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Ships and marine technology — Full-scale test method for propeller cavitation observation and hull pressure measurement

Navires et technologie maritime — Méthode d'essai grandeur nature pour l'observation de la cavitation de l'hélice et le mesurage de la pression de la coque

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Contents

Page

Foreword

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

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

Cavitation is responsible for significant propeller performance degradation and occurs at nearly all propellers, causing often vibrations, noise and propeller blade erosion. It has been a common practice to evaluate the propeller cavitation behaviour and its related hull pressure through model tests. However, the model test might not show the full-scale cavitation phenomena.

Full-scale cavitation observations and hull pressure measurements are very helpful as feedback for propeller design and prediction of full-scale performance through model test. This full-scale test method is needed to establish more accurate model-ship correlation, to come up with better experimental methods and to identify the cause of unexpected problems such as blade damage.

This document was developed to provide a standardized full-scale test method for propeller cavitation observation and hull pressure measurement.

Ships and marine technology — Full-scale test method for propeller cavitation observation and hull pressure measurement

1 Scope

This document specifies a full-scale test method for propeller cavitation observation and hull pressure measurement. The objective of the test is to investigate the propeller cavitation behaviour and its effects on the hull vibration problems.

The test method comprises the specification of the test instrumentation and implementation, construction requirements to ensure structural safety, test and measurement procedures, and reporting documentation.

This document is applicable to ships in the following stages:

— before or during sea-trial, prior to delivery stage (vessels under constructions), and

— after delivery stage.

2 Normative references

There are no normative references in this document.

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
measured ship speed
ship's speed during a speed run derived from the headway distance between start and end position and the elapsed time of the speed run

3.2
observation window
transparent window allowing to observe and investigate the occurrence of cavitation of a ship propeller

3.3
propeller plane
plane normal to the shaft axis and containing the propeller reference line, i.e. contain the reference point of the root section

3.4
ship speed
speed of the ship that is realised under stipulated conditions

Note 1 to entry: See also *measured ship speed* (3.1).

3.5
side scuttle
round or oval opening with an area not exceeding 0,16 m^2

Note 1 to entry: Round or oval openings with an area exceeding 0,16 m^2 are "windows", as defined in IACS UI LL62[3] or IMO Resolution MSC. 143(77)[4].

3.6
sea chest
fitting in a hull below the water line, for admitting or discharging water

4 Instrumentation and implementation

4.1 General

For the ship installation of all test equipment, it is necessary to thoroughly review the drawings on the ship subject to test, and the selection of sensor and equipment installation location, workspace and transportation route should be reflected in the design and construction stage.

4.2 Cavitation observation

4.2.1 General

Various methods for observing full-scale cavitation have been developed so far. This document introduces the characteristic of various cavitation observation methods and specifies the criteria for the necessary preparations for the cavitation observation test.

4.2.2 Cavitation observation method

A traditional method using a CCD camera with a stroboscopic lighting source has been commonly used for full-scale cavitation observation. Recently, a technique using a high-speed camera in daylight condition has been used. This technique minimizes the number of observation windows compared to the traditional method and enables to observe detailed motion of cavitation to study the phenomenological behaviour of the cavitation.

Furthermore, instead of the existing observation window, a high-speed bore-scope technique has been used in consideration of relative installation time and cost reduction. The small penetrations needed for the bore-scope equipment can be drilled with the ship in a float condition, which reduces the installation time from days to hours and saves money from expensive ship docking operations.

However, the high-speed bore-scope technique requires strong sun light and good water quality. The observation windows are more robust against the weather conditions and sea conditions. Thus, observation windows are still useful if there is sufficient construction time and space. Appropriate equipment should be selected depending on the purpose, situation and timing of the installation.

Although frequency of image heavily depends on illumination condition, Table 1 shows several examples of various observation methods for full-scale propeller cavitation.

Table 1 — Examples of cavitation observation methods

Observation method	Window/ hole size	Dry docking required for preparation	Dependence on daylight	Comments
Photographs/videos in daylight using a bore-scope	about M20 bores	no	yes	Easily affected by the environment (daylight, water quality, etc.) Easy installation Low frequency image
Photographs/videos in daylight using windows	about 200 mm to 300 mm	yes	yes	Moderately affected by the environment (daylight, water quality, etc.) To be installed during docking Low frequency image
High speed camera in daylight using windows	about 200 mm to 300 mm	yes	yes	Moderately affected by the environment (daylight, water quality, etc.) To be installed during docking High frequency image
High speed camera in daylight using a bore-scope	about M20 bores	no	yes	Easily affected by the environment (daylight, water quality, etc.) Easy installation High or low frequency image subject to light intensity
Photographs/videos under strobe light using windows	about 200 mm to 300 mm	yes	no	Relatively unaffected by the environment (daylight, water quality, etc.) To be installed during docking Time-lapse image

4.2.3 Observation window

The observation window should be designed, manufactured and installed with the following considerations:

— observation visibility;

— convenience in the setting-up;

— structural safety;

— water-tight performance.

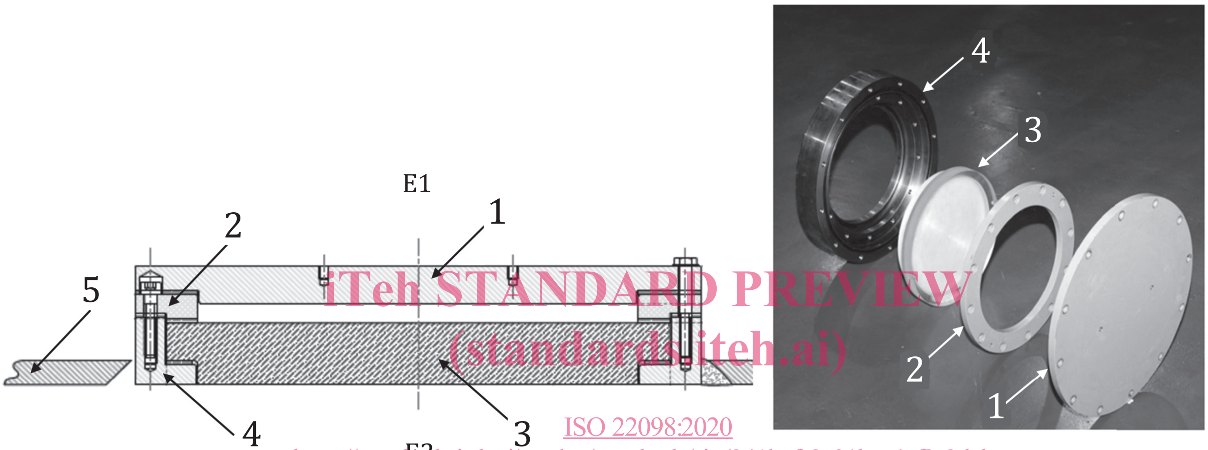
The designed observation window should be verified for safety through structural strength analysis or classification approval. It should be manufactured in compliance with the suitable materials and specifications so as not to cause problems in the installation of the ship.

Table 2 shows the components and materials of a typical observation window.

Figure 1 shows an example of a typical observation window.

Table 2 — Components and materials of a typical observation window — Example

Item	Materials
Steel plate cover	Mild steel or stainless steel
Frame 1 for fixing the window	Mild steel or stainless steel
Window glass	Acrylic or similar material
Frame 2 for fixing the window	Mild steel or stainless steel
Frame lockable bolts, For tightening various bolts, O-ring	Mild steel or stainless steel, Mild steel or stainless steel, Rubber or similar material



Key

1 steel plate cover
2 frame 1 for fixing window
3 window glass
4 frame 2 for fixing window
5 hull
E1 air
E2 water

NOTE See also Table 2.

Figure 1 — Example of a typical observation window

The number of observation windows depends on the observation method used. The installation, location and size of the observation windows should be selected by considering the following items through an analysis of the stern structure of the ship:

— cavitation occurrence position and observation range;

— easiness of installation, securing of workspace and moving route;

— ship operating draft;

— structural safety and arrangement onto the shell.

The exact position of the observation window can be selected through a 3D analysis of the hull shape using CAD modelling, as shown in Figure 2.

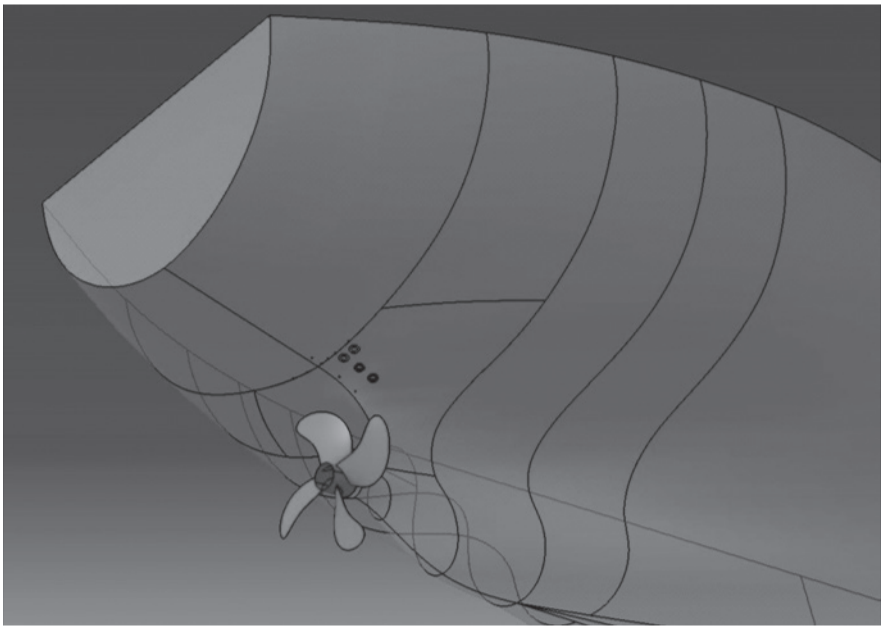


Figure 2 — Example of 3D modelling for the positioning of observation windows

4.2.4 High-speed camera

The high-speed camera used for the observation should be capable of shooting at weak daylight sources. The appropriate frame rate should be selected according to the weather conditions and the rotational speed of the full-scale propeller, since the frame rate and resolution have conflicting relationships. Several high-speed cameras can be used depending on the number of observation windows. In this case, a system configuration is recommended in which the cameras can be synchronized and recorded.

4.3 Hull pressure measurement

4.3.1 General

The hull pressures should be measured at the stern surface near the propeller where the maximum pressure fluctuation due to cavitation is generated. Pressure transducers should be installed on the stern surface above the propeller plane, and the measured hull pressures should be analysed by the signal processor.

4.3.2 Pressure transducer

The installation, position and number of the pressure transducers should be determined by considering the hull structure, the test purpose, the measurement range and the installation space.

The pressure transducers, if used, should be calibrated in accordance with the manufacturer's calibration reference.

An example of pressure pick-ups as mounted is a strain-gauge transducer, rated at a maximum pressure of 345 kPa and suitable for a frequency range from 0 Hz to 6 000 Hz in water, which is shown in Figure 3.