2024

Guidance for Radiated Noise from Ships

GC-37-E

KR

APPLICATION OF "GUIDANCE FOR RADIATED NOISE FROM SHIPS"

1. Unless expressly specified otherwise, the requirements in the Guidance apply to ships for which the application for Classification Survey is submitted to the Society on or after 1 July 2024.
2. The amendments to the Guidance for Underwater Radiated Noise(2021 edition) and their effective date are as follows;

Effective Date : 1 July 2024

CHAPTER 1 GENERAL

- Chapter 1 has been amended overall.

CHAPTER 3 UNDERWATER NOISE

- Chapter 3 has been amended overall.

CHAPTER 4 AIRBORNE NOISE

- Chapter 4 has been newly added.

CONTENTS

CHAPTER 1 GENERAL

Section 1 General

101. Application *(2024)*

1. This guidance applies to new and existing ships that have applied for the optional notation for the radiated noise from ships as follows.
   (1) "**URN**" for underwater radiated noise from ships (hereinafter referred to "underwater noise")
   (2) "**ARN**" for airborne radiated noise from ships (hereinafter referred to "airborne noise")

102. Definitions *(2024)*

1. For general terms not otherwise defined in this guidances, refer to ISO 18405 and ISO 17208 series.
2. **Shallow water** means a water shallower than that of deep water.
3. **Deep water** means a water with a depth greater than 150 m or 1.5×ship length, whichever is greater.
4. **Background noise** means the noise of all noise sources (bio and non-bio) other than the ship being measured, including its own noise or equipment noise.
5. **Closest point of approach (CPA)** means the point where the horizontal distance from the ship reference point of the ship under test to the hearing device i.e., hydrophone or microphone is the closest.
6. **Ship reference point** means the point indicating the position of the ship during the measurement of airborne noise and underwater noise, and in this guidance, it means the acoustic center.
   (1) Acoustic center of ship for URN measurement is defined per mode as follows.
      (A) Transit mode, quiet mode, research mode, seismic survey mode: the location along the center line of the ship, halfway between the propeller(s) and engine(s) arrangement and vertically at the nominal source depth defined at 0.7 times of the ship's aft draft.
      (B) Thruster mode: the location along the center line and center of thruster(s)
   (2) Acoustic center of ship for ARN measurement is defined as the location along the center line, center of the funnel outlets and vertically at the sea surface.
7. **Data window length (DWL)** means the distance between the start position and end positions of data for post-processing.
8. **Sound pressure level (L_p)** means to the mean squared sound pressure level measured with an hearing device in air or water, and is expressed in decibel (dB) with the following formula.

$$L_p = 20\log_{10}\left(\frac{p_{rms}}{p_0}\right) \qquad (dB)$$

p_{rms} : root-mean-square sound pressure
p_0 : reference sound pressure (i.e. 1 μPa in water, 20 μPa in air)

9. **Root mean square(r.m.s) value** is the square root value of time-average of the squared instantaneous values during a cycle.
10. **Underwater noise level (L_{URN})** means the value obtained by converting the measured sound pressure level to the underwater sound pressure level at a reference distance (1 m) from the ship's reference point. This Guidance consider hereby the ship as a monopole noise source, to be corrected for the water surface reflections.
11. **Airborne noise level (L_{ARN})** means the value obtained by converting the measured sound pressure

level to the airborne sound pressure level at a reference distance (100 m) from the hull surface of the ship.

12. **Propagation loss (N_{PL})** means the transfer function defined as the difference between source level and sound pressure level. For the propagation loss underwater it is to include the related water column and, if applicable, seabed characteristics.

13. **Measurement uncertainty** means the expected variance of measured radiated noise levels. It is expressed in decibels for a decidecade band or a 1/3 octave band using a given measurement method (average time, bandwidth-time product, etc.).

14. **Ship length** means the distance (m) measured on the waterline at the scantling draught from the fore side of stem to the after side of rudder post in case of a ship with rudder post, or to the axis of rudder stock in case of a ship without rudder post or stern post. Ship length is not to be less than 96 % and need not be greater than 97 % of the extreme length on the waterline at the scantling draught. In ships without rudder stock (e.g. ships fitted with azimuth thrusters), ship length is to be taken equal to 97 % of the extreme length on the waterline at the scantling draught.

15. **Normal mode** means the condition in which the ship's propeller output and all other machinery are operated under contractual normal seagoing conditions.

16. **Quiet mode** means the condition in which the ship's propeller output and all other machinery are operated under the adjusted operation conditions of the ship's propellers to operate in environmentally sensitive areas (i.e. underwater noise control areas). In the case of measuring underwater noise in quiet mode, the operating conditions of propeller output and other machinery are to be specified in the underwater noise measurement plan.

17. **Research mode** means the condition in which ship's propeller output and all other machinery are operated under the set conditions for marine or shipboard research. In the case of measuring underwater noise in research mode, the operating condition of propeller output and other machinery are to be specified in the underwater noise measurement plan.

18. **Seismic survey mode** means the condition in which ship's propeller output and all other machinery are operated under the set conditions while conducting surveys of underground structures and seismic activitiy. In the case of measuring underwater noise in seismic survey mode, the operating conditions of propeller power and other machinery are to be specified in the underwater noise measurement plan.

19. **Thruster mode** means the condition in which ships are operated using DP and/or thrusters that frequently utilize DP (Dynamic Position) and/or thrusters for voyage and operation of the ship are operated using DP and/or thrusters.

20. **A-weighted sound pressure level** is the quantity measured by a sound level meter in which the frequency response is weighted according to the A-weighting curve, obtained by using the frequency weighting A(dB(A)) which is the unit of external airborne noise level(see IEC 61672-1). The A-weighted sound pressure is corrected so that the measured sound pressure of each frequency gives the same magnitude to the human hearing in consideration of the sensitivity of hearing for each frequency felt by humans.

103. Class notations *(2024)*

1. Underwater noise(URN)

(1) Ships whose owner applies for inspection and that meet the requirements of **Ch 3** may be assigned additional classification notations of "**URN**" as follows.

(A) **URN(NXX):** ships which satisfies the criteria for normal mode. Here, N represents normal and XX represents the ship speed (knots) in still water corresponding to the propeller output at normal mode.

(B) **URN(QXX):** ships which satisfies the criteria for quiet mode. Here, Q represents quiet and XX represents the ship speed (knots) in still water corresponding to the propeller output at quiet mode.

(C) **URN(RXX)**: ships which satisfies the criteria for research mode. Here, R represents research and XX represents the ship speed (knots) in still water corresponding to the propeller output at reseach mode.

(D) **URN(SXX)** is the notation for seismic survey mode. Here, S represent seismic and XX repre-

sents the ship speed (knots) in still water corresponding to the propeller output at seismic survey mode.

(E) **URN(THR)** is the notation for thruster mode. Here, THR represents thruster.

(2) Additional classification notation of URN may be assigned together when the acceptance criteria for each mode in **Ch 3, Sec.6** are satisfied, respectively. For example, **URN(NXX, QXX)** may be assigned when the ship satisfies the acceptance criteria **URN(NXX)** and **URN(QXX)**.

2. Airborne noise(ARN)

(1) Ships whose owner applies for inspection and that meet the requirements of **Ch 4** may be assigned the additional classification notations of "**ARN**" as follows.

(A) For sailing: **ARN(S1)**, **ARN(S2)**

(B) For berthing: **ARN(B1)**, **ARN(B2)**

(2) **ARN(SM)** and **ARN(BM)** may be assigned when ARN of the ship is measured but does not meet the acceptance criteria. Here, **M** indicates that ARN of this ship was measured.

(3) Additional classification notation of ARN may be assigned together when the acceptance criteria for sailing and berthing are satisfied, respectively. For example, **ARN(S1, B2)** may be assigned when the ship satisfies the acceptance criteria **ARN(S1)** and **ARN(B2)** respectively. In addition, **ARN(SM, B2**) may be assigned when ARN for sailing is measured and ARN for berthing meets the acceptance criteria **ARN(B2)**.

Section 2 Plans and Documents

201. General

1. For ships to be inspected, the noise measurement plan specified in **202.** below is to be submitted to the Society for approval. In addition, after the noise measurement in the presence of the Surveyor of the Society has been carried out, a report of the measurement results specified in **202.** below is to be submitted to the Society for approval. If deemed necessary by the Society, the submission of additional documents may be requested.

202. Plans and documents to be submitted *(2024)*

1. Underwater noise (URN)

(1) Measurement Plan

A detailed measurement plan developed for the measurement of the underwater noise levels of the ship prior to the measurement. The plan is to include the following.

(A) Ship Information and Identification of Participants

(a) Ship information, including ship's name, IMO number, etc., as well as the ship's main dimensions

(b) Identification of participants, including person in charge of test, owner representative, shipyard representative and test personnel

(B) Measurement Test Site

(a) Geographical location, water depth and sea bottom conditions

(b) Wind speed and sea surface conditions for planned tests

(c) Weather conditions (Weather conditions are to be predicted based on a reliable weather forecast web site/service.)

(C) Measurement System

(a) Hydrophones (number, type and model) and deployment (method and hydrophone depths, including sketches to show the deployment configuration)

(b) Distance measurement system

(c) Calibration plans and current calibration certificates of all measurement instruments

(d) Detailed information of data acquisition and recording system to be used

(e) Acoustic calibrator

(D) Sea Test

(a) Description of measurement procedure

(b) Test agenda including test schedules, a description of the planned test courses (including sketches to show the sailing course and identification of the closest point of approach and various starting and ending points) and the operating profile which includes the speed, and loading condition of the test ship for each test course

(c) Methods to be used for monitoring the test site environment, checking the ship operation conditions and other auxiliary measurements

(E) Post Processing/Analysis

(a) Description of post processing and analysis procedures of measured underwater sound data

(b) Methods for evaluating the measurement uncertainty

(2) Measurement Report

A ship-specific underwater noise measurement report containing test information, description of data processing, analysis of measured underwater sound data and compliance evaluation against applicable criteria. The report is to contain the following.

(A) Introduction

(a) Objective of Measurement

(b) Ship Characteristics

(ⅰ)Ship Particulars

(ⅱ)Propulsion Characteristics

(ⅲ)Propeller Information

(c) Underwater Noise Criteria

(B) Underwater Noise Measurement

(a) Measurement Protocol

(b) Test Period and Site

(ⅰ)Location and Time of Measurement

(ⅱ)Environmental Conditions

(c) Instrumentation

(ⅰ)Hydrophones and Signal Conditioning (Calibration of Hydrophones)

(ⅱ)Distance Measurement System

(ⅲ)Data Acquisition/Processing System (Data Sampling Rate)

(d) Test Course and Maneuvering Configuration

(ⅰ)Nominal Closest Point of Approach

(ⅱ)Test Course and Test Runs

(ⅲ)Ship Operating Conditions

(ⅳ)Background Noise Measurements

(ⅴ)Measurement Procedure

(e) Other Auxiliary Measurements and Data

(f) Deviations from Approved Measurement Plan

(g) Data Sheet with Surveyor Signature

(C) Data Processing

(a) Data Processing Procedure

(b) Data Quality Assessment

(c) Background Noise Adjustments

(d) Distance Adjustments

(D) Decidecade Band Data Analysis

(a) Results for Each Hydrophone and Each Test Run

(b) Results for Multiple Hydrophones and Multiple Runs

(c) Verification against Defined Criteria

(E) Narrow-band Analysis (if applicable)

(F) Summary

2. Airborne noise (ARN)

(1) Measurement Plan

A detailed measurement plan developed for the measurement of the airborne noise level from ship prior to the measurement. The plan is to include the following.

(A) Ship information

(a) Ship information, including ship's name, IMO number, etc., as well as the ship's main dimensions

(B) Measuring equipment

(a) Details of the microphone (or sound level meter), windscreen, sound pressure calibrator and distance measurement system (e.g. manufacturer, type and serial number, accuracy, sampling frequency and resolution)

(b) Calibration plans and current calibration certificates of all measurement instruments

(C) Measurement Condition

(a) Details of test site location.

(b) Wind speed and sea surface conditions for planned tests
(c) Operating condition of essential devices for sailing or/and berthing (e.g. operating condition of main engine, shaft speed(rpm) and setting of controllable pitch propeller, operating condition of auxiliary engines and auxiliary machinery)

(D) Measuring location
(a) Location information of the vessel and the measuring point where the measurement is to be performed
(b) Details of the measurement location

(E) Data acquisition and analysis
(a) Description of procedures for data acquisition and analysis
(b) Information on software and devices

(2) Measurement result report

A ship-specific ARN measurement report containing test information, description of data processing, analysis of measured sound pressure data and compliance evaluation against applicable criteria. The report is to include the following.

(A) General
(a) The report is to be prepared in pdf format and submitted to the Surveyor of the Society.
(b) All measured data (raw data) and evaluated data should be available for further evaluation and will be provided to the Society upon request.
(c) All data is to be recorded at a minimum of 31.5 Hz to 8,000 Hz (10 Hz to 10 kHz, if possible) at 1/3 octave band level and at broadband level including 1/3 octave band.

(B) Official details of the report
(a) First page
(i) The first page must contain at least the following information.
- Ship name, IMO number
- Company name (measurement performed)
- Address of the company
- Report date
- Date of measurement
- Measurement location (port and pier name)
- Name of the person involved (author and measurement individual)
- Information on the total number of pages in the report, including appendices
- (Optional) quality procedure items

(b) Continuous information on the next page
(i) All pages after the first page are to contain the following information.
- Company name
- Date
- Numbering

(c) Signature
In general, the report is to be signed by its supervisor.

(C) Content to be documented in the report
(a) General information
(i) Day, time and place of measurement (test site, port name or berth name)
(ii) Meteorological conditions during measurements (including wind speed, wind direction, temperature, barometric pressure, humidity). This information shall preferably be requested from the ship owners/crew (measurement data from the ship itself)

(b) Ship's general information
(i) Ship type
(ii) Name of ship including IMO number
(iii) Year of built of the ship
(iv) Dead weight tonnage
(v) Length and width of the ship
(vi) Sketch of the ship's contour, indicating relevant sound sources, the position of the funnel outlet(s), bow and stern of the ship;

(c) Ship's technical information
(i) Number of auxiliary engines (including number and type of different auxiliary engine systems; number of funnel outlets)
(ii) The existence of a silencer in the exhaust system of the auxiliary engines
(iii) Maximum possible load of each auxiliary engine in kW
(iv) Rotational speed of the auxiliary engine(s) in maximum possible load

(v) Maximum combined electric load of all pumps/heaters/lights etc. installed that could be used while moored in kW
(vi) Number of each sound source on board (e.g. number of openings from the different ventilation inlets and outlets, number of cooling containers/reefers on board)
(vi) Maximum possible number of plugged in reefers
(vii) Typical average number of reefers at berth
(viii) Average electrical load that normally occurs while moored

(d) General information on the measurements
(i) Number of each sound source on board that was in operation during the measurements
(ii) Electrical load of each auxiliary engine during the measurements, preferably documented over time.
(iii) Number of plugged in reefers during the measurements
(iv) Sketch of the measurement positions at a certain distance from the ship with respect to the ship contour and orientation of the ship (bow and stern), including the position of the funnel outlet
(v) Height of the funnel above quay ground
(vi) Height of the microphone at the measurement positions at a certain distance from the ship above quay ground (h_m)

(e) Acoustic information
(i) Acoustic measurement equipment used during measurement (including type, serial number and calibration documents before/after measurement)
(ii) All recorded time signals including the ship name, date of measurement and time of measurement location (which is a sampling rate of at least 16 bits and a sampling frequency of 24 kHz.
(iii) For each measured sound source (measurement of noise emission from ship)
- L_{Aeq}: equivalent A-weighted continuous sound pressure level
- L_{Ceq}: equivalent C-weighted continuous sound pressure level
- $L_{AF,\max}$: Maximum sound pressure level during the measurement period

(iv) The total broadband ARN level (L_{ARN}) of the ship (including all 1/3 octave bands from 31.5 Hz to 8,000 Hz)
(v) The total low-frequency ARN level ($L_{ARN\leq 160}$) of the ship (including all 1/3 octave bands from 31.5 Hz to 160 Hz)

(f) Additional information
(i) Type (and recorded level) of residual noise/background noise (e.g. what kind of sources causing residual noise were present during measurements and at which time; for example passing ships and air planes, port noise etc.)
(ii) In addition, each deviation from the measurement plan needs to be documented. Including sketches if possible. Any comments and information regarding reproducibility or adjustments to the results of the noise measurement should be documented at the end of the report. This includes any problems encountered during the measurement and is relevant to the report.

CHAPTER 2 CLASSIFICATION SURVEYS

Section 1 General

101. General

1. The requirements not specified in this Chapter are to comply with those specified in **Pt 1** of **Rules for the Classification of Steel Ships**.

Section 2 Classification *(2024)*

201. General

1. In cases where a ship is to be surveyed in accordance with the Guidance, it is the responsibility of the Owner to notify Surveyors of the locations where they wish to undergo the relevant survey.
2. Applicants for surveys are to make necessary preparations to conduct radiated noise measurement in accordance with the requirement of this guidance.
3. Surveys may be suspended in cases where necessary preparations have not been made, no appropriate supervisor is present, or the Surveyor considers that the safety needed for the execution of the survey is not ensured.
4. In cases where the survey results do not satisfy the requirements of this Guidance, Surveyors are to notify survey applicants of the results.

Section 3 Periodical Surveys

301. On board installation and operation survey

1. Periodical Surveys are to be carried out at the Annual Survey, Intermediate Survey and Special Survey.
2. During Periodical Surveys, the non-existence of any alternations which may affect the radiated noise level is to be confirmed. Additional radiated noise measurements may be required in cases where deemed necessary by the Society in order to ascertain whether the relevant requirements given in this Guidance are satisfied.

Section 4 Occasional Surveys

401. Annual Surveys

1. Occasional Surveys are to be carried out on the following occasions at times other than Initial Surveys or Periodical Surveys:
   (1) In cases where any conversion affecting the radiated noise of a ship are carried out.
   (2) In cases where any applications for surveys are submitted by owners.
2. Occasional Surveys are to be carried out and radiated noise levels are to be confirmed as complying with those specified in this Guidance. ⚓

CHAPTER 3 UNDERWATER NOISE *(2024)*

Section 1 General

101. General

1. The measurement and result analysis are to be performed in accordance with the requirements in **Sec.2** to **Sec.5**, and the criteria specified in **Sec.6** are to be satisfied.
2. Measurement of underwater noise is to be performed by the service supplier registered with the Society.

Section 2 Instrumentation

201. General

1. In order to quantify the underwater noise from a ship, main instrumentation is to be in accordance with the requirements in **202.** to **206.**.

202. Hydrophone and signal conditioning

1. The hydrophone is to have the sensitivity, bandwidth and dynamic range necessary to measure the ship under test.
2. For underwater noise measurement, three hydrophones that should be omni-directional across the required frequency range of 10 Hz to 100,000 Hz are required.
3. The receiving voltage sensitivity (RVS) of a hydrophone relates the hydrophone voltage output to the measured sound pressure level. A maximum uncertainty of this sensitivity of ± 2.5 dB within the frequency range of the measurements is to be observed.

203. Data acquisition, recording, processing and display

1. The data acquisition, recording, processing and display system are to be capable of accurately acquiring, recording, processing and displaying data from the hydrophones.
2. These systems are to comply with the requirements of ISO 17208 series.

204. Distance measurement

1. Distance measurement is required to continuously determine the actual distance between the hydrophones and the ship reference point of the ship under test.
2. The distance measurement systems are to determine the horizontal distance from the sea surface position above the hydrophones (i.e. the device or buoy used to suspend the cable) to the ship reference point of the ship under test. The distance measurement device may utilize any method (e.g. optical, acoustical, GPS, radar) to achieve the required accuracy.
3. The distance measurement system is to be accurate in 10 m. Distances are to be measured with an accuracy of ± 10 m. The use of DGPS (Differential Global Positioning System) is strongly recommended.
4. Tilt angle measurements of the hydrophone array line are recommended to optimize the accuracy.

205 Water column speed properties

1. To be able to calculate the propagation loss via numerical modelling, the celerity profile of the water column needs to be ascertained.

2. This is to be performed using either a CTD (conductivity, temperature, depth) measurement device or via a direct sound speed sensor.
3. Onsite direct propagation loss measurements covering the whole range of frequencies for the test is an acceptable alternative to modelling.

206. Instrumentation Calibration

1. Calibration of underwater acoustic measurement equipment is to be carried out using IEC 60565-1.
2. The calibration of hydrophones is to be undertaken by an external recognized organization every 24 months at maximum and as recommended by the hydrophone manufacturer.
3. In addition, an in-situ check of the whole system using a dedicated calibrator (e.g., pistonphone) is to be performed prior and after the measurements. This calibrator is to be calibrated every 12 months at maximum.
4. The data acquisition system is to be checked by an external recognized organization every 24 months at maximum.
5. The measuring celerity profile device is to be calibrated every 24 months at maximum.

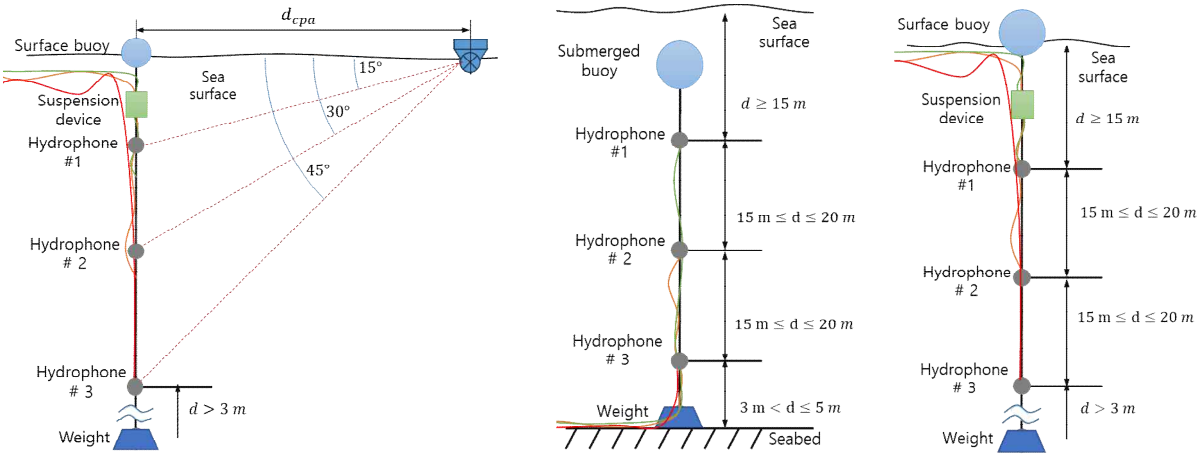
Section 3 Measurement Procedure

301. General

1. In order to perform an accurate measurement of a ship's underwater sound, several factors are to be addressed correctly, e.g. selection of an appropriate test site, proper deployment of hydrophones and proper operation of the ship under test.

302. Hydrophone deployment

1. Hydrophones are to be deployed as shown in **Figure 3.1** depending on required d_{cpa} and water depth of the test site for underwater noise measurement.
2. It is recommended that the hydrophone array incorporate a vertical line linked to a free-floating surface buoy decoupled from the sea surface (as shown in (1)① of **Figure 3.1**). The hydrophone array is not to be directly coupled to a support vessel not only to limit potential noise disturbances caused by the vessel behaviour but also to prevent masking from occurring. Additional mooring features (e.g. hardware swell compensation device) are also to be considered when appropriate.
3. The hydrophone line is to be bottom anchored. A free-floating line/array is acceptable when water depths prevent the deployment of bottom anchored lines (as shown in (2) of **Figure 3.1**).
4. The hydrophone vertical array line location should be broadcast via AIS equipment to ensure more accurate distance adjustments for CPA and safer measurement runs. If required by marine regulatory authorities, proper functioning of the AIS transponder is to be confirmed for identification on navigation e-charts.
5. The vertical arrangement of hydrophones is to ensure measurement of the beam aspect of the tested vessel at CPA. The arrangement is to be reported.
6. A minimum of three hydrophones on a single line array is to be used.



(1)① surface-suspended

(2)① bottom-anchored (recommended)

(2)② surface-suspended

(1) For water depth greater than d_{cpa}

(2) For water depth smaller than d_{cpa}

Figure 3.1 Deployment of hydrophones

303. Data acquisition and recording

1. The instrumentation set-up is to ensure, during the test runs, the synchronous acquisition, recording and processing of:
   (1) sound pressure measurements from hydrophones
   (2) distance between tested vessel and hydrophones
   (3) tested ship speed over ground
2. The Nyquist sampling theorem states that the sampling rates of the acoustic data is to be greater than twice the upper frequency of interest below.
3. Other measurement values (calibration checks, etc.) are to be recorded.
4. The measurement frequency range shall cover, in decidecade bands, the bandwidth 10 Hz – 50,000 Hz. For research vessels, the bandwidth is required to be 10 Hz – 100,000 Hz as per ICES "Cooperative Research Report No.209", May 1995.

304. Ship operation and test sequence

1. The main propulsion and auxiliary machinery conditions are to be set up according to the conditions as specified in the approved measurement plan. The operating conditions are to be verified by the Surveyor.
2. The hydrophones and measuring instruments used in the data acquisition system are to be calibrated prior to the underwater noise measurements. The relevant instrumentation reference calibration certificates, together with the results of the field setup and calibration check are to be provided to the Surveyor.
3. The recognized service supplier for underwater noise measurement is to verify that all the measurement systems for carrying out the underwater noise measurement are put in place and are functioning correctly.
4. At the start and the end of each measurement test run, the background noise measurement is to be carried out and recorded for at least 1 minute with the ship under test located at the farthest distance or at a distance of at least ≥ 2,000 m from the hydrophones, with the same hydrophone deployment and data acquisition methods.
5. During the recording of the background noise measurement, all main engines and generators are to operate only in idle conditions.
6. After the completion of the background noise measurement, the ship under test is to proceed to

operate at the prescribed operating condition as specified in the approved measurement plan. The operating conditions such as the main and auxiliary engine output, ship speed, propeller RPM and nominal pitch, and loading condition are to be recorded accordingly.

7. Before the acoustic center of the ship reaches the COMEX(start position of test range), the intended operating conditions of the ship under test are to be achieved. Between the COMEX and the FINEX(end posistion of test range), the direction and ship operating conditions are to remain the same.

8. The ship under test is to pass a straight course to achieve the required distance (d_{CPA}) at closet point of approach. d_{CPA} is 200 m or one ship length, whichever is larger. For ships with length less than 200 m, a minimum distance of 100 m can be accepted.

9. Recording of data is to be performed during the test range between (1) and (2) below. (as shown in **Figure 3.2**)

(1) a minimum of 800m before the fore end of the vessel reaches the CPA; this defines the COMEX, to

(2) a minimum of 800m after the aft end of the vessel has passed the CPA; this defines the FINEX.

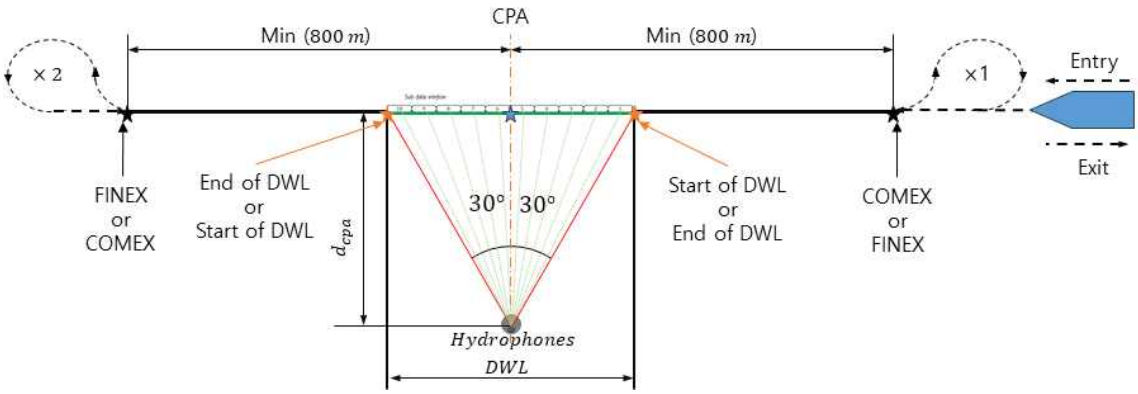


Figure 3.2 Test and Data window arrangement

10. During the test range, distance measurements between ship reference point and hydrophone alley are to be recorded for the ship under test. These include the distance (d_{CPA}) at the closest point of approach, horizontal distance from the ship reference point to each hydrophone and the vertical distance between the depth of each hydrophone and the sea surface.

11. The ship under test is to make a "Williamson Turn" after passing FINEX, where the ship will maneuver and prepare for the next set of runs on the alternate side of the ship repeating the measurement procedure from **4** to **10**.

12. A complete test course requires the ship under test to perform two repeated runs (with alternating approach) on each the port and starboard side of the ship under the same operating conditions.

13. If two lines of three hydrophones are used to measure port and starboard simultaneously, the number of runs may be reduced to two.

Section 4 Measurement Condition

401. General

1. Sea trials are to be carried out with the ship in loaded or ballast condition. The actual condition during the measurements is to be recorded on the measurement report.

2. When measuring underwater noise in shallow seas, the minimum water depth is to be the greater of 60 m or $0.3v^2$, where v = ship speed over bottom in m/s.

3. Measurements are to be taken under conditions of Sea State 3 or less, as defined by Sea State Code of the World Meteorological Organization (WMO) and of Beaufort wind force scale 4 or less. Rainy conditions are to be avoided due to background noise generation. If this cannot be achieved, the actual conditions are to be recorded on the measurement report.
4. Measurements are not to be undertaken when/where currents exceed 2 m/s and/or potential tidal current impacts be assessed accordingly.
5. In the case of reciprocal speed trial runs, a trial area is best avoided where the change of the current speed within the timespan of one double run is greater than 0.5 knots. Conducting testing around slack tide is ideal. Actual current information such as speed, direction, and tide related data is to be recorded on the measurement report.
6. The nature, including its characteristics and bathymetric topology, is to be recorded, if applicable. The seabed topography should be level (± 10 % depth variations are permissible) and flat.
7. Background noise is to be minimized as much as possible. The test site is to be as far as possible from vessel traffic lanes, port in/out lanes, marine works such as dredging, pile driving, fishing or diving zones, seismic exploration, mine clearing activities or coastal civil engineering works.
8. Ship's course has to be kept constant, with rudder angle less than 2 degrees from neutural position, for the duration of the measurement. If ship maneuvering is need, measurements are to be stopped until recovery of heading.
9. All machinery essential for ship operation is to operate under conditions specified in approved measurement plan throughout the measurement period. The list of machinery and equipment that are to operate normally during the measurement period is limited to the installed equipment.
10. Any deviations from operating conditions specified in the approved measurement plan is to be recorded in the measurement report.

402. Normal mode

1. During measurement, the propeller output is to be the normal seagoing speed of ship or at least 85 % of the maximum continuous rating (MCR) of the main engine.
2. Controllable pitch and Voith-Schneider propellers, if any, are to be in the normal seagoing position. For ships with special propulsion and power configurations, such as diesel-electric systems, the actual ship's design or operating parameters as defined in the ship's specifications will be used and are to be recorded on the measurement report.

403. Quiet mode, research mode, seismic survey mode

1. During measurement, the propulsion system (conventional propeller, controllable pitch propeller, Voith-Schneider propeller, etc.) is to be maintained in the operating condition specified in the approved measurement plan.
2. For vessel that need to be tested under towing conditions, the vessel should tow actual equipment or an alternative structure with a towing load equivalent to the towing loads calculated by simulation. Towing load calculation are to be submitted to the Society.
3. If the ship speed in knots are not specified in the measurement plan, the test vessel should be set to the propeller output corresponding to the following ship speed in still water.
   (1) for quiet mode: 11 knots
   (2) for research mode: 11 knots
   (3) for seismic survey mode: 5 knots.

404. Thruster mode

1. During measurement, the test vessel is to be operated at least 40% of the rated DP and/or thruster power, and no propulsion system other than DP and/or thrusters is to be operated.

Section 5 Data Post-processing

501. General

1. The data is to be post processed following the ordering/scheme of **Figure 3.3** below, where represents:
   (1) the k-th run,
   (2) the j-th sub data window, and
   (3) the i-th hydrophone.

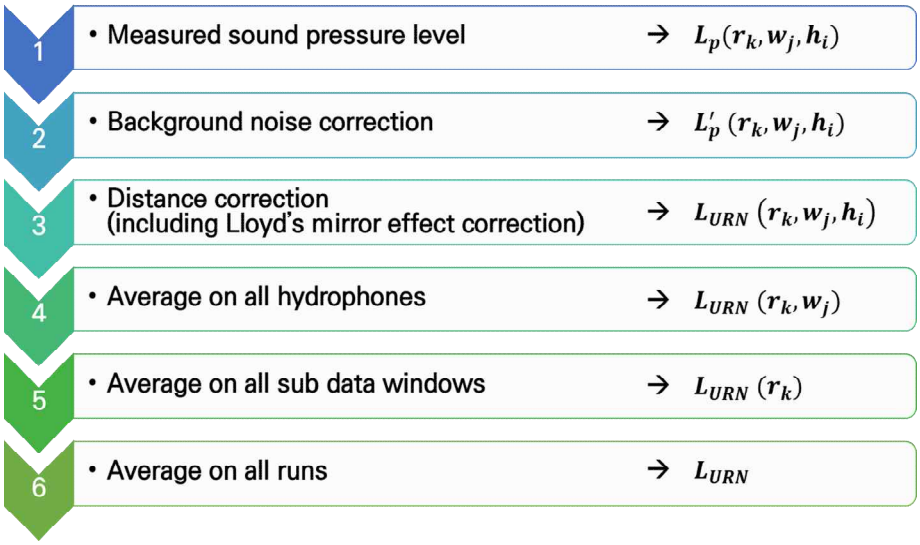


Figure 3.3 Data post-processing scheme for hydrophones, sub data windows, and test runs.

2. Raw time series measurements are to be recorded in order to be permit post trial detailed analysis including data correction, narrow band analysis as deemed necessary.
   (1) The start of data window is to occur at −30° (as shown below in Figure 6.2) from the hydrophones-CPA line
   (2) The end of data window is to occur at +30° (as shown below in Figure 6.2) from the hydrophones-CPA line
3. The underwater sound pressure measured at each hydrophone and recorded during the test range is to be collected while the ship reference point is within the data window, as shown in **Figure 3.4**, and analyzed by dividing it into 10 sub data windows. Each of the sub data windows is to be sized as evenly as possible.

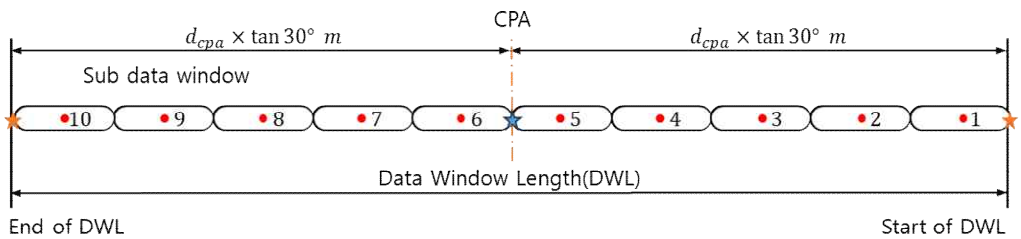


Figure 3.4 Configuration of Data Window

4. The middle instant of a sub data window is reached when the acoustic center of the vessel is superimposed with the center of this window.

5. For each sub data window, a root-mean-square linear averaged decidecade band spectrum of the measured underwater sound pressure level is to be performed for every hydrophone and recorded.
6. The data post-processing described in **502.** through **504.** is to be performed per decidecade band.

502. Background noise adjustments

1. Each root-mean-square linearly averaged decidecade band spectrum is to be corrected for background noise according to the following procedure for each hydrophone.
2. In detail the process is as follows:
   (1) Calculate the arithmetic mean (linear average) of the sound pressure level measured for the hydrophone(h_i) prior to and after ship test runs. This is the background noise.
   (2) Calculate the variation of background noise between the start and end of runs.
   (3) Calculate signal-plus-noise-to-noise level difference(ΔL) for each run (r_k), sub data window (w_j) and hydrophone (h_i).

$$\Delta L(r_k, w_j, h_i) = L_{p_{s+n}}(r_k, w_j, h_i) - L_{p_n}(h_i)$$

ΔL : signal-plus-noise-to-noise level difference for each decidecade band (dB)
$L_{p_{s+n}}$: root-mean-square sound pressure level with ship under test present for each run (dB)
L_{p_n} : background root-mean-square sound pressure level with the ship under test not influencing the measurement away 2,000 m from hydrophones (dB)

   (4) If $\Delta L \geq 3\ dB$, the measurement can be considered acceptable with regards to the background noise. The following correction is to be applied:

$$L_p'(r_k, w_j, h_i) = 10\log\left[10^{\left(\frac{L_{p_{s+n}}(r_k, w_j, h_i)}{10}\right)} - 10^{\left(\frac{L_{p_n}(h_i)}{10}\right)}\right]$$

L_p' : background noise adjusted root-mean-square sound pressure level of the ship under test (dB)

   (5) If $\Delta L < 3\ dB$, the result of the measured underwater sound pressure level may be considered as invalid data, and the effectiveness of the data is to be evaluated on a case-by-case basis by the Society

503. Distance adjustments

1. In order to obtain the underwater noise level (L_{URN}) at a reference distance of 1 m from the noise source, the propagation loss (N_{PL}) in water should be considered. The underwater noise levels, including the Lloyd's mirror effect correction, are to be calculated and reported.
   (1) The propagation loss ($N_{PL}(r_k, w_j, h_i)$) should be calculated through modeling augmented with on-site actual water column properties using CTD measurement device or a sound speed sensor for each run (r_k), data window (w_j) and hydrophone (h_i).
      (A) It is recommended to calibrate the model with a series of measured propagation losses with a controlled active source (known calibrated source level and known signal, recommended 4s-LFM-type signal, in the minimum frequency band 50 Hz - 20 kHz) at CPA, COMEX and FINEX. The model is be consistent with those propagation losses by adjusting the geo-acoustic parameters (compressional speed (m/s), density, compressional absorption) to minimize the difference between the model and the measured propagation losses. Differences and the best geo-acoustic parameters are to be reported.
      (B) To take into account that the vessel is a moving noise source, the modelling propagation loss may be range-average smoothed.
      (C) For the calculation of propagation loss, the following numerical modeling methods are recom-

mended:
(a) Parabolic equation model: For low-frequency bands below 1kHz
(b) Ray theory model: For high-frequency bands above 1kHz

(D) The model should be run for each window (w_j), each hydrophone (h_i), and each frequency between 10 Hz and 50 kHz.

(E) The model should be run with the following information:
(a) Source depth: depth of the acoustic center
(b) Hydrophone depth: each hydrophone(h_i) depth
(c) Range: Horizontal distance between the acoustic center and each hydrophone (h_i)
(d) Sound speed profile: As recommended in **205**., the sound speed profile should be measured and reported from the CTD measurement device or a sound speed sensor. Alternatively, the information should be obtained from operational oceanography services at the day of the measurement or at the closest date and place from the actual measurement.
(e) Bottom geo-acoustic parameters should be adjusted from the propagation losses specified in (A) above. Alternatively, it would be obtained from bottom geo-acoustic databases. The model is to be consistent with those propagation losses and this model calibration shall be reported.
(f) Sea-surface roughness should be modelled with the assumption of flatness (Hrms= 0 m).
(g) Bathymetry: Bathymetry between acoustic center and hydrophone (h_i) issued from databases such as GEBCO, EMODNet, or local bathymetric map.
(h) Frequencies: The model is to be run for a minimum of 3 frequencies in each decidecade bands.

(F) The result of the modeled propagation loss should is averaged for above frequencies of each decidecade band.

(2) If it is not practical to follow above (1), the propagation loss may be calculated with the following simple propagation law and correction factor.

$$N_{PL} = X\log\left(\frac{d_{Total}}{d_{ref}}\right) + \Delta_{LME}$$

$$d_{Total} = \sqrt{d_{vertical}^2 + d_{horizontal}^2}$$

$d_{vertical}$: the vertical distances from the sea surface to each hydrophones, i.e., water depth of hydrophone (m)

$d_{horizontal}$: the horizontal distances from each center of sub data window to each hydrophones (m)

d_{ref} : reference distance (=1 m)

X : 19 for water depth $<$ 100 m, 20 for water depth $\geq$ 100 m

Δ_{LME} : correction factor considering the Lloyd's mirror effect as per ISO 17208-2.

2. The underwater noise level (L_{URN}) for each measurement run (r_k), sub data window (w_j) and hydrophone (h_i) is determined by the following equation.

$$L_{URN}(r_k, w_j, h_i) = L_p'(r_k, w_j, h_i) + N_{PL}(r_k, w_j, h_i)$$

504. Determination of the final underwater noise level

1. The level of underwater noise for each measurement run and sub data window is determined by the following equation.

$$L_{URN}(r_k, w_j) = 10\log\left[\frac{1}{3}\sum_{h=1}^{3} 10^{\frac{L_{URN}(r_k, w_j, h_i)}{10}}\right]$$

$L_{URN}(r_k,w_j)$: the underwater noise level for each run (r_k) and each sub data window (w_j)

2. The underwater noise level for each run is determined by the following equation.

$$L_{URN}(r_k) = \frac{1}{10}\sum_{j=1}^{10} L_{URN}(r_k,w_j)$$

$L_{URN}(r_k)$: the underwater noise level for each run (r_k)

3. The final underwater noise level of the ship under test is determined by the following equation.

$$L_{URN} = \frac{1}{4}\sum_{r=1}^{4} L_{URN}(r_k)$$

L_{URN} : the final underwater noise level for ship under test ($dBre\,1\mu Pa@1m$)

Section 6 Criteria

601. General

1. The final underwater noise level of ship under test calculated in **504. 3** are to satisfy the acceptance criteria of underwater noise level for the relevant operating mode in accordance with **Table 3.1** and **Figure 3.5**.

2. The underwater noise level is assessed for each decidecade band, and the allowable criteria for the underwater noise level in each band are calculated based on the center frequency (f_c) of the band. ⚓

Table 3.1 Acceptance criteria of underwater noise level (dB)

Center Frequency (f_c) range	Normal mode NXX(1)	Quiet mode QXX(1)	Research mode RXX(1)	Seismic Survey mode SXX(1)	Thruster mode THR
10 Hz ~ 100 Hz	-5log(f_c/10) +178	-3log(fc/10)+168	-4log(fc/10)+149.5	168	-
100 Hz ~ 315 Hz	-5log(f_c/100)+173	-3log(fc/100)+165	+8.5log(fc/100)+145.5	168	-
315 Hz ~ 1k Hz	-5log(f_c/100)+173	-3log(fc/100)+165	+8.5log(fc/100)+145.5	-	-
1k Hz ~ 50k Hz	-12log(f_c/1000)+168	-12log(fc/1000)+162	-12log(fc/1000)+154	-	-12log(fc/1000)+165
50k Hz ~ 100k Hz	-	-	-12log(fc/1000)+154	-	-

note
(1) XX means the ship speed (knots) corresponding to the propeller output for each operation mode of the ship under test and rounded off to the nearest decimal point.

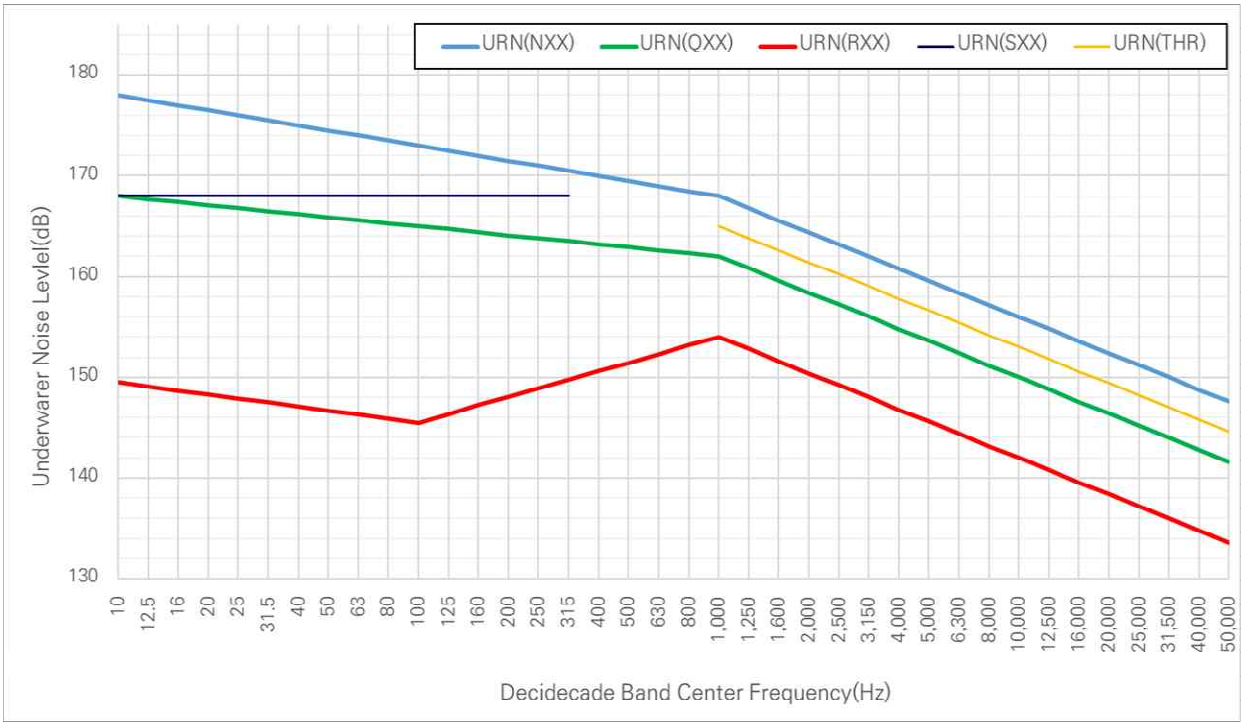


Figure 3.4 Acceptance criteria of underwater noise level (graph)

CHAPTER 4 AIRBORNE NOISE *(2024)*

Section 1 General

101. General

1. The measurement and result analysis are to be performed in accordance with the requirements in **Sec 2** to **Sec 5** and the criteria specified in **Sec 6** are to be met.
2. Measurement of ARN is to be performed by the service supplier registered with the Society.

102. Sound source on board of the ships

1. The overall sound emission from each ship can be traced back to several individual sound sources on board of the ship. The most relevant noise sources to be measured are listed below but not limited to.
   (1) The funnel outlet(s) of main and/or auxiliary engines
   (2) The opening(s) of engine room ventilation inlets and outlets
   (3) The opening(s) of the cargo holds ventilation and air-conditioning inlet(s) and outlet(s).
   (4) The opening(s) of the ventilation and air-conditioning of passenger rooms
   (5) Additional relevant ventilation openings (e.g., sanitary or galley exhaust).
   (6) Cargo loading and unloading facilities
2. The operation of cooled containers/reefers on container ships strongly depends on several indicators, including the (cooling) type of the container, the type and size of the ship, the ships load, and port conditions. Furthermore, their operation is also part of the cargo handling process of a ship at berth. Therefore, cooled containers/reefers are not considered for measurements and will not be considered in the calculation of the total sound pressure level of the measured ship in this Guidance.

Section 2 Instrumentation

201. General

1. In order to quantify the ARN from ships, main instrumentation is to be in accordance with the requirements in **202.**.

202. Instrumentation

1. The equipment for acoustic measurements must consist of the following equipment.
   (1) Integrating sound level meter with a microphone, (cable) and windscreen, in compliance with IEC 61672-1 and IEC 61672-2, class 1.
   (2) Acoustic calibrator in compliance with IEC 60942, class 1
2. The microphones need to be equipped with a windscreen (diameter ≥ 6 cm) for each measurement.
3. The calibration of the measuring system needs to be checked with the sound calibrator before each measurement series.
4. For data post-processing, analysis software is required comprising the following methods.
   (1) 1/3 octave band analysis according to IEC 61672-1.
   (2) Frequency weighting, time weighting and averaging.
5. During all measurements the time weighting fast (F) is to be used.
6. Distance measuring system is to have an accuracy of 2 % with results from 10 to 600 m.
7. Acoustic measuring system and distance measuring system are to be checked for calibration certificate and valid calibration status during measurement.

Section 3 Measurement Location

301. General

1. Measurements are to be carried out taking into account the location of noise sources specified in **102. 1.** Additional measurements can be carried out as required by the Society in case of excessive noise level is identified.
2. Measurements are to be made at a distance of 100 m from the hull surface for at least 30 seconds. All measurement points are to be at least 4 m above sea surface or ground surface where the microphone is located.
3. Distance measurement is necessary to determine the distance between the vessel surface and the measuring point. If the measured distance differs from 100 m, it should be recorded and corrected during the data post-processing.

302. Airborne noise for berthing

1. The recommended distance between the hull side and the microphone is 100 m. If 100 m distance is not practical, measurement can be performed at a distance ranging from 80 to 120 m from the vessel. The side of the vessel is to be directly exposed to the microphone, and there should be no barrier or refecting surface between the noise source (vessel) and the receiver (microphone).
2. At least 4 noise measurements is to be taken on each side of the vessel (starboard and port). One measurement point corresponds to a location 100 m perpendicular to the ship's side from the position of the funnel outlet of auxiliary engines, and two points in the bow direction is to be at 1/4 and 1/2 points of the ship length (L), and one point at the 1/4 L point in the stern direction. However, in case of ships having a biased auxiliary engine outlet toward bow or midsection, the 1/2 L point in the bow direction may be adjusted to the 1/2 L point in the stern direction.
3. Background noise is to be measured before and after measuring ARN for each side of the ship. The background noise is to be at least 3 dB lower than that of each measurement point.

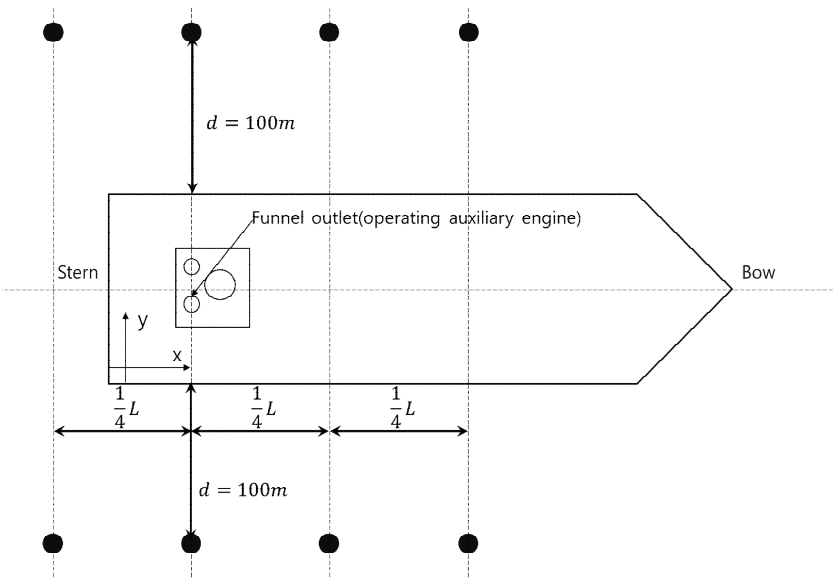


Figure 4.1 Measurement outline of ARN for berthing

303. Airborne noise for sailing

1. The ship under test is to pass a straight course to achieve the required distance (d_{CPA}) at closet point of approach (CPA). d_{CPA} which is the distance between hull surface and microphone is 100 m. To ensure the safety of ships and workers, if necessary, ARN may be measured at d_{CPA} greater than 100 m.

2. Recording of data is to be performed during the test range between (1) and (2) below. (as shown in **Figure 4.2**)
   (1) a minimum of 800m before the fore end of the vessel reaches the CPA; this defines the COMEX, to
   (2) a minimum of 800m after the aft end of the vessel has passed the CPA; this defines the FINEX.
3. Unless otherwise required by the approved measurement plan, the ship under test is to maintain a constant speed, fixed engine conditions and minimum use of helm to maintain course until it has passed the end test range location.
   (1) At the start and the end of each measurement test run, the background noise measurement is to be carried out and recorded for at least 1 minute with the ship under test located at the farthest distance or at a distance of at least ≥ 2,000 m from the microphones, with the same microphone and data acquisition methods.
   (2) After the completion of the background noise measurement, the ship under test is to proceed to operate at the prescribed operating condition as specified in the approved measurement plan. The operating conditions such as the main and auxiliary engine output, ship speed, propeller RPM and nominal pitch, and loading condition are to be recorded accordingly.
   (3) Before the ship reference point reaches COMEX, the intended operating conditions of the ship under test are to be achieved. Between the COMEX and the FINEX, the direction and ship operating conditions are to remain the same.
   (4) Distance measurements are to be recorded for the ship under test. These include the distance (d_{CPA}) at the closest point of approach, horizontal distance from the hull surface of the ship to each microphone.
   (5) The ship under test is to make a turn after passing the FINEX, where the ship will maneuver and prepare for the next set of runs on the alternate side of the ship repeating the measurement procedure from (1) to (4).
   (6) A complete test course requires the ship under test to perform two repeated runs each on the port and starboard side of the ship under the same operating conditions.

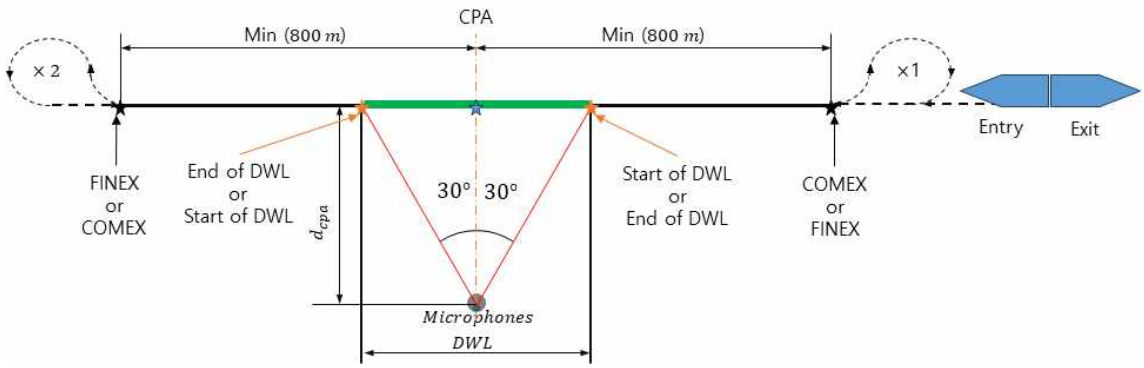


Figure 4.2 Arrangement of test and data window for sailing

Section 4 Measurement Condition

401. General

1. Sea trials are to be carried out with the ship in loaded or ballast condition. The actual condition during the measurements is to be recorded on the measurement report.
2. The main propulsion and auxiliary machinery conditions are to be set up according to the conditions as specified in the approved measurement plan. The operating conditions are to be verified by the Surveyor.
3. Measurements are to be taken under conditions of Sea State 3 or less. Wind velocity is to be below 7 m/s and measurements are to only be performed when no rain or snow is present.
4. The microphone and measuring instruments used in the data acquisition system are to be calibrated

prior to the ARN measurements. The relevant instrumentation reference calibration certificates, together with the results of the field setup and calibration check are to be provided to the Surveyor.

5. The recognized service supplier for ARN measurement is to verify that all the measurement systems for carrying out the ARN measurement are put in place and are functioning correctly.

6. Residual noise (or background noise) is to be avoided as far as possible in the vicinity of the measurement location, and measurements are not to be distorted by background noise and surroundings (eg. large reflecting surfaces).

402. Airborne noise for berthing

1. Throughout the measurements, the ship is to operate under the characteristic/normal load condition when at berth. It is to be ensured that the chosen load condition during measurements prevents the measured sound emissions from exceeding the levels observed at berth in any subsequent port of call (typically during high/maximum load conditions of the ship). It is important that the electric load is kept as constant as possible during all measurements.

2. To align the electric load of the auxiliary engine(s) with the representative load, consumers on board may need to be selectively switched on or off. The consumers that, in most cases, can be controlled manually include the following.
   (1) cargo hold fans,
   (2) engine room fans,
   (3) fans and air-conditioning of passenger rooms and
   (4) further fans on board.

3. Furthermore, the operating conditions during all measurements need to be documented in detail.

403. Airborne noise for sailng

1. In the case for ships confirmed to sail in sea areas within 1 km from inland or in coastal areas under separately defined operating conditions the operational conditions are to be explicitly specified in the measurement plan. If the operating speed is not specified in the approved measurement plan, the default operating speed is to set at 12 knots for container ships and car carriers and 10 knots for other type of vessels.

2. Ship's course has to be maintained steadily, with the rudder angle kept less than 2 degrees to portside or starboard throughout the measurement. If ship maneuvering is required. measurements are to be halted until the heading is restored.

3. All machinery essential for ship operation is to operate under normal conditions during the measurement period. The list of machinery and equipment that are to operate normally is restricted to the installed equipment.

4. Controllable pitch and Voith-Schneider propellers, if present, are to be in the normal seagoing position. For ships with special propulsion and power configurations, such as diesel-electric systems, the actual ship's design or operating parameters as defined in the ship's specifications will be used and are to be documented in the measurement report.

5. Any deviations from operating conditions specified in the approved measurement plan is to be documented in the measurement report.

Section 5 Data Post-processing

501. General

1. The measured sound pressure by a microphone is to be subjected to post-processing steps such as background noise adjustments and distance adjustments.

2. The data post-processing described in **502.** through **504.** is to be performed per 1/3 octave band in the range of 31.5 ~ 8,000 Hz.

502. Background noise adjustments

1. The difference (ΔL) between the measured sound pressure level ($L_{p_{s+n}}$) and background noise level (L_{p_n}) for each 1/3 octave band is determined by the following equation.

$$\Delta L = L_{p_{s+n}} - L_{p_n}$$

ΔL : signal-plus-noise-to-noise level difference (dB) for each 1/3 octave band

$L_{p_{s+n}}$: root-mean-square sound pressure level (dB) with ship under test present for each run

L_{p_n} : background root-mean-square sound pressure level with the ship under test not influencing the measurement away 2,000 m from microphones (dB)

2. The sound pressure level (L_p') of the ship under test is determined as follows depending on the magnitude of ΔL.

(1) For $\Delta L \geq 3$ dB

$$L_p' = 10\log\left[10^{\left(\frac{L_{p_{s+n}}}{10}\right)} - 10^{\left(\frac{L_{p_n}}{10}\right)}\right]$$

L_p' : background noise adjusted root-mean-square sound pressure level of the ship under test (dB)

(2) For $\Delta L < 3$ dB: The sound pressure level (L_p') may be considered as the same as the background noise level(L_{p_n}), and whether to use the data or re-measure airborne noise is to be discussed with the Society.

503. Distance adjustments

1. In order to obtain the sound pressure level at a reference distance of 100 m from the ship, the transmission loss (TL) due to sound wave transmission in the air should be considered.

$$L_p = L'_p + TL$$

$$TL = 20\log\left(\frac{d}{d_{ref}}\right)$$

d : the distance from the hull surface of the ship under test to the microphone (m)

d_{ref} : reference distance (=100 m)

504. Determination of the final airborne noise level

1. For the sound pressure level at the standard distance (100m) from the ship, airborne noise level per each 1/3 octave band is to be calculated according to the following procedure.

2. Calculate the average sound pressure level per each 1/3 octave band of airborne noise for berthing.

(1) The average sound pressure levels on the port and starboard sides are determined by the following equation.

$$L_{p,P,avg} = 10\log\left(\frac{1}{n}\sum_{k=1}^{n} 10^{\frac{L_{p,P}(k)}{10}}\right)$$

$$L_{p,S,avg} = 10\log\left(\frac{1}{n}\sum_{k=1}^{n} 10^{\frac{L_{p,S}(k)}{10}}\right)$$

$L_{p,P}(k)$: the sound pressure level for each measuring point (k) on port side

$L_{p,S}(k)$: the sound pressure level for each measuring point (k) on starboard side

n : the number of measuring point (k) on each side

(2) The average sound pressure level of the ship is determined by the following equation.

$$L_{p,1/3octave} = 10\log\left[\frac{1}{2}\left(10^{\frac{L_{p,P,avg}}{10}} + 10^{\frac{L_{p,S,avg}}{10}}\right)\right]$$

$L_{p,P,avg}$: the average sound pressure level (dB) on port side

$L_{p,S,avg}$: the average sound pressure level (dB) on starboard side

3. For average sound pressure level per each 1/3 octave band of airborne noise for sailing, the sound pressure level can be calculated by time averaging the measured sound pressure after background noise adjustments and distance adjustments, or vice versa.

4. The frequency-weighted sound pressure level (L_{Aeq} or L_{Ceq}) is calculated using the 1/3 octave band sound pressure level calculated according to paragraphs **2** and **3**.

5. The broadband total airborne noise level (L_{ARN}) is calculated as the sum of A-weighted sound pressure levels in the 1/3 octave band from 31.5 Hz to 8,000 Hz.

Section 6 Criteria

601. General

1. The final airborne noise level of ship under test calculated in **504. 5** are to meet the acceptance criteria of each airborne noise level depending on frequency ranges specified in **Table 4.1.** ⚓

Table 4.1 Acceptance criteria of airborne noise level (dB(A))

Center Frequency range	For sailing		For berthing	
	S1	S2	B1	B2
31.5 Hz ~ 8,000 Hz	63	58	50	45

GUIDANCE FOR RADIATED NOISE FROM SHIPS

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36, Myeongji ocean city 9-ro, Gangseo-gu,
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