Environmental protection: underwater noise and noise in port

Elisa Fassola[a,1]
[a] *RINA Services S.p.A, Genoa, Italy*

Abstract. Typically, pollution is considered as the diffusion of toxic or harmful materials on our earth. But pollution can also refer to the propagation of dangerous or harmful sounds in the environment, both in the water and the air.
Currently no mandatory regulations are present to regulate noise emitted by ships, only Classification Societies in the recent years developed voluntary class regulations to introduce a measurement protocol and noise limits. The aim of this paper is to present the measurement protocols developed by RINA Services for underwater noise and noise emitted in port and understand current limitations.

Keywords. Pollution, noise, underwater noise, port, measurement

1. Introduction

Historically, pollution is considered as the diffusion of toxic and harmful materials in air, water or soil. Only recently people started to think about pollution as dangerous and harmful sound emitted in the environment, both in water and air. Currently society is not yet familiar with noise pollution and a lack of international regulations is still present [1].

Marine traffic is a significant source of noise both in water, where marine fauna life is affected by commercial routes, and in port, where inhabitants complain about all day long noise.

Nowadays, noise pollution reduction is an important theme that is regularly discussed in maritime committees and many countries are developing new regulations to restrict noise, both underwater and in port, and rewarding low emissions ships.

In the meantime, different registries developed voluntary class notation to provide shipowners and shipyards measurement protocols and limits reflecting the current state of the art. RINA Services too developed two voluntary class notation, one dedicated to underwater noise and one to noise emitted by ship in port.

But being the noise pollution a topic continually under development it is important to have a frequent incisive review of these rules in order to understand possible criticalities or modifications to the standards and promptly revise the protocols and the limits.

In the following chapter RINA rules measurement protocols, according to [2] and [3], will be presented and information about future modifications will be provided.

[1] Elisa Fassola, RINA Services, Marine Environmental & Safety Innovation, Via Corsica 12, 16128 Genoa, Italy; E-mail: elisa.fassola@rina.org.

2. Water and Air Noise Pollution Regulations

Currently, at both national and international level, no mandatory regulations are present to regulate noise emitted by ships, neither underwater nor in air in port.

Nowadays, several committees and financed project are working on these themes but only voluntary notations are present at the moment.

2.1. RINA Services Dolphin Class Notation

Regarding underwater noise emissions RINA Rules in 2016 proposed for the first time the voluntary notation Dolphin Class Transit and Quiet. The notation proposes a measurements protocol and limit curve that should be respected.

Ship owner and shipyard can decide to achieve the standard at normal seagoing condition (Dolphin Transit Ship) or at 10 knots (Dolphin Quiet Ship) or both.

2.2. RINA Services Noise in Port Notation

In 2020 RINA Rules promoted the new noise in port voluntary regulation. The notation proposes a measurements protocol and assigns a score considering an upper and lower sound pressure level limit. The limits were studied based on Environmental Noise Guidelines for the European Region [4].

The aim of the notation is to help port authorities in understanding which ship are more silent and deserve to be placed nearer inhabited areas.

The notation also gives a parameter to shipowners and shipyards to understand the state of the art and improve their noise emission in port.

3. Underwater Noise Measurements and Post Processing

3.1. Underwater Noise Measurements

According to Dolphin Class Notation [2] underwater radiated noise should be measured by means of a hydrophone array positioned at a certain distance from the passing ship. In Figure 1 the configuration of the testing facility is presented.

This procedure is in accordance to ISO standard 17028-1 [5] that proposes an underwater noise measurement method valid for deep water.

Distance between the hydrophone array and the ship should be recorded during the measurements campaign and noted in the final report. A special correction, if necessary, will be applied in the post processing phase to account for any change of position of the hydrophone array during the measurements.

In Figure 2 three microphone array configurations, suggested both in RINA Dolphin Class and ISO standard, are proposed.

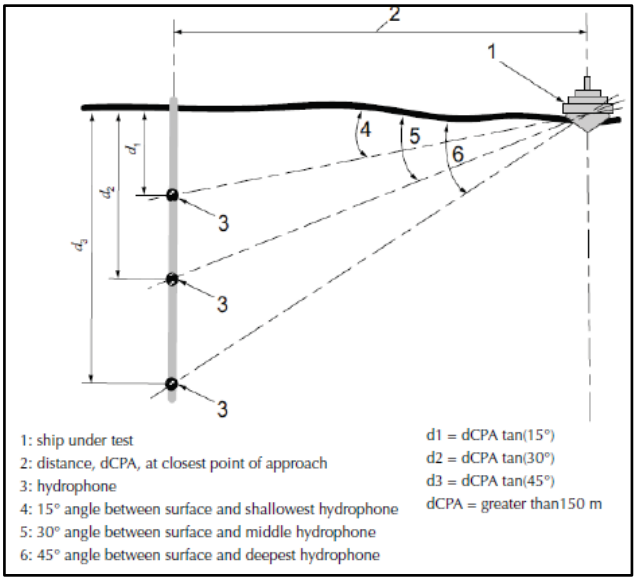

Figure 1. Configuration of the hydrophones

As described in [5] the minimum seabed depth should be 150 m. In fact, currently no ISO Standard for shallow water measurements are available.

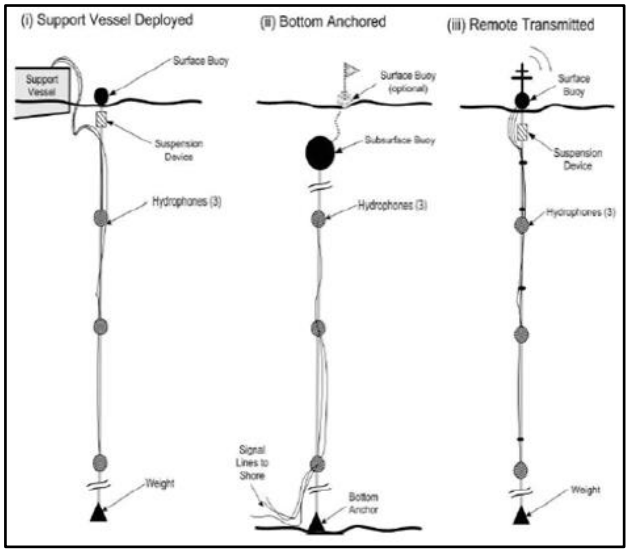

Figure 2. Hydrophone array deployment configuration

At least four run (two per sides) should be carried out. In Figure 3 a representation of the route of the ship during measurement test is presented.

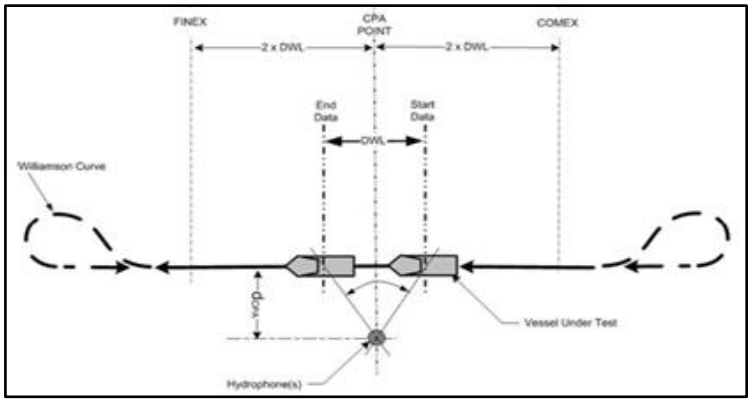

Figure 3. Test configuration

3.2. Underwater Noise Post Processing Corrections

In order to identify a benchmark to compare measurements with, background noise should be recorded before and after the survey campaign. Indeed, the difference between the recorded measurements and the background noise should be no less than 3dB. Data could be collected without background correction if the difference is greater than 10 dB.

As mentioned above, the distance between the hydrophone array and the ship should be constantly measured. The typical distance, according to ISO regulation [5], is 150 m but it can vary of a 10% due to current and wind.

By assuming that the ship is directive source at the surface, it is possible to define the distance normalization required to report data to the source by means of Eq. (1). The results are (o The result is) the underwater sound radiated noise level, $L(r,h)$, at reference distance of 1 m.

$$L(r,h) = L_P'' + 20\,\mathrm{Log}\left(\frac{d_{TOT}}{d_{ref}}\right) \quad (1)$$

where L_P'' is the unweighted sound pressure level after background adjustment, d_{TOT} is the total distance from the ship under test to each hydrophone (meters), and d_{ref} is 1m.

The hypothesis behind this post processing calculation is assuming that the ship is a directive source at the surface.

3.3. Future Modifications

As already highlighted, no corrections for water depth are present because the RINA Rules assume a seabed depth of at least 150 m (deep water conditions). The target for 2024 is to introduce a new procedure for shallow water measurements with dedicated post processing corrections.

This procedure will be in accordance with the new ISO standard 17028-3 expected for 2024 and will be based on measurements carried out by Port of Vancouver with the ECHO Program [6].

Regarding measurements carried out thanks to ECHO Program, Dolphin Class limits will also be modified in order to promote the notation to cargo ship, which currently are excluded due to excessive stringent limits. Currently, the notation is better suited to cruise and ro-pax vessels even if cargo vessels, in fact, represent 87% [7] of merchant vessel world fleet. The purpose of limit modification for future RINA Rules is to give to shipyards and owners of cargo vessels the incentive to improve their underwater noise emissions.

4. Noise in Port Measurements and Post Processing

4.1. Noise in Port Measurements

According to [3] and [8] noise emitted by ships in port should be measured at a certain distance from the ship with no barriers and low background noise.

Several measurement points are recommended (at least 9) to cover all ship perimeter. In Figure 4 a hypothesis of measurement plan is presented. In order to capture all noise sources all around the ship the notation suggest to measure 3 points on each side of the ship, 1 point in front of the bow and of the stern and 2 points 45 degrees from the stern.

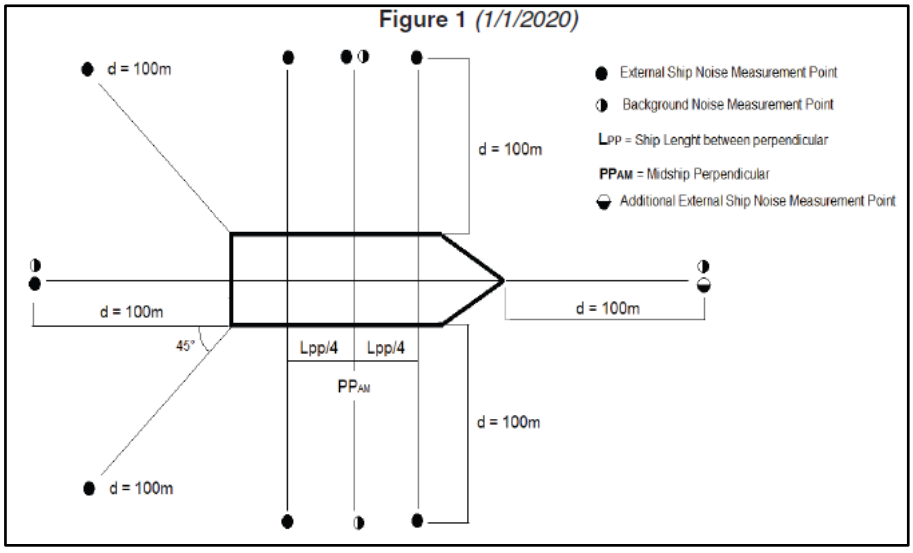

Figure 4. Measurements points around the ship

Due to architectural barriers, it is not always possible to measure all described points of the ship. In this case RINA Services surveyors will evaluate case by case the number and

the position of points to be measured and, based on port architecture, will suggest the better measurement plan to correctly characterize the noise emitted by the ship.

Unfortunately, measurements in port are always affected by background noise, due to other ships and cargo operations, and architectural and geographical barriers.

Background noise should be measured in different positions before or after the measurements without the ship at quay.

4.2. Noise in Port Post Processing

No measurements with a difference between recorded noise and background noise lesser than 3 dB are accepted. A correction for differences between 3 and 10 dB is proposed and no correction is necessary if the difference is higher than 10 dB.

As highlighted in paragraph 4.1 architectural and geographical barriers often do not permit to measure at a distance of 100 m as required.

In order to account for measurements carried out at different positions, a distance correction is to be applied, K_2, to all measurements as described in Eq. (2).

$$K_2 = 20\log\left(\frac{d}{d_{ref}}\right) \quad (2)$$

where K_2 d is the distance of the ship from the measuring point and $d_{ref,}$ the reference distance of 100 m, is to be added to the measured sound pressure level at each position.

4.3. Future Developments

Background noise is normally very high in port area due to the presence of several ships, loading and unloading operations and proximity with infrastructure. In addition, it is impossible to stop port operation during measurements, even at night.

A possible solution could be to use an acoustic camera instead of a sound pressure meter. Indeed, the latter would allow technicians to exclude all external noise sources [9], during the post processing phase.

In addition, architectonical barriers represent a serious issue because the measurements are influenced by architectural and geographical constraints that make measurements not repeatable in other ports.

In this case possible solution for these issues could be to study a measurement protocol directly onboard the ship and simulate the outboard noise through a ray tracing software [10]. Of course, this solution currently presents some complications, for example it will be possible to measure only noise sources in communication with the outdoor (i.e. funnels, cargo ventilation systems, etc.) and not inside noise source (i.e. main engines, generators, etc.). This procedure should be validated to understand how much inside noise sources influence the emitted noise by ships in port.

Currently RINA Services is studying and validating a new notation, alternative to the actual Comfort Noise in port, considering an onboard measurement protocol.

5. Conclusion

As seen in previous paragraph voluntary notation currently supplies the lack of mandatory regulations with measurements protocols and reference standards.

These voluntary notations are aimed to help shipyards and owners to understand the state of the art and improve their noise emissions.

However, considering the increasing interest in noise pollution, notations are constantly under revision to better represent the reality. In particular, measurement methodology has to change to respond to difficulties encountered during past measuring sessions.

But also regulation limits have to change considering the improvements developed by the world fleet in years and the growth of the measurement database.

References

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