Underwater Radiated Noise (URN)

July 2018

Rule Note
NR 614 DT R02 E

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MARINE & OFFSHORE - GENERAL CONDITIONS

1. INDEPENDENCY OF THE SOCIETY AND APPLICABLE TERMS

1.1. The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.

1.2. The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not, in any circumstances, involve monitoring or exhaustive verification.

1.3. The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of them above listed being relieved of any of their expressed or implied obligations as a result of the interventions of the Society.

1.4. The Services are carried out by the Society according to the applicable Rules and to the Bureau Veritas' Code of Ethics. The Society only is qualified to apply and interpret its Rules.

1.5. The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.

1.6. Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the rules applicable at the time of the Services' performance and con tract's execution.

1.7. The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

2.1. "**Certificate(s)**" means class certificates, attestations and reports following the Society's intervention. The Certificates are an appraisement given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules or to the documents of reference for the Services provided. They cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

2.2. "**Certification**" means the activity of certification in application of national and international regulations or standards, in particular by delegation from different governments that can result in the issuance of a certificate.

2.3. "**Classification**" means the classification of a Unit that can result or not in the issuance of a class certificate with reference to the Rules.

2.4. "**Client**" means the Party and/or its representative requesting the Services.

2.5. "**Conditions**" means the terms and conditions set out in the present document.

2.6. "**Industry Practice**" means International Maritime and/or Offshore industry practices.

2.7. "**Intellectual Property**" means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and proto cols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.

2.8. "**Parties**" means the Society and Client together.

2.9. "**Party**" means the Society or the Client.

2.10. "**Register**" means the register published annually by the Society.

2.11. "**Rules**" means the Society's classification rules, guidance notes and other documents. The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.

2.12. "**Services**" means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: ship and company safety management certification, ship and port security certification, training activities, all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

2.13. "**Society**" means the classification society '**Bureau Veritas Marine & Offshore SAS**', a company organized and existing under the laws of France, registered in Nanterre under the number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.

2.14. "**Unit**" means any ship or vessel or offshore unit or structure of any type or part of it or system whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

3. SCOPE AND PERFORMANCE

3.1. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.

3.2. Subject to the Services performance and always by reference to the Rules, the Society shall:

- review the construction arrangements of the Unit as shown on the documents provided by the Client;
- conduct the Unit surveys at the place of the Unit construction;
- class the Unit and enters the Unit's class in the Society's Register;
- survey the Unit periodically in service to note that the requirements for the maintenance of class are met. The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.

The Society will not:

- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
- engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

4.1. The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit after surveys; (iii) present the Unit for surveys; and (iv) inform the Society in due course of any circumstances that may affect the given appraisement of the Unit or cause to modify the scope of the Services.

4.2. Certificates referring to the Society's Rules are only valid if issued by the Society.

4.3. The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.

5. ACCESS AND SAFETY

5.1. The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawings, etc. required for the performance of the Services must be made available in due time.

5.2. The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

6.1. The provision of the Services by the Society, whether complete or not, involve, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.

6.2. Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interests equal to twelve (12) months LIBOR plus two (2) per cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold certificates and other documents and/or to suspend or revoke the validity of certificates.

6.3. In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to solve the dispute.

7. 7. LIABILITY

7.1. The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:

- Indirect or consequential loss;
- Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.

The Client shall save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.

7.2. In any case, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cents (150%) of the price paid by the Client to the Society for the performance of the Services. This limit applies regardless of fault by the Society, including breach of contract, breach of warranty, tort, strict liability, breach of statute.

7.3. All claims shall be presented to the Society in writing within three (3) months of the Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

8.1. The Client agrees to release, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services except for those claims caused solely and completely by the negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

9.1. The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.

9.2. In such a case, the class granted to the concerned Unit and the previously issued certificates shall remain valid until the date of effect of the termination notice issued, subject to compliance with clause 4.1 and 6 above.

10. FORCE MAJEURE

10.1. Neither Party shall be responsible for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.

10.2. For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts

11. CONFIDENTIALITY

11.1. The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, are treated as confidential except where the information:

- is already known by the receiving Party from another source and is properly and lawfully in the possession of the receiving Party prior to the date that it is disclosed;
- is already in possession of the public or has entered the public domain, otherwise than through a breach of this obligation;
- is acquired independently from a third party that has the right to disseminate such information;
- is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure.

11.2. The Society and the Client shall use the confidential information exclusively within the framework of their activity underlying these Conditions.

11.3. Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.

11.4. The Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

12.1. Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.

12.2. The Intellectual Property developed for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain exclusive property of the Society.

13. ASSIGNMENT

13.1. The contract resulting from to these Conditions cannot be assigned or transferred by any means by a Party to a third party without the prior written consent of the other Party.

13.2. The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

14.1. Invalidity of one or more provisions does not affect the remaining provisions.

14.2. Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.

14.3. In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

15.1. The Conditions shall be construed and governed by the laws of England and Wales.

15.2. The Society and the Client shall make every effort to settle any dispute amicably and in good faith by way of negotiation within thirty (30) days from the date of receipt by either one of the Parties of a written notice of such a dispute.

15.3. Failing that, the dispute shall finally be settled by arbitration under the LCIA rules, which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be London (UK).

16. PROFESSIONNAL ETHICS

16.1. Each Party shall conduct all activities in compliance with all laws, statutes, rules, and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption. Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official, or candidate.

16.2. In addition, the Client shall act consistently with the Society's Code of Ethics of Bureau Veritas. http://www.bureauveritas.com/home/about-us/ethics+and+compliance/

RULE NOTE NR 614

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Section 1 General Requirements

Section 2 Measurement Procedure

Section 3 Level Requirements

SECTION 1 GENERAL REQUIREMENTS

1 General

1.1 Purpose

1.1.1 The additional class notation **URN** defined in this Rule Note deals with underwater radiated noise emitted by any self-propelled ships. It aims at managing and mitigating acoustical impact on marine fauna.

This notation covers both shallow and deep waters.

The measurement procedure is set up focusing on measurement uncertainty. The aim is to improve the measurement repeatability and to control the measurement global uncertainty.

1.2 Application

1.2.1 The additional class notation **URN** is assigned to self-propelled ships meeting the underwater radiated noise level limits defined in this Rule Note.

The notation **URN** is to be completed as follows:

- **URN - controlled vessel**, for vessels complying with the applicable limits given in Sec 3, [2]
- **URN - advanced vessel**, for vessels complying with the applicable limits given in Sec 3, [3]
- **URN - specified vessel**, for vessels complying with the applicable limits given in Sec 3, [4].

1.2.2 The notation **URN** concerns only the continuous noise from shipping. The noise generated by specific activities (pile driving, seismic, etc.) is not concerned.

1.2.3 URN - specified vessel

URN - specified vessel is applicable to vessels which require low radiated noise in relation to their specificities, such as seismic vessels, research vessels, etc.

1.2.4 The notation **URN** includes procedures and methodologies for measurements in shallow and deep water conditions. Differences between these two measurement procedures are detailed in this Rule Note.

1.3 Basic principles

1.3.1 The methodology is to assess the underwater sound pressure levels normalized at a distance of 1 m from the source. The measured quantity is the sound pressure level radiated by the ship considered as a monopole source. This sound level is back calculated to a level at 1 m from the source. The resulting quantity is expressed in terms of spectral density of the sound pressure level (in dB re 1µPa.m/Hz).

Note 1: More precisely, 1 m from the source means 1 m from the hull, considering the maximum breadth.

1.3.2 Granting of **URN** notation is made on the basis of measurements performed during sea trials, or in service, by an acoustic specialist from the Society or by an acoustic specialist from an external company provided that this company has duly obtained the relevant delegation from the Society.

1.3.3 This Rule Note takes into account various international standards and is deemed to preserve their general principles.

1.4 Conditions of assignment

1.4.1 The measurements required for the assignment of the additional class notation **URN** have to be performed in shallow or deep water under the conditions specified in Sec 2.

1.4.2 The notation **URN** may be assigned only if none of the measured levels exceeds the corresponding requested limits provided in Sec 3.

1.5 Regulations and standards

1.5.1 This notation refers to the edition in force of the following standards:

- ISO 17208-1: Underwater acoustics - Quantities and procedures for description and measurement of underwater sound from ships - Part 1: Requirements for precision measurements in deep water used for comparison purposes
- ICES Cooperative Research Report Nº 209. Underwater noise of research vessels, review and recommendations. ISSN 1017-6195, May 1995
- IEC 60565, Underwater acoustics - Hydrophones - Calibration in the frequency range 0,01 Hz to 1 MHz
- IEC61260, Electroacoustics - Octave-band and fractional-octave-band filters.

1.6 Terms and definitions

1.6.1 Background noise

Noise coming from any sources other than the vessel being measured.

1.6.2 Closest Point of Approach (CPA)

During a test run, point where the reference acoustic centre of the vessel under test is the closest to the hydrophones.

1.6.3 COMEX (COMmence EXercise) - Start data location

Position of the reference acoustic centre of the vessel under test where data recording is started.

1.6.4 Data window

Time data window in which an averaged spectrum is computed.

1.6.5 Data Window Length (DWL)

Distance covered by the reference acoustic centre of the vessel during a data window.

1.6.6 FINEX (FINish EXercise) - End data location

Position of the reference acoustic centre of the vessel under test where data recording is stopped.

1.6.7 Hydrophone cable tilt angle

Angle between the vertical axis and the hydrophone line.

1.6.8 Monopole source or point sound source

Hypothesis considering that source radiates sound from a single point.

1.6.9 Pistonphone

Acoustical calibrator that delivers an accurate sound pressure level for the calibration of microphones or hydrophones.

1.6.10 Reference acoustic centre

Single point on the vessel where all the noise sources are assumed to be located. Except in case of specific vessel architecture, the reference acoustic centre is located:

- in the longitudinal direction: halfway between the main engines center and the propeller
- in the vertical direction: at 2/3 of the vessel draught from waterline.

1.6.11 Sound celerity profile

Measurement of the sound speed in seawater as a function of depth, measured vertically through the water column.

1.6.12 Transmission loss

Difference between the source level at 1 m produced by an emitter and the underwater sound pressure level measured by a receiver at a given distance from the emitter.

1.6.13 Underwater sound pressure level Lp

Twenty times the logarithm to the base ten of the ratio of the root-mean-square of an underwater sound pressure p, in a stated frequency band, to the reference sound pressure p_{ref} , expressed in dB:

$Lp = 20 \log (p/p_{ref})$, where $p_{ref} = 1\mu Pa$

1.7 Symbols

1.7.1

Δf : Bandwidth of the one-third octave band (Hz)

v : Speed of the vessel during the sea trials ($m \cdot s^{-1}$)

m : Number of data windows

n : Number of runs

f : Third-octave band central frequency (Hz)

c : Sound celerity in water, ($m \cdot s^{-1}$)

d : Source depth, i.e. 2/3 of the aft draught of the vessel during the measurement (m)

θ : Average angle between the water surface and the line passing through the source and the hydrophone (°)

d_{cpa} : Nominal distance (m) between the hydrophone and the CPA of the closest run

$D_H(r_k, w_j, h_i)$: Horizontal distance (m) from the reference acoustic centre of the vessel to hydrophone i for data window j and run k

$D_V(r_k, w_j, h_i)$: Vertical distance (m) from the reference acoustic centre of the vessel to hydrophone i for data window j and run k

$D(r_k, w_j, h_i)$: Distance (m) from the reference acoustic centre of the vessel to hydrophone i for data window j and run k, computed from $(D_H^2 + D_V^2)^{1/2}$

$TL[D(r_k, w_j, h_i)]$: Transmission loss (dB) at the distance:

$D(r_k, w_j, h_i)$

$L_{S+N}(r_k, w_j, h_i)$: Measured underwater sound pressure level of the vessel for hydrophone i, data window j and run k (dB re 1 µPa)

$L_N(h_i)$: Linear average underwater background noise level for hydrophone i (dB re 1 µPa)

$\Delta L_n(h_i)$: Underwater background noise variation between the beginning and the end of the measurements for hydrophone i (dB re 1 µPa)

$L_{Nstart}(h_i)$: Measured underwater sound pressure level of the background noise at the beginning of the tests for hydrophone i (dB re 1 µPa)

$L_{Nend}(h_i)$: Measured underwater sound pressure level of the background noise at the end of the tests for hydrophone i (dB re 1 µPa)

$L'_S(r_k, w_j, h_i)$: Underwater sound pressure level corrected from the background noise for hydrophone i, data window j and run k (dB re 1 µPa)

$L_S(r_k, w_j, h_i)$: Underwater sound pressure level corrected from the background noise and transmission loss for hydrophone i, data window j and run k (dB re 1 µPa.m)

$L_S(r_k, w_j)$: Power average underwater sound pressure level on all hydrophones for data window j and run k (dB re 1 µPa.m)

$L_S(r_k)$: Linear average underwater sound pressure level on all hydrophones and all data windows for the run k (dB re 1 µPa.m)

L_S : Linear average underwater sound pressure level on all hydrophones, all data windows and all runs (dB re 1 µPa.m)

$L_{S\,1Hz}$: Spectral density of the underwater sound pressure level L_S (dB re 1 µPa.m/Hz)

$LF_{cor}(f)$: Low frequency correction term coming from the Lloyd's Mirror Effect (dB).

1.8 Documents to be submitted

1.8.1 Prior to measurements

Prior to the sea trials, the following documents are to be submitted to the Society:

- general arrangements
- measurement program:
  - loading conditions
  - propulsion operating conditions
  - other equipment to be run
  - test location parameters (bathymetry, seabed type, current expected).

1.8.2 Bio acoustic impact

- the introduction of underwater noise in the marine environment is to be linked to the impact on the marine fauna
- in reference to the European Directive 2008/56/EC and Commission decision 2010/477/EU, the Indicator 11.2 "Continuous low frequency sound" is to be assessed
- for that purpose a dedicated assessment of the pressure levels of the 1/3 octave band centered at 63 Hz and 125 Hz is to be done
- the measurement procedure and post-processing described in this Rule Note implicitly enable this assessment
- for specific cases of vessels operating in a restricted and defined area, an additional report on the species of underwater noise concern could be requested.

2 Instrumentation

2.1 Underwater acoustic measurements

2.1.1 Number of hydrophones

The measurement system is to include three (3) omni-directional hydrophones.

2.1.2 Hydrophone sensitivity uncertainty

The hydrophone sensitivity is to have a maximum uncertainty of ± 2.5 dB within the frequency range of the measurements.

2.1.3 Calibration

a) The hydrophones are to be laboratory calibrated every two (2) years

b) Any pistonphone or similar calibration reference device is to be laboratory calibrated every two (2) years

c) The data acquisition system is to be laboratory checked every two (2) years.

2.2 Distance measurement

2.2.1 A distance measurement is required in order to determine the distance between the reference acoustic centre of the vessel under test and the hydrophones.

2.2.2 The distance is to be measured with an accuracy of ± 10 m. Any device may be used (e.g. optical, acoustical, GPS, radar) as long as the required accuracy is achieved.

2.2.3 The tilt angle is to be measured so that the distance accuracy requirement is fulfilled. As the same distance measurement accuracy is required for deep and shallow water assessment, the tilt angle is to be lower for the deep water measurement configuration.

2.3 Celerity profile measurement

2.3.1 In order to calculate the transmission loss using an accurate numerical modeling (see Sec 2, [4.4]), the celerity profile in the water column is to be measured using either a CTD (Conductivity, Temperature, Depth) measurement device or a direct sound speed sensor.

2.3.2 If applicable, the measuring celerity profile device is to be calibrated every two (2) years.

2.4 Vessel speed measurement

2.4.1 The vessel speed is to be recorded during each run. Speed measurement device commonly used on board the vessel could be relevant.

2.5 Data acquisition, recording and processing

2.5.1 The measurement equipment is to be able to acquire, record and process data from hydrophones, from distance measurement device, from vessel speed measurement and, if any, from celerity profile measurement device.

2.5.2 Acoustic, distance and speed measurement devices are to be synchronous.

2.5.3 The frequency range is to be adapted so as to analyze third-octave band from 10 Hz to 50 kHz. The sampling frequency is to be at least equal to 2,56 times the maximum frequency.

2.5.4 The analyzer is to include third-octave band filters in accordance with IEC 61260 in order to perform an appropriate post processing (see Sec 2, [4]).

3 Testing conditions

3.1 Test site requirements

3.1.1 General

The test site is to be defined jointly by the Client and the Society, considering the following parameters:

- water depth (see [3.1.2])
- sea bottom profile (see [3.1.3])
- lowest background noise (e.g. area with low ship traffic and low current)
- local weather (see [3.1.4])
- maneuverability and safety for the vessel under test
- distance from the harbour.

3.1.2 Minimum water depth

For shallow water assessment, the minimum depth is to fulfil the greatest of the following conditions:

- be greater than 60 m
- be greater than 0,3 v^2.

Note 1: Measurements performed in water depth of less than 60m could be accepted by the Society, however low frequency results may be impacted.

For deep water assessment, the minimum depth is to fulfil the greatest of the following conditions:

- be greater than 200 m
- be greater than twice the ship length or 1,5 times the ship length for ship greater than 200 m.

3.1.3 Sea bottom profile

For shallow water assessment, the sea bottom is to be as flat as possible and neither sloping seabed nor seabed features are to be present in the test site.

The sea bottom features could be extracted from database.

3.1.4 Weather conditions

The measurement is not to be performed during a rainy day. The sea state should not exceed:

- Beaufort 2, for floating line configuration (see Sec 2, [2.1])
- Beaufort 3, for bottom mounted configuration (see Sec 2, [2.1]).

Measurements carried out with worse weather conditions or during unexpected rainy day may be accepted by the Society at the sight of the results. Otherwise, another sea trial is to be conducted.

3.2 Vessel operations

3.2.1 A representative continuous propulsion power condition is to be assessed. This condition is to be determined according to the contract specifications or, by default, at NCR.

3.2.2 A representative loading condition of the vessel is to be assessed. This condition is to be determined according to the contract specifications.

3.2.3 During the tests, the following conditions are to be kept constant:

- power provided by the main engines
- rotational speed, pitch and load of any propeller or thrusters
- loading conditions
- fore and aft draught
- machinery working during the test.

3.2.4 Any equipment frequently used (more than 1/3 of the time at sea) is to be run at its normal operating condition (if practicable).

4 Measurement report

4.1 Requirements

4.1.1 The measurement report is to contain:

- the main characteristics of the vessel, as indicated from Tab 1 to Tab 6
- the trial conditions, as indicated in Tab 7
- the auxiliaries configuration, as indicated in Tab 8
- the propulsion configuration for each run recorded, as indicated in Tab 9
- the capacity plan of the vessel.
- any equipment which could impact the underwater noise of the vessel is to be listed. The state (On/Off) of these noise sources during the measurement is to be noted (see Tab 8).

4.1.2 In addition to the previous information, the following items are to be provided in the report:

- calibration sheets of the instrumentation
- transmission loss calculation details
- linear average by one-third octave of the sound pressure levels of each run $L_S(r_k)$
- final spectral density of the sound pressure level by one-third octave bands L_{S1Hz} in comparison with the limits.

4.1.3 The complete raw data are to be available on request.

Table 1 : General information

Place of test:			Date:
Name of the organization responsible for the test:			
Name of the person performing the test:		Telephone:	e-mail:
Ship name:		Register number: IMO number:	
Ship type:	Shipyard:	Yard number:	Date built: Place built:

Table 2 : Characteristics of the hull

Length between perpendiculars, m:
Breadth moulded, m:
Maximum draught, m:

Table 3 : Characteristics of the main engine

Type:	Number of cylinders:
Number of engines:	Power (kW):
Speed (rpm):	Type of mounting:

Table 4 : Characteristics of the auxiliary engines

Type:	Number of cylinders:
Number of auxiliary engines:	Power (kW):
Speed (rpm):	Type of mounting:

Table 5 : Characteristics of the propulsion

Type:	Number of blades:
Number of propellers:	Nominal pitch:
Speed (rpm):	Diameter:
Others:	

Table 6 : Characteristics of other sources

Type of source	Location	Further information (rpm, etc.)

Table 7 : Trial conditions

Date and start time of measurements	
Location (GPS coordinates of the antenna)	
Sea state	
Wind velocity / directions	
Water depth	
Acoustic measurement system: • hydrophone(s) type • hydrophone(s) depth • sampling frequency • hydrophone sensitivity.	
Distance measurement system	
Celerity profile measurement system	
Vessel under test	
Last hull and propellers cleaning	
Echo sounder off (Yes/No)	
Known problems or concerns that may affect underwater sound levels:	

Table 8 : Auxiliaries configuration

Equipment	Location	State 1 = ON 0 = STOPPED	Notes

Table 9 : Propulsion configuration

Run N°	Time beginning/ end	Heading	d_{cpa}	GPS speed (KTS)	Log speed (KTS)	Propulsion engine speed		Shaftline speed		Propeller pitch		Notes
						Port	Stbd	Port	Stbd	Port	Stbd	

SECTION 2 MEASUREMENT PROCEDURE

1 General

1.1 On-site verification

1.1.1 Before and after the tests, the full acoustic measurement system is to be field calibrated by means of a single frequency device (such as a pistonphone) or using an insert voltage calibration.

1.2 Background noise recording

1.2.1 The background noise is to be recorded before and after the trials. The vessel under test is to be totally disconnected or located far from the hydrophones (at least 2 miles).

1.2.2 Background noise is to be recorded at least during two minutes. Real time signal stability is to be checked during the recording in order to ensure the reliability of the measurement.

1.3 Time series recording

1.3.1 Time series measurements are to be stored for traceability matters and in order to perform narrow band analysis, if necessary.

1.4 Measurement uncertainty

1.4.1 A satisfactory measurement procedure leads, for each third octave band, to the following expected uncertainties:

- ± 4,0 dB for shallow water assessment
- ± 3,5 dB for deep water assessment.

2 Instrumentation deployment

2.1 Hydrophone line

2.1.1 The hydrophone line is to be deployed from a buoy which is to be uncoupled from the sea surface. This could be ensured by a swell compensation device. A deployment from a support vessel is to be avoided as it increases the measurement uncertainties.

2.1.2 For shallow water assessment, the hydrophone line is to be bottom mounted. For deep water assessment, the hydrophone is preferably bottom mounted, but the use of a floating line is acceptable.

2.1.3 The hydrophones are to be arranged vertically in the water column and located to measure the beam aspect (e.g. direction to either side) of the vessel under test.

2.1.4 The hydrophone depths for shallow and deep water assessments are to fulfill the conditions indicated respectively in Fig 1 and Fig 2.

Figure 1 : Hydrophone positions
Shallow water assessment (bottom mounted)

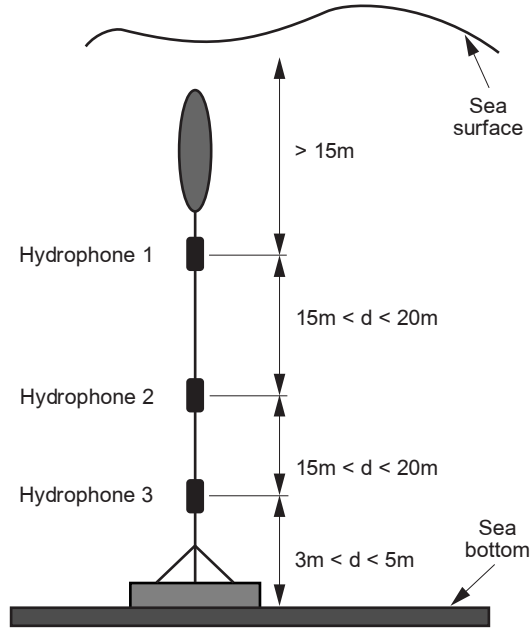
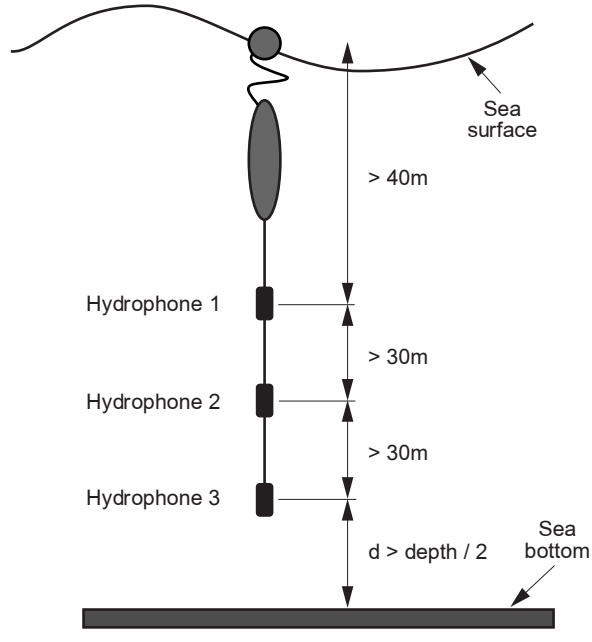


Figure 2 : Hydrophone positions
Deep water assessment (floating line)



2.2 Distance measurement

2.2.1 Distance between each hydrophone and the reference acoustic centre is to be continuously recorded during every whole run with a minimum period of one second.

2.3 Sound celerity profile measurement

2.3.1 The celerity profile is to be measured every 2 m down to the sea bottom before and after the trials, when applicable (see [4.4]).

3 Measurement test sequence

3.1 Condition of runs

3.1.1 The vessel under test is to transit a straight line course to achieve the required distance at CPA for the run in progress. Recording of data is to be performed from approximately the minimum of 800 m or 4 minutes before the fore end of the vessel reaches the CPA (COMEX) to the minimum of 800 m or 4 minutes after the aft end of the vessel has passed the CPA (FINEX). Before the vessel reaches the starting point of the record, the required run conditions are to be achieved.

3.2 Test course configuration

3.2.1 Six runs are to be performed as indicated in Fig 4:

- 2 runs at d_{cpa}
- 2 runs at min (1,5 d_{cpa} ; 400)
- 2 runs at min (2,0 d_{cpa} ; 500).

Note 1: Except in case of specific unsymmetrical design of the vessel with regard to acoustic sources, no difference is to be made on ship sides.

3.2.2 Whether the ship gross tonnage is above 10000 GT, only two runs at d_{cpa} could be accepted. In this case, the measurement uncertainty would be risen by 1,5 dB, that is a final measurement uncertainty of 5,5 dB for shallow water and 5,0 dB for deep water assessment.

3.2.3 Whether the ship gross tonnage is above 10000GT, only one run at d_{cpa} could be accepted. In this case, two identical hydrophone lines should be deployed in such way that the run is performed along the bisection of the segment formed by the two hydrophone lines (see Fig 3). The marine environment on each side of the run should have equivalent characteristics, especially for the flat bathymetry and the homogeneity of the sediment. This should be assessed by measuring and comparing the levels from a towed sound source and known signal along the run.

3.3 Nominal distance to CPA

3.3.1 The nominal distance dcpa between the vessel and the hydrophones is to be defined so that the vessel may be considered as a monopole source and that any background noise issues are avoided. Consequently, the minimum value of dcpa is taken equal to:

d_{cpa} = max (200 ; one ship length)

3.3.2 Whether background noise issues are anticipated for the run at the furthest distance or the vessel is expected to be silent, d_{cpa} could be lowered to the following value:

d_{cpa} = max (100 ; one ship length)

This value is to be decided by the person in charge of the measurements, under the control of the Society.

3.3.3 Due to the effects of current and swell, d_{cpa} may vary, which is acceptable as long as the distance from the hydrophones to the reference acoustic centre of the vessel is known and the minimum distance to CPA is achieved, at ±10 m.

Figure 3 : Alternate test course configuration for ships above 10 000GT

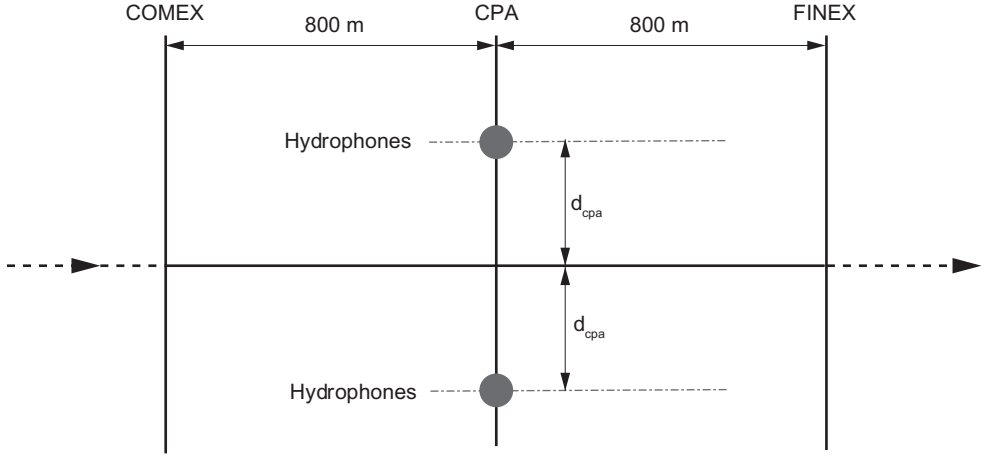


Figure 4 : Standard test course configuration

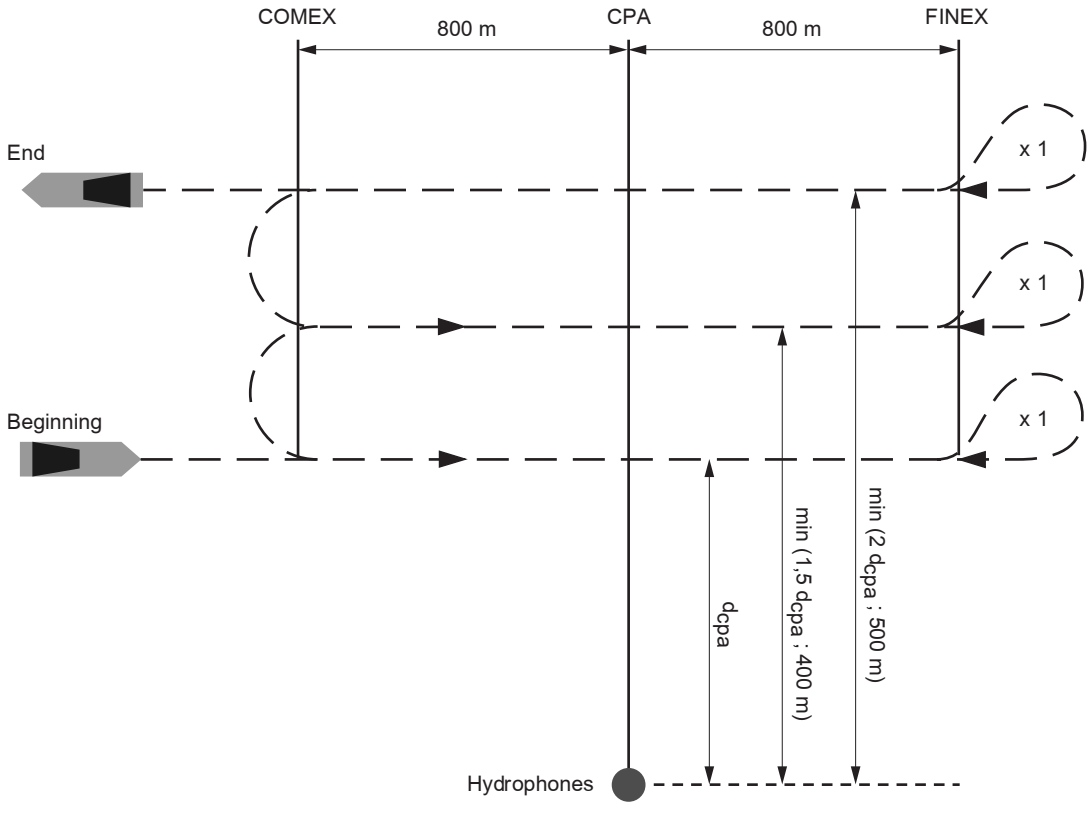


Figure 5 : Data windows

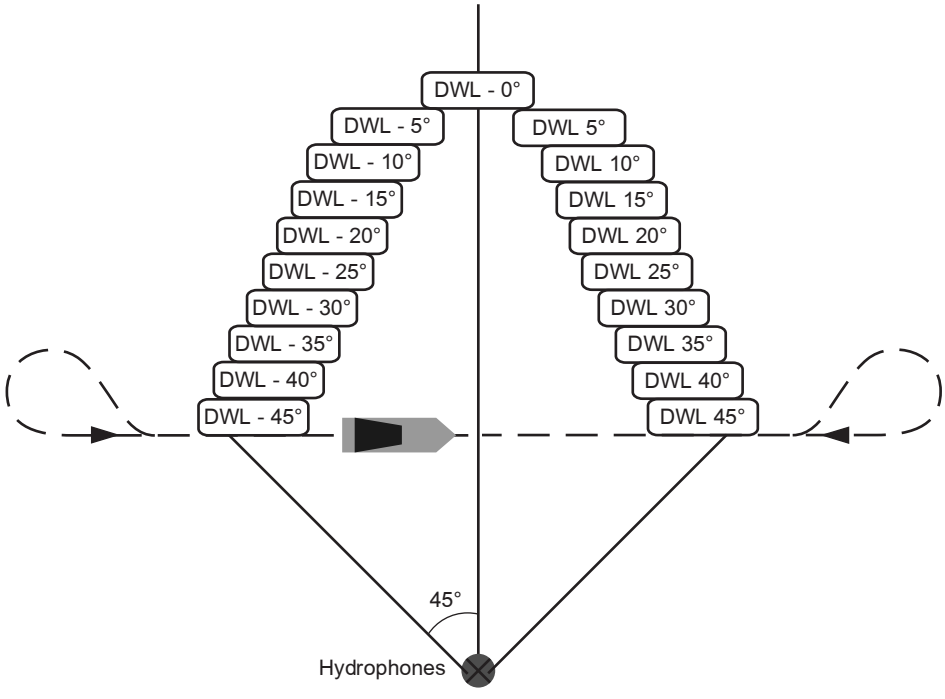


Table 1 : Summary of the measurement steps

Actions	Comments
Weather condition checking	Sea state < 3 Beaufort (bottom mounted configuration) Sea state < 2 Beaufort (floating line configuration)
Measurements of sound celerity profile	When applicable
Measurement system verification	By means of a single frequency device or an insert voltage calibration
Deployment of the hydrophone line(s)	
Background noise measurements	Recording during at least 2 minutes Vessel totally disconnected or located far from the hydrophones (at least 2 miles)
Verification of the background noise level	
Measurements during runs	For each run: • underwater noise measurements between COMEX and FINEX • distance measurements between COMEX and FINEX • vessel speed measurement.
Background noise measurements	Recording during at least 2 minutes Vessel totally disconnected or located far from the hydrophones (at least 2 miles)
Measurements of sound celerity profile	When applicable
Measurement system verification	By means of a single frequency device or an insert voltage calibration
Weather condition checking	Sea state

3.4 Summary of measurement steps

3.4.1 The steps to be followed for the measurement procedure are summarized in Tab 1.

4 Post processing

4.1 Procedure

4.1.1 The present Article details the steps to gather the final spectral density of the sound pressure level.

4.2 Data windows

4.2.1 For each run, the measured data are analyzed with multiple data windows at different angles from –45° to +45° with a step of 5° as shown on Fig 5.

4.2.2 The length of each data window is at least equal to 100 m or one ship length, whichever is greater.

4.2.3 The middle instant of a data window is reached when the reference acoustic centre of the vessel is superimposed with the centre of this window.

4.2.4 For each data window, a root-mean-square linear averaged one-third octave band spectrum of the measured underwater sound pressure level is performed for every hydrophone and is recorded as $L_{S+N}(r_k, w_j, h_i)$.

4.2.5 Post-processing steps detailed from [4.3] to [4.8] are to be conducted for each one-third octave band from 10 Hz to 50 kHz.

4.3 Background noise correction

4.3.1 Each root mean square linear averaged one-third octave band spectrum defined in [4.2.4] is to be corrected from background noise according to the following procedure:

a) The linear average background noise level $L_N(h_i)$ is calculated from the following formula:

$$L_N(h_i) = \frac{L_{Nstart}(h_i) + L_{Nend}(h_i)}{2}$$

b) The background noise variation ΔL_n between the beginning and the end of measurements is equal to:

$$\Delta L_n(h_i) = |L_{Nstart}(h_i) - L_{Nend}(h_i)|$$

c) The signal plus noise to noise ratio $\Delta L(r_k, w_j, h_i)$ is calculated from the following formula:

$$\Delta L(r_k, w_j, h_i) = L_{S+N}(r_k, w_j, h_i) - L_N(h_i)$$

- If $\Delta L(r_k, w_j, h_i) > 10$ dB, no background noise correction is necessary and it turns out the following formula:

$$L'_S(r_k, w_j, h_i) = L_{S+N}(r_k, w_j, h_i)$$

- If 3 dB $\leq \Delta L(r_k, w_j, h_i) \leq 10$ dB and if the background noise is sufficiently stationary, a background noise correction is applied according to the following formula:

$$L'_S(r_k, w_j, h_i) = 10\log\left[10^{\frac{L_{S+N}(r_k, w_j, h_i)}{10}} - 10^{\frac{L_N(h_i)}{10}}\right]$$

Note 1: The steady-state background noise is to be checked in order to ensure that the maximal error due to the background noise correction does not exceed 2 dB. It allows achieving the global expected measurement uncertainty indicated in [1.4].

The error due to the background noise correction is calculated from the following formula:

$$Error = 10\log\left(\frac{1-10^{\frac{-\Delta L(r_k, w_j, h_i)}{10}}}{1-10^{\frac{-\Delta L(r_k, w_j, h_i)+\Delta L_n(h_i)}{10}}}\right) < 2\,dB$$

If the steady state background condition is not verified, the expected measurement uncertainty ensured by the procedure would not be achieved. In this case, it is to be clearly mentioned in the report.

- If $\Delta L(r_k, w_j, h_i) < 3$ dB, data could not be considered as valid and a case-by-case investigation on the background noise is to be performed by the Society.

4.4 Distance correction

4.4.1 The transmission loss due to sound propagation into water is to be taken into account to obtain the underwater sound pressure levels at a reference distance of 1 m from the source.

a) The transmission loss is to be calculated from an accurate numerical modeling method using the following parameters:

- celerity profile
- noise source depth
- hydrophone depth
- sea bottom features/characteristics (i.e. compressional sound speed, density, compressional absorption as a function of frequency).

The following numerical modeling methods are recommended for such transmission loss calculations:

- Parabolic waves equations (see Note 1)
- Scooter/Fields model (wave integration model) for low frequencies (below 1000Hz) (see Note 2)
- Bounce or Bellhop model (ray trace based model) for higher frequencies (see Note 3).

Any other model, which details and references are to be submitted to the Society, may be accepted.

In order to take into account the fact that the vessel is a moving noise source, the modeling transmission loss is to be range-average smoothed.

The underwater sound pressure level corrected from the transmission loss is obtained from the following formula:

$$L_S(r_k, w_j, h_i) = L_S'(r_k, w_j, h_i) + TL[D_H(r_k, w_j, h_i), D_V(r_k, w_j, h_i)]$$

Note 1: Collins, M. D. (1994). Generalization of the Split-Step Pade. J. Acoust. Soc. Am., 96, 382-385.

Collins, M. D., Cederberg, R. J., & King, D. B. (1996). Comparison of Algorithms for Solving Parabolic Wave Equations. J. Acoust. Soc. Am., 100, 178-182.

Note 2: P.C. Etter, Underwater Acoustic modeling and simulation, 4th Edition (CRC Press, 2013).

Note 3: F. B. Jensen, W. A. Kuperman, M. B. Porter, H. Schmidt, Computational Ocean Acoustics, 2nd Edition (Springer, 2011).

b) In case such a method cannot be implemented, an alternative method would be to use a simple propagation law. It is reminded that this second method is conservative and less accurate than the first one. As a consequence, the final measurement uncertainty would be increased by 0,5 dB.

In this case, the transmission loss depends on the water depth:

- for water depth < 100 m:

$$TL[D(r_k, w_j, h_i)] = 19\log[D(r_k, w_j, h_i)]$$

- for water depth ≥ 100 m:

$$TL[D(r_k, w_j, h_i)] = 20\log[D(r_k, w_j, h_i)]$$

The underwater sound pressure level corrected from the transmission loss is obtained from the following formula:

$$L_S(r_k, w_j, h_i) = L_S'(r_k, w_j, h_i) + TL[D(r_k, w_j, h_i)]$$

4.5 Sound power average on hydrophone

4.5.1 The underwater sound pressure levels are power-averaged on the three hydrophones using the following formula:

$$L_s(r_k, w_j) = 10\log\left(\frac{1}{3}\Sigma_{h_i=1}^{3} 10^{\frac{L_S(r_k, w_j, h_i)}{10}}\right)$$

4.6 Linear average of all data windows

4.6.1 The underwater sound pressure levels are linearly averaged on all data windows using the following formula:

$$L_S(r_k) = \frac{\Sigma_{w_j=1}^{m} L_S(r_k, w_j)}{m}$$

4.7 Linear average of all runs

4.7.1 The underwater sound pressure levels are linearly averaged on all runs using the following formula:

$$L_S = \frac{\Sigma_{r_k=1}^{n} L_S(r_k)}{n}$$

Note 1: In case only 1 run is performed according to [3.2.3], n corresponds to each hydrophone line.

4.8 Spectral density of the sound pressure level

4.8.1 The spectral density of the underwater sound pressure level is obtained using the following formula:

$$L_{S1Hz} = L_S - 10\log(\Delta f)$$

5 Exception

5.1

5.1.1 URN measurements and post processing performed according to ISO 17208-1 could be accepted by the Society on a case-by-case study. In this case, the measurement uncertainties are expected to be increased, as specified in the standard.

SECTION 3 LEVEL REQUIREMENTS

1 General

1.1 Applicable limits

1.1.1 The underwater radiated noise levels obtained from Sec 1 and Sec 2 are to comply with the applicable limits calculated according to this Section.

1.2 Low frequency correction

1.2.1 If the transmission loss is calculated from the accurate numerical modelling method (see Sec 2, [4.4.1]), a low frequency correction term, LF_{cor}, is to be applied to the definition of the limits. This term is necessary in order to fulfill the monopole source hypothesis and depends on the ship particulars, namely the depth d (see Sec 1, [1.7]):

$$LF_{cor}(f) = \max\left[0;10\log\left(\frac{1}{2}+\frac{1}{\left(\frac{4\pi f}{c}d\sin(\theta)\right)^2}\right)\right]$$

where:

c = 1515 $m \cdot s^{-1}$

θ = 10° for shallow water (see Sec 1, [3.1.2])

θ = 15° for deep water (see Sec 1, [3.1.2]).

2 Limits for URN - controlled vessel

2.1 Definition of the limits

2.1.1 The maximum underwater radiated noise levels corresponding to the notation **URN - controlled vessel** are indicated in Tab 1.

Table 1 : Limits for URN - controlled vessel

Frequency range per third-octave band	L_{S1Hz} (dB, ref 1µPa@1m / Hz)
10 - 50 Hz	169,0 – 2 log(f) + LF_{cor}
63 Hz - 1 kHz	165,6 – 20 log(f/50) + LF_{cor}
1,25 kHz - 50 kHz	139,6 – 20 log(f/1000) + LF_{cor}

2.2 Graphical output

2.2.1 Fig 1 shows:

- **URN - controlled vessel** limits without low frequency correction
- an example of applicable **URN - controlled vessel** limits in shallow water (θ = 10°) for d = 5 m.

Figure 1 : Graphical output of URN - controlled vessel limits

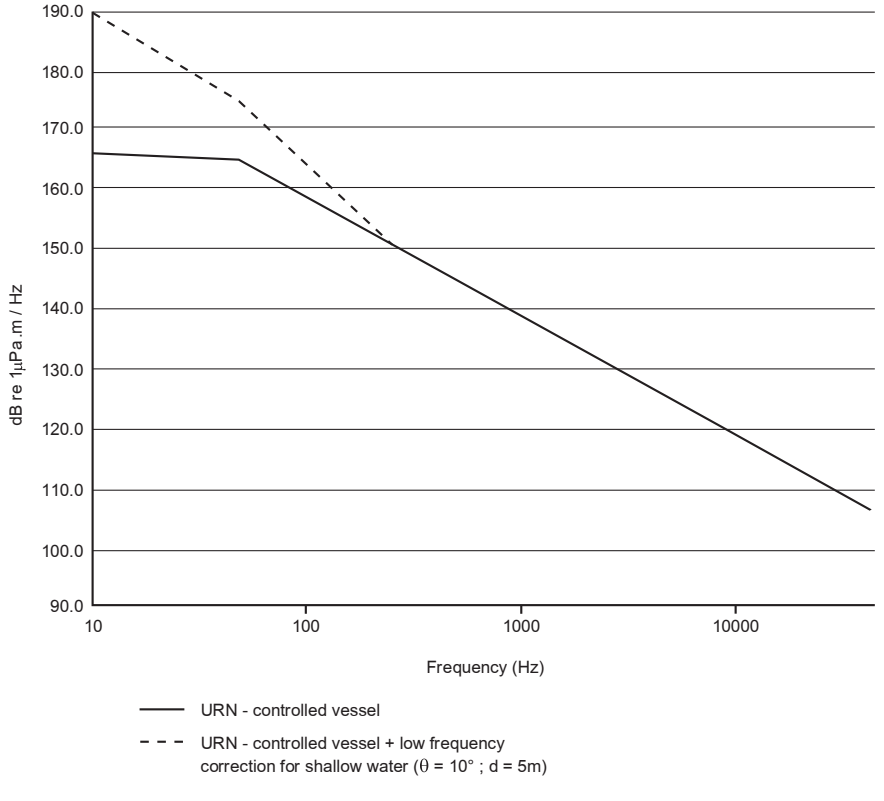
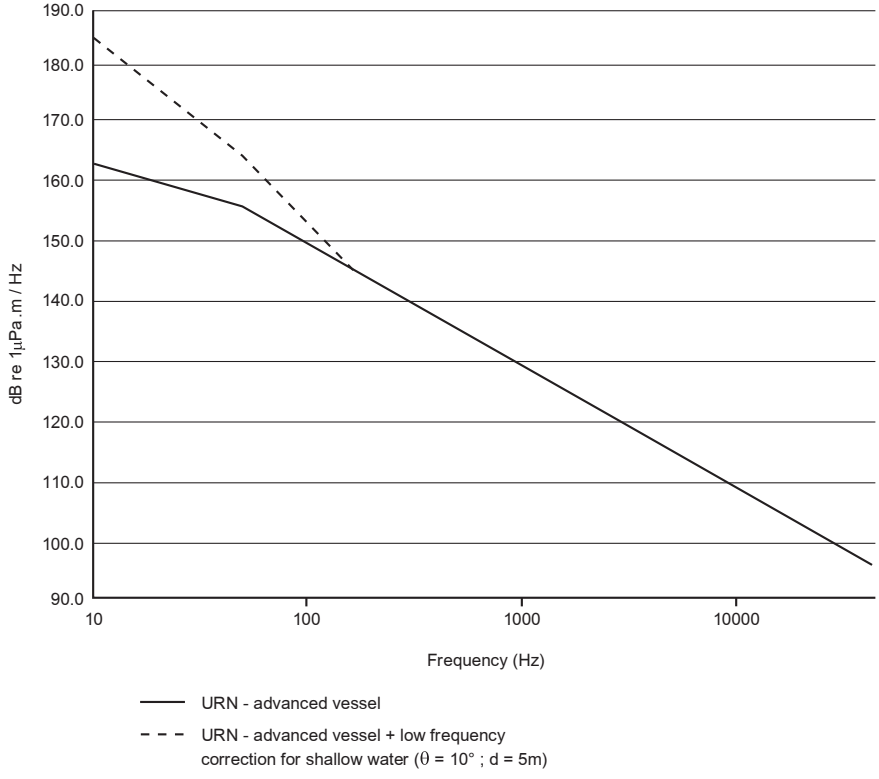


Figure 2 : Graphical output of URN - advanced vessel limits



3 Limits for URN - advanced vessel

3.1 Definition of the limits

3.1.1 The maximum underwater radiated noise levels corresponding to the notation **URN - advanced vessel** are indicated in Tab 2.

Table 2 : Limits for URN - advanced vessel

Frequency range per third-octave band	L_{S1Hz} (dB, ref 1µPa@1m / Hz)
10 - 50 Hz	$174 - 11 \log(f) + LF_{cor}$
63 Hz - 1 kHz	$155{,}3 - 18 \log(f/50) + LF_{cor}$
1,25 kHz - 50 kHz	$131{,}9 - 22 \log(f/1000) + LF_{cor}$

3.2 Graphical output

3.2.1 Fig 2 shows:

- **URN - advanced vessel** limits without low frequency correction
- an example of applicable **URN - advanced vessel** limits in shallow water ($\theta = 10°$) for d = 5 m.

4 Limits for URN - specified vessel

4.1 Definition of the limits

4.1.1 For vessels assigned with the notation **URN - specified vessel**, a case-by-case study is performed by the Society in order to define the underwater radiated noise limits.

4.1.2 Any applicable references, such as ICES 209 for fishery research vessels, could be applied regarding the limits.

4.1.3 Specific requirements could come from equipment specifications or special protected areas.