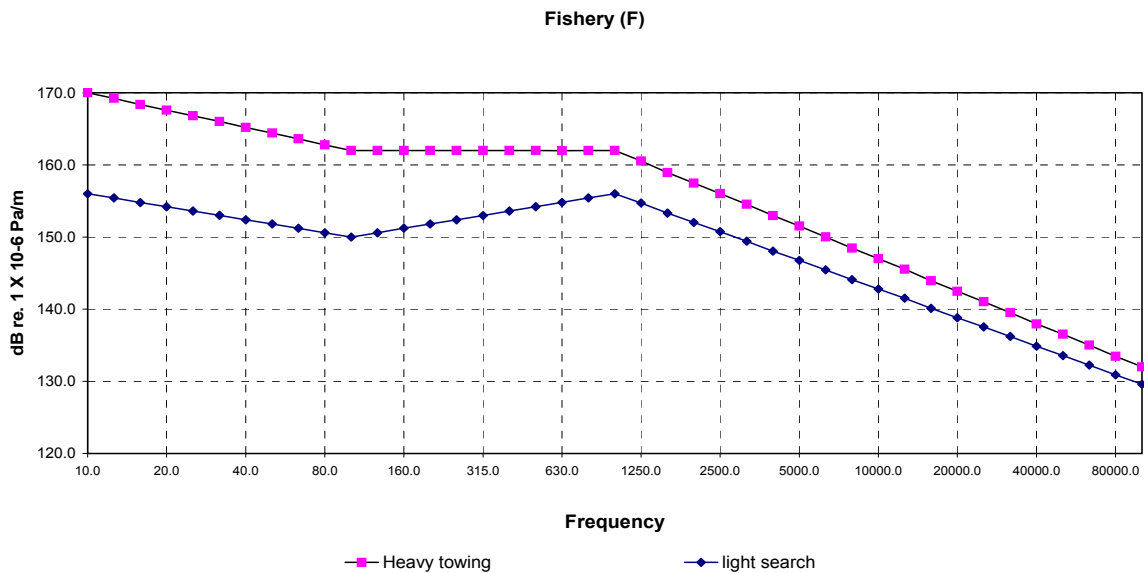
**Guidance note:**

The requirements have been derived based on an assumed distance from the vessel to the first hydrophone groups of 250 m and transmission loss approaching spherical dispersion. For streamers with longer distance to the first hydrophone group the noise will reduce progressively by 20 log (distance in meters/250) dB.

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**B 400 Fishery (F) requirements**

**401** Maximum allowable noise levels are specified in Fig.3 for two conditions, one heavy towing condition / trawling, and one light search / fish finding condition:



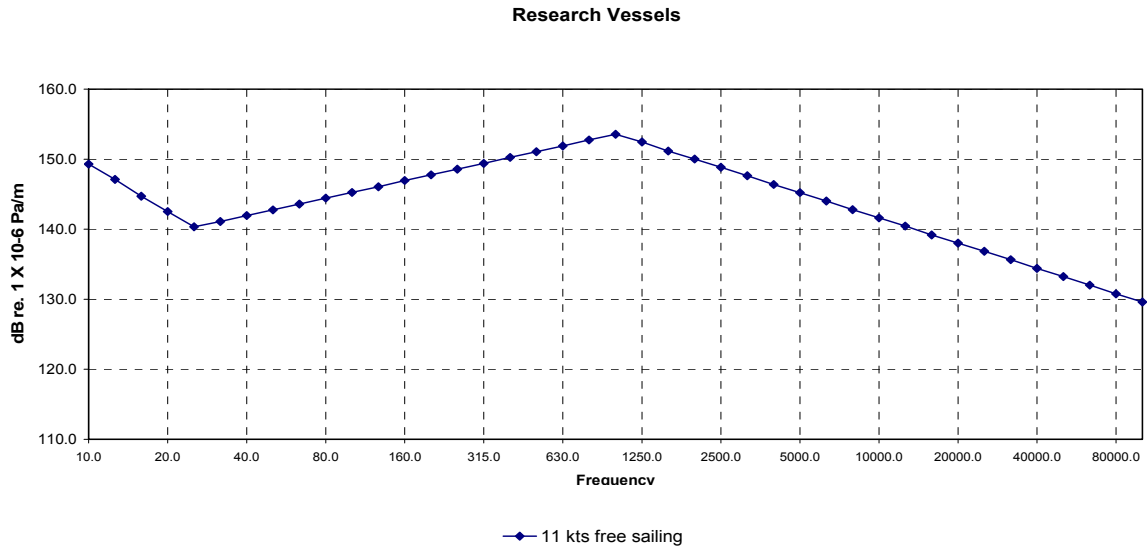
**Fig. 3**  
Maximum allowable noise levels in 1/3 octave bands for fishery **SILENT-F**.  
See Table B1 for numeric specification of the criteria



**B 500 Research vessel (R) requirements**

**501** Maximum allowable noise levels are specified in Fig.4

and are based on the recommendations in ICES Cooperative Research Report no. 209, but are modified for frequencies below 25 Hz.

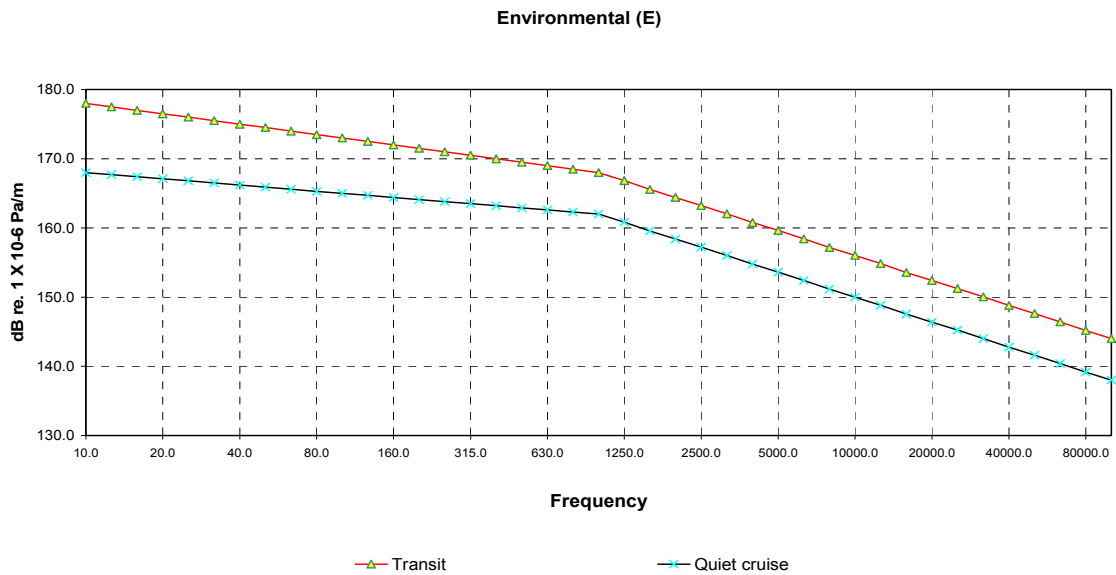


**Fig. 4**  
Maximum allowable noise levels in 1/3 octave bands for research vessels **SILENT-R**.  
See Table B1 for numeric specification of the criteria

**B 600 Environmental (E) requirements**

**601** Maximum allowable noise levels are specified in Fig. 5

for two conditions, a normal transit condition and a quiet cruise condition:



**Fig. 5**  
Maximum allowable noise levels in 1/3 octave bands for environmental class notation **SILENT-E**.  
See Table B1 for numeric specification of the criteria

<b>Table B1 Summary of criteria</b>		
<i>Operational group</i>	<i>Criteria in dB re. 1<math>\mu</math>Pa/m</i>	<i>Frequency range</i>
A. Acoustic	Light survey: 156 – 12 log f(kHz)	1 kHz – 100 kHz
A. Acoustic	Thruster condition: 165– 12 log f(kHz)	1 kHz – 100 kHz
S. Seismic	168 in each 1/3 octave band	3.15 Hz – 315 Hz
S. Seismic	175 integrated over the frequency range	3.15 Hz – 315 Hz
F. Fishery	Light search: 162 – 6 log f(Hz)	10 Hz – 100 Hz
F. Fishery	Light search: 138 + 6 log f(Hz)	100 Hz – 1 000 Hz
F. Fishery	Light search: 156 – 13.2 log f(kHz)	1 kHz – 100 kHz
F. Fishery	Heavy towing: 178 – 8 log f(Hz)	10 Hz – 100 Hz
F. Fishery	Heavy towing: 162 in each 1/3 octave band	100 Hz – 1 000 Hz
F. Fishery	Heavy towing: 162 – 15 log f(kHz)	1 kHz – 100 kHz
R. Research	171.8 – 22.5 log f(Hz)	10 Hz – 25 Hz
R. Research	128.7 + 8.3 log f(Hz)	25 Hz – 1 000 Hz
R. Research	153.6 – 12 log f(Hz)	1 kHz – 100 kHz
E. Environmental	Quiet cruise: 171 – 3 log f(Hz)	10 Hz – 1 000 Hz
E. Environmental	Quiet cruise: 162 – 12 log f(kHz)	1 kHz – 100 kHz
E. Environmental	Transit: 183 – 5 log f(Hz)	10 Hz – 1 000 Hz
E. Environmental	Transit: 168 – 12 log f(kHz)	1 kHz – 100 kHz

## SECTION 3 MEASUREMENTS AND TESTING

### A. General

#### A 100 Measurement procedures

**101** The underwater noise emission for a vessel aiming to achieve one of the Underwater Noise Class notations or a Certificate of Compliance shall be verified through measurements complying with the requirements specified below.

**102** The measurements shall be executed by a company approved by the Society or by the Society. In the former case, the measurements shall be witnessed by a DNV surveyor.

**Guidance note:**

The company shall be able to demonstrate proven capability in underwater noise measurements and should be in possession of necessary high precision instrumentation.

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**103** The underwater noise levels shall be measured at a noise range or at a suitable site which shall be approved by the Society before the measurements are initiated.

**104** The measurements shall follow the procedures given in Appendix A.

**Guidance note:**

Exemption from 104 may be granted by the Society based upon approval of procedures adopted by a permanent noise range as well as track records.

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#### A 200 Test conditions

**201** A plan for the required operating conditions shall be submitted to the Society for approval prior to the testing. The plan shall at least contain the information specified in Sec.1 Table C1.

**202** The operating conditions for the vessel under test shall adhere to the requirements given in one or more of Sub-section elements A300, A400, A500, A600 or A700 depending on the type of operation for which the vessel shall be tested.

**203** The operating conditions shall be monitored during the measurements and the information specified in Sec.1 Table C1 shall as a minimum be recorded as accurately as practicable during the measurements.

**204** The vessel shall be fully outfitted and carry a load within the normal load range for the operation in question. For vessels with larger variation than 25% in relevant displacements, measurements at two loading conditions close to the heavy and light displacement conditions may be decided by the Society in each particular case.

**205** All equipment and systems normally in use, except hydro-acoustic equipment shall be running at their normal rated capacity or in the normal mode for the operation in question. Hydro-acoustic equipment shall be turned off during the measurements except if these systems are necessary for safe navigation of the vessel. If hydro-acoustic equipment has to be used for safety reasons, the type of equipment and frequency range of the signals shall be stated in the record of measuring conditions.

#### A 300 Acoustic (A) test conditions

**301** The vessel shall be tested for a standard set of operating conditions which represent typical or expected operating conditions for the vessel.

**302** Vessels which document that use of thrusters is irrelevant during acoustical operations can be allowed to conduct tests at the light survey condition only.

**303** Vessels designed to use thrusters to conduct a survey shall be tested at the two sets of operating conditions specified further below.

**Guidance note:**

Light survey, represents a condition where the vessel is able to perform a survey using the main propulsion propeller(s) only. The thruster condition simulates the noise which will be generated if additional thrusters have to be used to maintain a course during a survey.

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**304** An operational speed profile for typical hydro-acoustic operations for the vessel shall be submitted to the Society prior to the tests. The speed profile shall contain the maximum speed allowed when using the main hydro-acoustic equipment as well as expected operational speed(s) for the majority of the operations. The profile shall also indicate if side thrusters are expected to be used. Based on the received information, the Society will determine speed(s) at which the vessel shall be tested.

**305** When relevant speed(s) for testing has been established, measurements shall be performed with the propulsion system in a normal configuration for the relevant speed(s).

**306** When a thruster noise test is required, see 303, measurements shall be carried out with the thruster(s) operating at 40% of the rated load for the thruster(s).

#### A 400 Seismic (S) test conditions

**401** Measurements shall be carried out towing the ordinary seismic equipment or simulated equivalent towing load. The equivalent towing load procedure shall be forwarded to the Society for approval prior to testing.

**Guidance note:**

Equivalent load may be established by calculations or from measured experience data from other vessels with similar seismic gear. The towing load shall be established for the normal seismic towing speed for the vessel, or at 5 knots, or through a bollard pull method. The measured noise levels during bollard pull will be corrected using the DNV "Tip vortex method". No cavitating vortices should occur between the propeller and the hull during bollard pull.

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#### A 500 Fishery (F) test conditions

**501** Vessels which can document that they will perform heavy towing / trawling only will be allowed to test at that condition only.

**502** An operational speed profile for typical hydro-acoustic search equipment for the vessel shall be submitted to the Society prior to the tests. The speed profile shall contain the maximum speed allowed when using the main hydro-acoustic equipment as well as expected operational speed(s) for the majority of the operations. Based on the received information, the Society will determine speed(s) at which the vessel shall be tested.

**503** For the trawling condition, the vessel shall tow its usual trawl or an alternative object yielding equivalent towing force at a distance of at least 150 m from the vessel at 4 knots or at the highest allowable speed for the trawl if this is less than 4 knots. The trawl or alternative object shall not touch the bottom.

**504** If an alternative object will be towed, calculated or measured towing force for the standard trawl that the vessel

will be equipped with as well as calculated or measured towing force for the alternative object shall be submitted to the Society for approval.

#### **A 600 Research (R) test conditions**

**601** Research vessels > 50 m in overall length shall sail at 11 knots without towing any object and without the use of side thrusters.

**602** Research vessels ≤ 50 m overall length or less shall sail at 8 knots without towing any object and without the use of side thrusters.

**603** Only equipment and machinery necessary to achieve the stated free running speed and to maintain normal electric load shall be used during the testing.

#### **A 700 Environmental (E) test conditions**

**701** Each vessel shall be tested at two different conditions: transit and quiet cruise.

**702** The transit condition shall correspond to the contractual normal seagoing condition, or 85% of maximum continuous power available at the propeller shaft(s).

**703** The quiet cruise condition shall be performed at a speed

of 11 knots if the overall vessel length > 50 m. For vessels ≤ 50 m, the test shall be performed for a speed of 8 knots.

**704** All other machinery shall be run at normal operating conditions during the tests.

## **B. Reporting**

### **B 100 General**

**101** The measured source levels shall be reported in 1/3 octave bands. The reporting shall comply with the requirements in Appendix A.

**102** The Society will assess the reported results, documented operating conditions and any other relevant information. If the results are found to be acceptable the relevant underwater noise class will be issued.

**103** A summary of the required documents to be forwarded to the Society is shown in Sec.1 Table C1.

**104** The Society may, based on an evaluation of all factors associated with the measurements, accept deviations from the requirements.

## APPENDIX A MEASUREMENT PROCEDURE

### A. Scope

#### A 100 General

**101** This Appendix defines procedures for measurement of underwater noise generated by vessels to be tested for the requirements in the DNV underwater noise class.

### B. Test Procedures

#### B 100 General

**101** The procedure requires use of an external bottom mounted hydrophone. The vessel under test shall sail past the hydrophone as indicated in Fig.1 and Fig.2 for free sailing vessels, or as indicated in Fig.1 and Fig.3 for thruster tests. The noise from the vessel is then recorded during a defined portion of the sailing path. The vessel shall sail in a straight line with minimal use of rudders and steer-able thrusters for free sailing runs. The vessel shall rotate as close to the hydrophone as practical within the defined measuring range for thruster spins.

#### B 200 Geometry of test site

**201** A sloping seabed as indicated in Fig.1 is preferred, but measurements from a flat bottom area are also allowed. The recording equipment can be located in a moored auxiliary vessel if measurements are taken offshore or when land access is limited.

**202** The measurements shall be carried out within a source to hydrophone distance range of 150 m to 250 m at the closest point of approach (cpa) to restrict the influence of variation in distance correction errors.

**203** The depth below the keel of a vessel shall not be less than 30 meters. For vessels operating at high speeds, the minimum depth of water at the test site shall at least satisfy the following relationship for minimum depth under the keel:  $d \geq 0.64v^2$  where  $v$  represents the maximum ship speed in m/s required for the test and  $d$  is the depth in m.

**204** The distance between the down sloping seabed and a rising seabed to the same level as the hydrophone (typical opposite side of a fjord or a bay) shall be at least 500 m.

**205** The hydrophone shall be mounted in a cage or fixture able to keep the hydrophone in a stable position at a maximum height of 0.2 m above the sea bottom. The bottom shall be firm and able to be support the cage without significant subsidence, e.g. sand, firm clay or stone. An example of a cage construction is shown in Fig.5. The cage structure shall be open, stiff and well damped. The structural members of the cage shall be slim with a maximum diameter of 20 mm in order to limit shadowing effects on the hydrophone. The base of the cage shall be between 0.4 m<sup>2</sup> and 0.7 m<sup>2</sup>. The method relies on the seabed giving a diffuse reflection not a perfect mirror reflection, i.e. the surface shall not be perfectly flat.

### C. Recording of Data

#### C 100 Preparations

**101** Before start of the measurements the following preparations are to be carried out:

a) Selection of measuring site and agreement with vessel about timing of survey

- b) Preparation of test protocol covering operating conditions to be tested and number of test runs to be carried out
- c) Preparation and check of calibration for instrumentation to be used
- d) Instructions for ship crew to monitor operating conditions and briefing on procedures for execution of the tests
- e) Instructions to ship crew for construction of measuring cage or for suitable threaded holes for through the hull transducers.
- f) Establish a method of undisturbed communication between vessel operating crew and measuring crew.
- g) Ensure that any auxiliary equipment needed for the test is available, e.g. battery power sources, auxiliary vessel, etc.

#### C 200 Measurements

**201** For free sailing verification tests, data for averaging shall be recorded from when the vessel midship position is abeam the hydrophone position and until the vessel has passed abeam the hydrophone position by half a ship length for speeds  $\leq 5$  kts. For speeds  $> 5$  kts, recording of data shall be performed from abeam the front of the vessel and until the vessel has passed the hydrophone with one ship length, see Fig.4. Distance correction shall assume the distance of cpa for the complete data segment.

**202** For all free sailing tests, two sets of measurements shall be taken with the vessel sailing in opposite directions at the same operating condition. The results of the two runs shall be averaged on a power basis in order to establish the resulting noise level for that operating condition.

**203** The noise during bollard pull shall be measured as if the vessel had been passing the hydrophone from a location abeam the propeller plane. The averaging time shall be set to 1 minute for each set of data acquired.

**204** For thruster tests, the spin is to start with the bow facing the hydrophone position. Data shall be averaged over a time of 30 seconds. Distance correction shall be carried out for segments of approximate 10 seconds of data using the average distance within each segment for each distance correction.

**205** For thruster tests, two sets of measurements shall be taken for each operating condition with the thrusters running in opposite directions during the two runs. The results of the two runs shall be averaged on a power basis in order to establish the resulting noise level for that operating condition.

**206** For multi thruster configurations, the thrusters can be operated in the same direction letting the vessel rotate or alternatively the thrusters can be run in opposite directions thereby limiting the motion of the vessel.

**207** Before the start of the tests, the position and depth of the hydrophone shall be determined within an accuracy of  $\pm 5$  m. The position of the ship shall be recorded by differential GPS or equivalently accurate navigation equipment. The source to hydrophone distance can then be calculated using Pythagoras theorem. As an alternative the distance between hydrophone and ship can be measured using an acoustic beacon. The response at the frequency of the latter shall then be accounted for during the analysis of data.

**208** The background noise at the test site shall be monitored at least at the start and end of the measurement survey. If the background noise is more than 10 dB below the noise from the object under test - no correction is necessary.

**209** For background noise 5 dB – 10 dB below the noise

from the tested object – the background noise to be subtracted from source noise level on a power basis.

**210** If the background noise is in the range 3 dB – 5 dB below the noise from the object under test, the source of background noise to be investigated and if possible removed. If impractical to remove the source of background noise, background noise can be subtracted from source noise level.

**211** For background noise levels less than 3 dB below the noise from the object under test, the source of background noise to be investigated and if possible removed. If it is impossible to remove the source of the background noise, the results will not be valid. If the excessive background noise occurs over a limited part of the frequency range, data can be presented for the remaining part of the spectrum with a statement of the reason for the lack of data in the frequency range blocked by background noise. Later assessment will then determine if the measured results can be accepted or not.

**212** The instrumentation used to record and analyse the data shall have a dynamic range of 90 dB or higher. It is important that the instrument operator attempts to utilise the full dynamic range in order to limit data sinking below the instrument threshold noise at high frequencies.

**213** The instrumentation shall be of high precision and shall be maintained and calibrated in accordance with the instructions of the instrument manufacturer. At the beginning and end of each measurement survey the entire measurement system shall be checked by an appropriate check calibrator.

### C 300 Analysis of data

**301** The data shall be analysed using real time 1/3 octave filters or FFT analysers. In the latter case the data shall be converted to apparent 1/3 octave bandwidth by integration of each narrow frequency point within the bandwidth of the relevant filter to a filter with characteristics in compliance with minimum IEC 61260 class 2. Narrow band data may be presented on a voluntary basis for information.

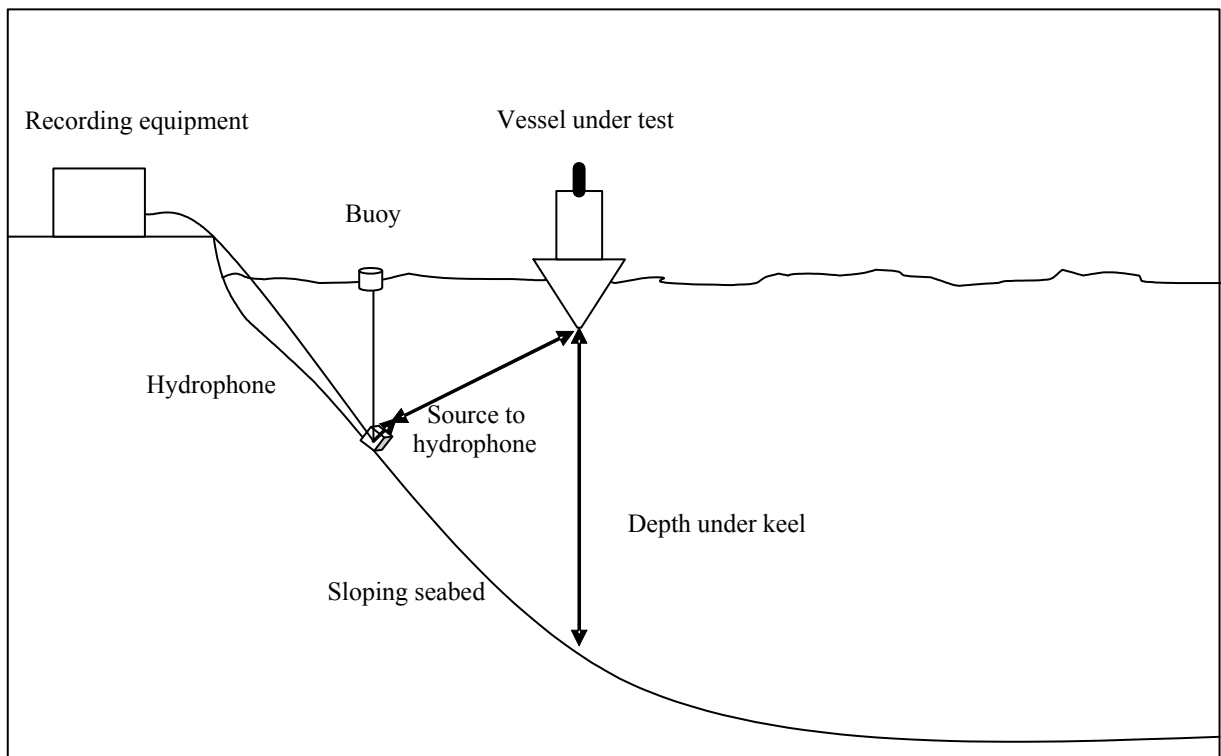
**302** The frequency range of the measurements shall cover the relevant 1/3 octaves, however, the frequency range 50 kHz to 100 kHz can be omitted if it can be proved that the data will fall below the required 90 dB dynamic range.

**303** Distance correction shall be carried out using the actual measured transmission loss at the test site or the relationship:  $+ 18 \log r$ , where r is the distance in meters for which correction is to be made.

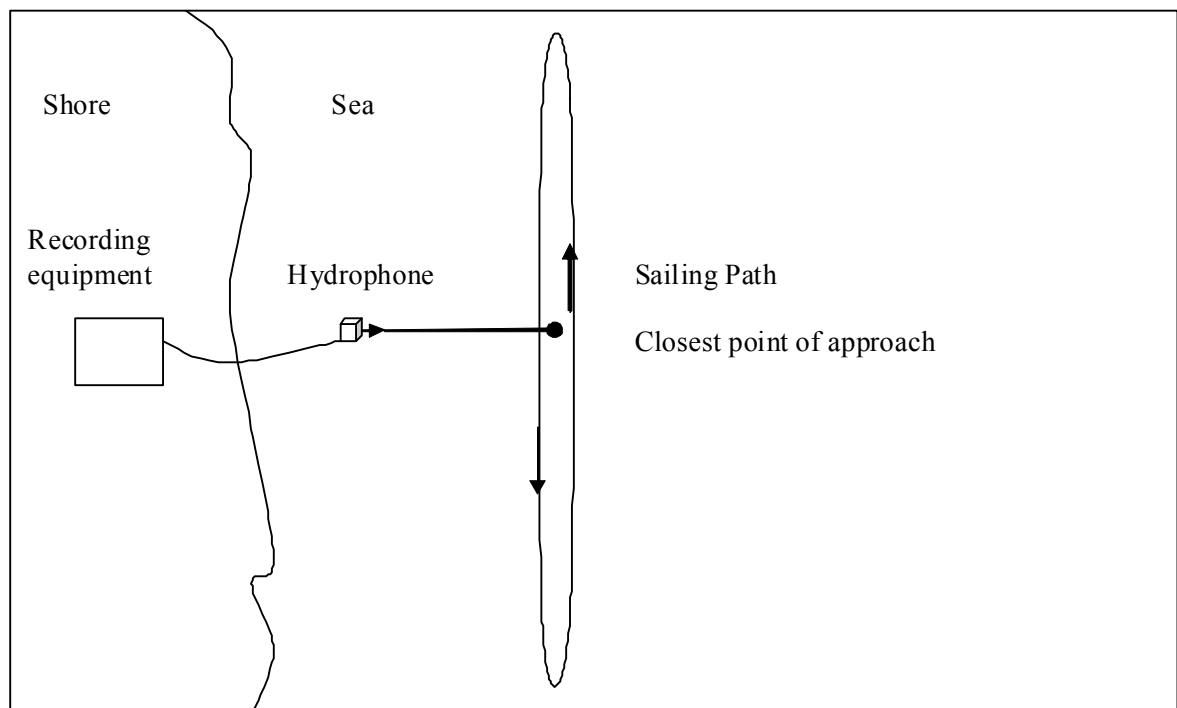
**304** A pressure reflection correction of -5 dB shall be applied to measurements made with bottom mounted hydrophones located on the bottom in a fixture with hydrophone height not exceeding 0.2 m above the bottom.

**305** The results of the tests shall be presented as source level values for each of the 1/3 octave filters used during the analysis of the data. An example of data presentation format is shown in Fig.6.

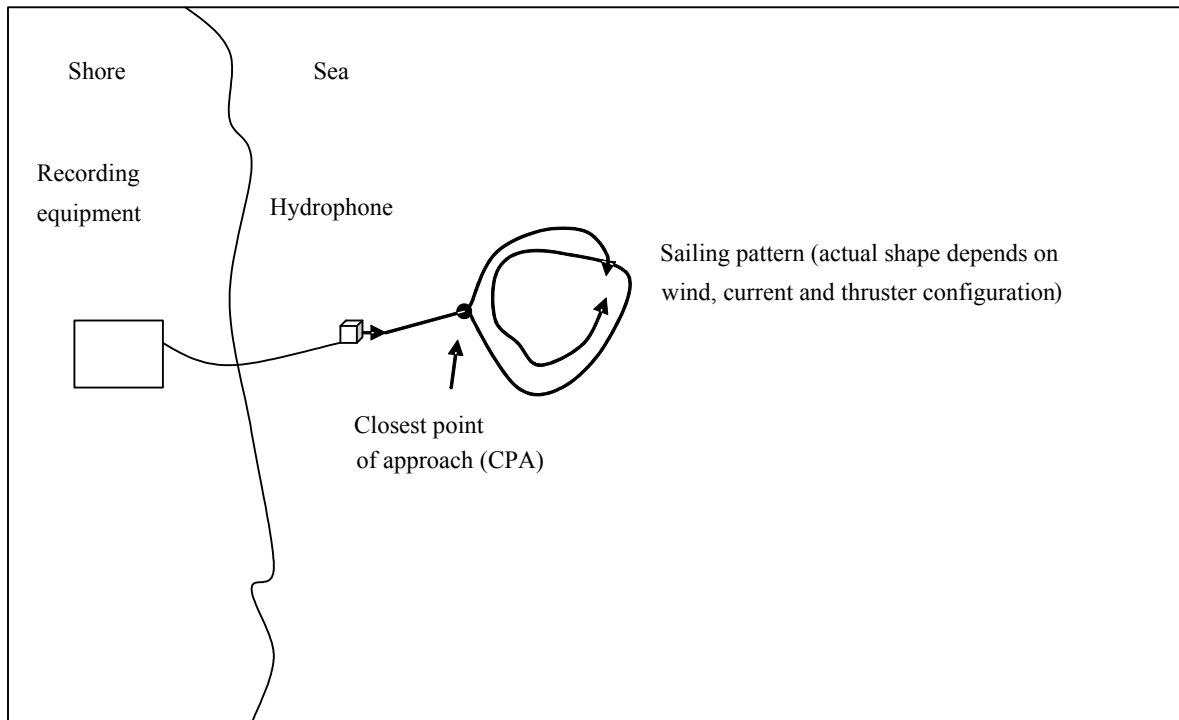
Measurement reporting unit	dB re 1 $\mu$ Pa at 1 m
Reference distance	1 meter
Distance adjustment factor	Measured transmission loss or $18 \log_{10}(r/r_{1m})$
Hydrophone installation	In fixture max. 0.2 meter above bottom. Bottom not perfectly flat
Correction for surface reflection	- 5 dB
Acoustical source centre, vessel	At 0.7 propeller radius when the blade is pointing upwards
cpa distance, vessels	150 m – 250 m
Minimum depth under vessel	30 m and $d \geq 0.64v^2$
Required accuracy of depth and distance measurements	+/- 5 meters
Frequency range	All relevant 1/3 octave bands
Frequency analysis	1 / 3 octave
Frequency analysis, optional	Narrowband
Averaging time for data, vessels free sailing:	$\leq 5$ kts, ship length/speed $> 5$ kts, 2 x ship length/speed
Vessels thruster spin:	30 seconds
Bollard pull:	1 minute
Signal / Background noise	$> 10$ dB no action $< 10$ dB, follow specified procedure
Minimum dynamic range of instrumentation	90 dB
Weather conditions	Max. Beaufort 4 / Sea State 3



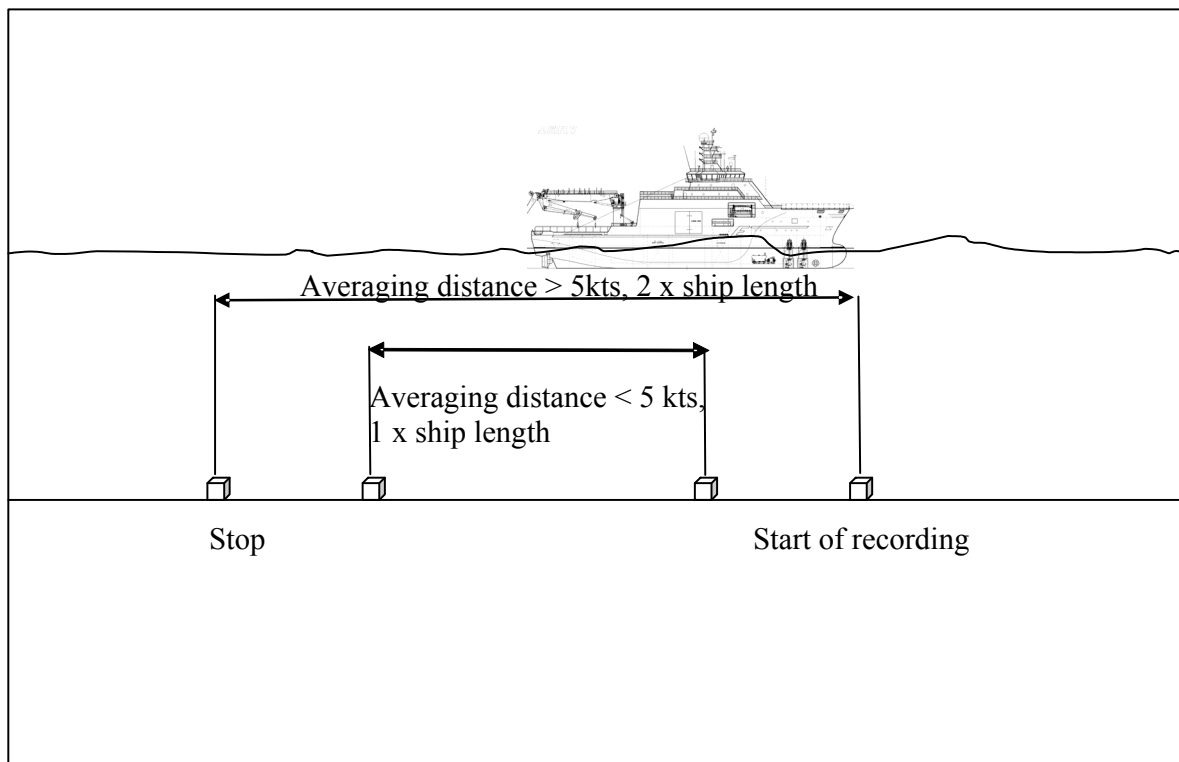
**Fig. 1**  
Schematic drawing of measuring situation for surface vessel



**Fig. 2**  
Measuring situation seen from above, free sailing tests



**Fig. 3**  
Measuring situation seen from above, thruster tests

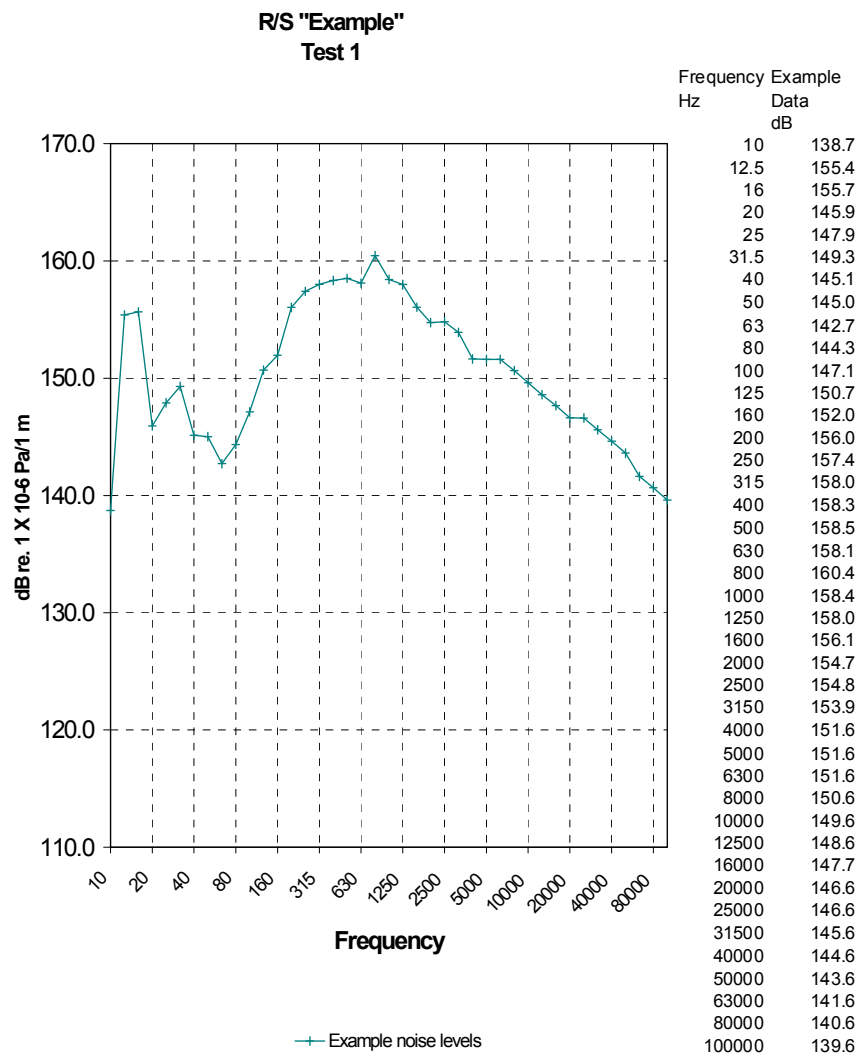


**Fig. 4**  
Sketch of averaging distance for different free sailing speeds





**Fig. 5**  
Hydrophone attached to an example of a seabed cage



**Fig. 6**  
Example on data format

