INTERNATIONAL STANDARD

ISO 19030-1

First edition
2016-11-15

Ships and marine technology — Measurement of changes in hull and propeller performance —

Part 1: General principles

Navires et technologie maritime — Mesurage de la variation de performance de la coque et de l'hélice —

Partie 1: Principes généraux

Reference number
ISO 19030-1:2016(E)

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on 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.

The committee responsible for this document is ISO/TC 8, *Ships and marine technology*, Subcommittee SC 2, *Marine environment protection*.

A list of all parts in the ISO 19030 series can be found on the ISO website.

Introduction

Hull and propeller performance refers to the relationship between the condition of a ship's underwater hull and propeller and the power required to move the ship through water at a given speed. Measurement of changes in ship specific hull and propeller performance over time makes it possible to indicate the impact of hull and propeller maintenance, repair and retrofit activities on the overall energy efficiency of the ship in question.

The aim of the ISO 19030 series is to prescribe practical methods for measuring changes in ship specific hull and propeller performance and to define a set of relevant performance indicators for hull and propeller maintenance, repair and retrofit activities. The methods are not intended for comparing the performance of ships of different types and sizes (including sister ships) nor to be used in a regulatory framework.

The ISO 19030 series consists of three parts.

— ISO 19030-1 outlines general principles for how to measure changes in hull and propeller performance and defines a set of performance indicators for hull and propeller maintenance, repair and retrofit activities.

— ISO 19030-2 defines the default method for measuring changes in hull and propeller performance and for calculating the performance indicators. It also provides guidance on the expected accuracy of each performance indicator.

— ISO 19030-3 outlines alternatives to the default method. Some will result in lower overall accuracy but increase applicability of the standard. Others may result in same or higher overall accuracy but include elements which are not yet broadly used in commercial shipping.

The general principles outlined, and methods defined, in the ISO 19030 series are based on measurement equipment, information, procedures and methodologies which are generally available and internationally recognized.

Ships and marine technology — Measurement of changes in hull and propeller performance —

Part 1:
General principles

1 Scope

This document outlines general principles for the measurement of changes in hull and propeller performance and defines a set of performance indicators for hull and propeller maintenance, repair and retrofit activities.

The general principles outlined and performance indicators defined are applicable to all ship types driven by conventional fixed pitch propellers, where the objective is to compare the hull and propeller performance of the same ship to itself over time.

NOTE Support for additional configurations (e.g. variable pitch propellers) will, if justified, be included in later revisions of this document.

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:

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

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

3.1
hull and propeller performance
relationship between the condition of a ship's underwater hull and propeller and the power required to move the ship through water at a given speed

3.2
delivered power
P_D
power delivered to the propeller (propeller power)

3.3
speed through the water
V
ship's speed through water for a given set of service (environmental) and loading (displacement/trim) conditions

3.4
accuracy
described by trueness and precision, where trueness refers to the closeness of the mean of the measurement results to the actual (true) value and precision refers to the closeness of agreement within individual results

Note 1 to entry: See ISO 5725-1:1994, 3.6 and Introduction 0.1.

3.5
uncertainty
probability that the measurement of a quantity is within the specified accuracy to that quantity's actual (true) value

3.6
filtering
method of removing unwanted data

3.7
normalization
refers to the creation of shifted and scaled versions of statistics, where the intention is that these normalized values allow the comparison of corresponding normalized values in a way that eliminates the effects of specific influences

3.8
performance indicators
PIs
used to evaluate the effectiveness of, or to trigger, a particular activity

3.9
dry-docking
bringing the ship onto dry land to maintain, repair and/or retrofit the parts of the hull that are submerged while the ship is in service

3.10
out-docking
period immediately following a dry-docking

3.11
dry-docking interval
period between two consecutive dry-dockings

4 General principles

4.1 Hull and propeller performance

Hull and propeller performance refers to the relationship between the condition of a ship's underwater hull and propeller and the power required to move the ship through water at a given speed. Hull and propeller performance is related to variations in power, because ship hull resistance and propeller efficiency are not directly measurable quantities.

4.2 Ship propulsion efficiency and total resistance

Hull and propeller performance is closely linked to the concepts of ship propulsion efficiency and ship resistance. The performance model is based on the relation between the delivered power and the total resistance where delivered power, P_D, can be expressed as Formula (1):

$$P_D = \frac{R_T \times V}{\eta_Q} \tag{1}$$

where

R_T is the total in-service resistance (N);

V is the ship speed through water (m/s);

η_Q is the quasi-propulsive efficiency (-).

The total resistance consists of several resistance parts and can be written as Formula (2):

$$R_T = R_{SW} + R_{AA} + R_{AW} + R_{AH} \tag{2}$$

where

R_{SW} is the still-water resistance (N);

R_{AA} is the added resistance due to wind (N);

R_{AW} is the added resistance due to waves (N);

R_{AH} is the added resistance due to changes in hull condition (fouling, mechanical damages, bulging, paint film blistering, paint detachment, etc.), (N).

Likewise, the quasi-propulsive efficiency consists of different efficiency components expressed as Formula (3):

$$\eta_Q = \eta_0 \eta_H \eta_R \tag{3}$$

where

η_0 is the open-water propeller efficiency;

η_H is the hull efficiency;

η_R is the relative rotative efficiency.

The added resistance due to changes in hull condition can be expressed as Formula (4):

$$R_{AH} = \frac{P_D \times \eta_Q}{V} - (R_{SW} + R_{AA} + R_{AW}) \tag{4}$$

where

V is the ship speed through water, can be measured directly;

P_D is the delivered power, must be approximated – for example based on calculations of shaft power;

P_S is from measurements of shaft torque and shaft revolutions or, alternatively, from calculations of brake power;

P_B is from SFOC reference curves, measurements of fuel flow and temperature and data on calorific value, density and density change rate for the fuel being consumed.

Variations in the delivered power required to move the ship through water at a given speed, and the same environmental conditions and operational profile, are due to changes in the underwater hull resistance and/or propeller efficiency. Changes in underwater hull resistance are due to alterations in the condition of the hull. Changes in the propeller efficiency are due to both alterations in the condition of the propeller and to modifications to the flow of water to the propeller (the hull wake) as consequence of alterations to the hull condition.

For a vessel in service, both environmental conditions and operational profile (e.g. speed, loading, trim) vary. In order to measure changes in the speed-power relationship for a vessel in service, it is necessary to compare two periods (a reference period and an evaluation period) where the environmental conditions and the operational profile are adequately comparable (filter the observed data) and/or apply corrections (normalize the observed data).

There are a number of alternative procedures for filtering and normalizing observed data. These procedures each have advantages and disadvantages in terms of the resulting accuracy of the measurements. This document prescribes a practical blend of filtering and normalization procedures found to yield sufficient accuracy.

NOTE The relative importance of the different resistance components varies to certain degree with the operational and environmental condition the vessel is exposed to. Also, the accuracy of the models to correct/normalize for such variations depends on the operational and environmental conditions. These dependencies impact the accuracy of the hull and propeller performance indicators as described in the current standard. Therefore, in the estimation of the accuracy of the performance indicators and for the intended use comparable operational and environmental conditions over the reference and evaluation period (see Annex A) are assumed. Future revisions of this document will re-evaluate if more accurate correction formulae are available that take the above mentioned dependencies into consideration.

Hull and propeller maintenance, repair and retrofit activities have an effect on the energy efficiency of a ship in service. An indication of these effects can be obtained by measurement of changes in the delivered power required to move the ship through water at a given speed between two periods for which the environmental conditions and operational profiles have been made adequately comparable through filtering and/or normalization of the observed data.

4.3 Primary parameters when measuring changes in hull and propeller performance

The above definition gives ship's speed through the water and delivered power as the two primary parameters when measuring changes in hull and propeller performance.

NOTE If hull performance is to be separated from propeller efficiency, propeller thrust would also have to be measured.

For these parameters, different measurement approaches, and for each approach, different sensors with different signal qualities are available. In ISO 19030-2, default measurement approaches and associated "minimum required" signal quality values are specified.

If sensors with the minimum required signal quality are not available, alternative measurement approaches can be used, but they introduce additional uncertainty. In ISO 19030-3, alternative measurement procedures are described. For each alternative, the minimum required signal quality is specified together with an estimation of the additional uncertainty introduced.

4.4 Secondary parameters

In order to apply the filtering and normalization procedures necessary to make the reference period and evaluation period adequately comparable, measurements of both the environmental conditions and the ship's operational profile are required. Relevant environmental factors are as follows:

— wind speed and direction;

— significant wave height, direction and spectrum;

— swell height, direction and spectrum;

— water depth;

— water temperature and density.

Relevant operational factors are as follows:

— speed;

— loading conditions (static draught, static trim, heel);

— dynamic floating conditions (motions, dynamic draught, dynamic trim);

— rudder angle / frequency of rudder movements.

If reliable sensor signals are not available for all parameters, either signals from alternative sensors can be used to approximate and/or for practical purposes one must assume their effects "average out over time". Using alternative sensors or relying on an equal distribution assumption introduces additional uncertainty.

In ISO 19030-2, a "minimum set" of sensor signals and the "minimum required" signal quality for each sensor are specified for the default method for measuring changes in hull and propeller performance.

In ISO 19030-3, alternative sets of sensor signals and "minimum required" signal quality are defined, together with estimations of their effect on the expected accuracy of the performance indicators.

4.5 Measurement procedures

4.5.1 General

There are three basic procedural steps involved when measuring changes in hull and propeller performance. Figure 1 summarizes these three steps.

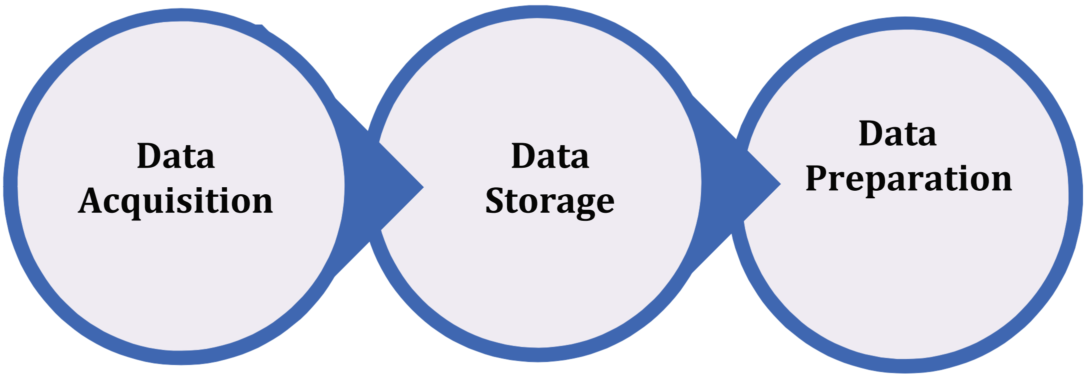

Figure 1 — Procedural steps when measuring changes in hull and propeller performance

The accuracy of a measurement is determined by both its trueness and its precision (see ISO 5725). Trueness refers to the closeness of the mean of the measurement results to the actual (true) value. Precision refers to the closeness of agreement within individual results and is a function of both repeatability and reproducibility. Reproducibility refers to the variation arising using the same measurement process among different instruments and operators, and over longer time periods. Measurement procedures have a considerable impact on the reproducibility of, and therefore on the accuracy of, the performance indicators.

NOTE The procedural steps do not have to be conducted in the above sequence. For example, some preparation of the data can be done as a part of data acquisition.

4.5.2 Data acquisition

Data acquisition refers to the systematic process of recording (manually and/or automatically) signals/data from the relevant sensors, equipment installed on the vessel and external information providers. Manual data collection is typically performed once every day (noon data). Generally, automated data collection occurs at a much higher frequency.

4.5.3 Data storage

Data storage refers to the saving and retention of collected data in a suitable format. This process should allow previously stored data to be kept together with new data, and ordering it in a sequence so that it is easy to retrieve when required.

4.5.4 Data preparation

Data preparation includes extracting, compiling, screening and validating the data to give it a structure, format and quality suitable for further processing. A set of non-dimensional performance values, that reflect the changes in the hull and propeller performance over the given period of time, are then calculated. Different sub-sets of the performance values are used to calculate the various performance indicators. Data preparation can be partially or fully automated.

Practical approaches to data acquisition, data storage and data preparation that yields a high expected accuracy is defined in ISO 19030-2, the default method for measuring changes in hull and propeller performance.

In ISO 19030-3, alternatives to the measurement procedures are defined and the impacts on the expected accuracy of the performance indicators are described.

5 Performance indicators

Measurements of ship specific changes in hull and propeller performance can be used in a number of relevant performance indicators to determine the effectiveness of hull and propeller maintenance, repair and retrofit activities. Table 1 outlines four basic hull and propeller performance indicators.

