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Ships and marine technology — Model test method for propeller cavitation noise evaluation in ship design —

Part 2:
Noise source localization

Navires et technologie maritime — Méthode d'essai sur modèle pour évaluer le bruit de cavitation des hélices dans la conception des navires —

Partie 2: Localisation de la source de bruits

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 8, *Ship design*.

A list of all parts in the ISO 20233 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Propeller cavitation is the major noise source in commercial ships. The propeller cavitation noise can be assessed by experimental and/or numerical methods in propeller design stage. The numerical methods, such as computational fluid dynamics (CFD) or empirical formulae, might be a good alternative to propeller cavitation noise evaluations. However, the model tests are still used widely for research on propeller cavitation noise.

The objective of the model test is to reduce the propeller noise in ship design by evaluating propeller cavitation noise characteristics at the design phase. Localizing the noise sources in the design stage, as well as predicting its noise levels, might be very helpful. ISO 20233-1 addresses the prediction of propeller noise levels. In order to specify the location of noise source, visual observation of cavitation is the most practical way in view of spatial resolution and efficiency, as the main source of hydrodynamic noise in merchant ship is cavitation. In addition to this observation, noise source localization technique using hydrophone array is under development for verifying the observed noise source location[1]. Thus this document devotes to the source localization method as a new part of a model test method for propeller cavitation noise evaluation in ship design.

The estimation methods of the propeller noise via model tests were widely studied for a long time and can be used in the shipbuilding industry nowadays. However, the noise source localization is easily accomplished by cavitation observation. This document also serves to provide an example of protocols for acoustic localization which is a relatively new research area.

Ships and marine technology — Model test method for propeller cavitation noise evaluation in ship design —

Part 2: Noise source localization

1 Scope

This document specifies a model test method for propeller cavitation noise evaluation in ship design, focusing mainly on the noise source localization.

The procedure comprises the model test set-up, noise measurements, data processing and source localization. The target noise source being propeller cavitation, this document describes the test set-up and conditions to reproduce the cavitation patterns of the ship, which is the same as in ISO 20233-1. The noise measurements are performed using a hydrophone array for the source localizations. Therefore, the instrumentation of the hydrophone array is also addressed, as well as a suitable array signal processing of the measured data. Finally, a method to visualize and to interpret the results is presented.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 20233-1:2018, *Ships and marine technology — Model test method for propeller cavitation noise evaluation in ship design — Part 1: Source level estimation*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
acoustic centre
position where all the noise sources are co-located as a single point source

Note 1 to entry: The acoustic centre is the centre of the expected cavitation extent.

3.2
background noise
noise from all sources other than the source under test

3.3
hydrophone
underwater electro-acoustic transducer
underwater microphone
device to measure acoustic pressure, including any signal conditioning electronics such as pre- or charge amplifiers either within or exterior to it

Note 1 to entry: Piezoelectric hydrophones are usually used for the measurement of underwater sound pressure in a test facility.

3.4
noise source
noise-generating mechanism or object

Note 1 to entry: For the purposes of this document, the main noise source is the propeller cavitation.

3.5
propeller plane
imaginary plane orthogonal to the shaft centre line and including the intersection (point) of the shaft centre line and generator line

3.6
reference field
sound pressure field that is measured using a virtual source located at a given position, i.e. the acoustic centre

Note 1 to entry: The reference field is used to calibrate the hydrophone array.

3.7
virtual source
artificial sound source of which the transmitting power is known *a priori*

4 Model test setup and conditions

In order to evaluate the propeller cavitation noise performance via model tests, it is important to reproduce accurately the noise sources, i.e. the cavitation patterns, based on the similarity laws between the model and the ship. Accuracy in reproducing the noise sources is required for the noise source localization as well as for the source level estimation. The test setup and conditions described in ISO 20233-1:2018, Clause 4, shall be applied to the model test for the noise source localization.

5 Noise measurement instrumentation

5.1 Hydrophone array

5.1.1 General

In order to localize the noise source, i.e. to find the position where the most probable noise occurs, the use of a special device to enable noise measurement with high directivity is required. The hydrophone array is the typical device for that purpose.

5.1.2 Hydrophone

Recommended specifications of the hydrophones are listed in Table 1.

The hydrophones should be individually calibrated before the test and periodically (typically every 12 months), either with respect to the manufacturer's calibration reference, e.g. by using a hydrophone calibrator, or in accordance with IEC 60565[2].

Table 1 — Recommended specifications of the hydrophones

Receiving sensitivity	−220 dB re 1 V/μPa or higher
Frequency range	1 Hz to 100 kHz or wider
Directivity	Omni-directional
Operating static pressure	40 atm to 100 atm

5.1.3 Array types

For the noise source localization, various types of hydrophone arrays can be used. The typical array types are listed in Table 2[3]. Especially in the propeller cavitation model tests, from the practical perspective it is recommended to use a 2-dimensional array, considering the performance and the cost-effectiveness.

A design method of hydrophone array patterns can be found in Annex A for information.

Table 2 — Hydrophone array types

1-Dimenonal array	— uniform line array — nested line array
2-Dimenonal array	— uniform linear plane array — nested linear plane array — circular-typed array — spiral-typed array — random array
3-Dimenonal array	volume array

5.1.4 Array setup

For the noise source localization, a single array or multiple arrays can be used.

The arrays can be variously mounted, depending on the test facility. For the cavitation tunnel, the hydrophone arrays can be located in the acoustic chamber below the test section. They can be mounted outside of the walls (or windows) or be flushed to walls (or windows). For the towing tank, the arrays can be located inside the basin.

Regardless of the mounting method, however, the hydrophone should be installed in order to reduce the effects of flow and vibration on the hydrophones and to avoid unwanted acoustic phenomena such as resonance due to the mounting and the hydrophone setups.

5.1.5 Array calibration

When calibrating the hydrophone as recommended in 5.1.1, it should be confirmed that the hydrophone is correctly positioned in the array. In addition, it should be checked that the array localizes the correct virtual source position during the reference field measurement as described in 6.3.

5.2 Data acquisition

5.2.1 General

Data acquisition is performed using analogue-digital converters (A/D). 5.2.2 to 5.2.6 should be considered for the A/D converter.