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

## Part 1: Source level estimation

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

*Partie 1: Estimation du niveau d'émission de la source*

Reference number
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# Contents

Page

**Foreword** ... **iv**
**Introduction** ... **v**
**1 Scope** ... **1**
**2 Normative references** ... **1**
**3 Terms and definitions** ... **1**
**4 Model test setup and conditions** ... **3**
4.1 Test setup ... 3
4.1.1 Test facility ... 3
4.1.2 Model propeller ... 3
4.1.3 Wake generation ... 3
4.2 Test conditions ... 4
4.3 Calibration ... 5
**5 Noise measurement instrumentation** ... **5**
5.1 Hydrophone and signal conditioning ... 5
5.2 Data acquisition ... 6
5.2.1 General ... 6
5.2.2 Sampling frequency ... 6
5.2.3 Resolution ... 6
5.2.4 Synchronization for multiple channel sampling ... 6
5.2.5 Filtering ... 6
5.2.6 Acquisition time ... 6
**6 Noise measurement procedure** ... **6**
6.1 Propeller cavitation noise measurement ... 6
6.2 Background noise measurement ... 6
6.3 Reference field measurement ... 7
6.3.1 Objective ... 7
6.3.2 Virtual source and input signal ... 7
6.3.3 Measurement condition ... 7
**7 Post processing and scaling** ... **7**
7.1 Sound pressure level ... 8
7.2 Background noise adjustment ... 8
7.3 Transmission loss ... 8
7.4 Model scale source level ... 9
7.5 Scaling to the full-scale noise levels ... 9
7.6 Other option for full-scale noise prediction ... 10
**8 Uncertainty** ... **10**
**Annex A** (informative) **Wake extrapolation methods** ... **11**
**Annex B** (informative) **Uncertainty assessments** ... **12**
**Bibliography** ... **13**

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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 on 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 the following URL: www.iso.org/iso/foreword.html.

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


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# Introduction

In order to reduce shipping noise, the characteristics of ship noise should be understood. Propeller noise, which is the major noise source in commercial ships, is mainly due to its turns as spectral harmonics and to cavitation as broadband noise. Special ships such as fishery research vessels and military vessels require quiet propellers with less or no cavitation in their operating conditions.

The propeller cavitation noise can be assessed by experimental and/or numerical methods in the propeller design stage. The numerical method such as CFD or empirical formulae might be a good alternative to propeller cavitation noise evaluations. However, the model tests are still used widely to predict the full-scale acoustic source strength of the propeller cavitation for a wide range of frequencies.

This document was developed to provide a standardized model test method for propeller cavitation noise evaluation. This document is aimed for appropriate evaluation of the propeller cavitation noise characteristics at the early design phase via model tests.

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

# Part 1: Source level estimation

## 1 Scope

This document specifies a model test method for propeller cavitation noise evaluation in ship design.

The procedure comprises reproduction of noise source, noise measurements, post processing and scaling. The target noise source is propeller cavitation. Thus, this document describes the test set-up and conditions to reproduce the cavitation patterns of the ship based on the similarity laws between the model and the ship. The propeller noise is measured at three stages. The measurement targets for each stage are propeller cavitation noise, background noise, and transmission loss. For the source level evaluations, corrections for the background noise and the transmission loss are applied to the measured propeller cavitation noise. Finally, the full-scale source levels are estimated from the model scale results using a scaling law.

## 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 17208-1:2016, *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*

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

ITTC — Recommended Procedures and Guidelines 7.5-02-01-05: *Model scale propeller cavitation noise measurements*

## 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:

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

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

**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

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**3.3**
**cavitation number**
$\sigma_n$
non-dimensional quantity defined as $(p_0 - p_v)/\left(\frac{1}{2}\rho n^2 D^2\right)$ where

$p_0$ is the total static pressure;

$p_v$ is the vapour pressure;

$\rho$ is the density of the fluid;

$n$ is the propeller rotational speed (rps);

$D$ is the diameter of the propeller.

Note 1 to entry: The total static pressure ($p_0$) consists of atmospheric pressure and submergence depth pressure which is usually taken at a specific point approximating the centre of the expected cavitation extent in the upper part of the disk, such as 0,7 R(R : radius of the propeller), 0,8 R or 0,9 R above the propeller centreline, although the propeller centreline is also used.

**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**
**propeller thrust coefficient**
$K_T$
non-dimensional quantity defined as $T/(\rho n^2 D^4)$, where $T$ is the thrust of the propeller

**3.7**
**propeller torque coefficient**
$K_Q$
non-dimensional quantity defined as $Q/(\rho n^2 D^5)$, where $Q$ is the torque of the propeller

**3.8**
**reference distance**
distance used for source level conversion and defined as 1 m apart from the acoustic centre

**3.9**
**reference field**
sound pressure field that is measured using a virtual source located at a given position, i.e. acoustic centre

Note 1 to entry: The reference field shall be used to calculate the source level.

**3.10**
**sound pressure level**
**SPL**
$L_p$
ten times the logarithm to the base 10 of the ratio of the time-mean-square pressure of the measured sound pressure, in a stated frequency band, to the square of a reference value expressed in decibels by

$L_p = 10\log_{10}\left(\frac{p^2}{p_{ref}^2}\right)$ where $p_{ref}$=1$\mu Pa$


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**3.11**
**source level**
**SL**
converted quantity of the measured sound pressure at a reference distance 1 m apart from the acoustic centre

**3.12**
**virtual source**
artificial sound source of which transmitting power is known *a priori*

**3.13**
**wake**
simulated ship wake at the propeller plane

Note 1 to entry: For the model test, ship wake is simulated using a wake screen or a ship model.

# 4 Model test setup and conditions

## 4.1 Test setup

In order to evaluate the propeller cavitation noise performance via model tests, it is important to reproduce noise sources accurately, i.e. the cavitation patterns, based on the similarity laws between the model and the ship. Test setup for the purpose comprises test facilities, model propellers, and wake fields generation.

### 4.1.1 Test facility

Test facilities might vary between variable pressure water tunnels, circulating water channels with a free surface in the test section to a depressurized towing tank. The variable pressure water tunnels, which are called cavitation tunnels, are widely used for the model tests. Depending on their test section sizes, suitable devices to generate wake fields should be utilized.

### 4.1.2 Model propeller

The size of a model propeller depends on the capacity constraint of the test facilities and on the acceptable range of test section blockage. The size of the model propeller should be determined to achieve the highest Reynolds number within the capacity constraints of the test facility. A typical propeller diameter for a model scale propeller is in the range between 180 mm to 300 mm. The accuracy of the model propeller geometry should be according to ITTC — Recommended Procedures and Guidelines 7.5-01-02-02[1] which specifies that the offsets of the blade sections should be in the range ±0,05 mm.

### 4.1.3 Wake generation

For the propeller cavitation model tests, the wake fields are to be generated by the wake screen or the model ship. In general, the former is used in small-sized and medium-sized cavitation tunnels, while the latter is used in the large cavitation tunnel. The important scaling parameter for the cavitation test is the Reynolds number but its similarity cannot be achieved for practical reasons. In order to reduce scale effect, the Reynolds number should be determined as high as possible within the capacity of the test facilities.

For the medium-sized cavitation tunnels, the wake distributions are to be generated inside the cavitation tunnel by using a wake screen composed of wire meshes. When a full-scale ship wake is required, it is to be obtained by extrapolating the model scale wake field or by using computational fluid dynamics (CFD). A dummy model in combination with wake screens can be applied in the medium-sized tunnel as well. For twin screw ships, the inclined shaft, brackets and bossing can be mounted in small- to medium-sized test sections.

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