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

Part 2: Default method

Navires et technologie maritime — Mesurage de la variation de performance de la coque et de l'hélice —
Partie 2: Méthode par défaut

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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 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. Measurements of changes in ship specific hull and propeller performance over time make 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 this document 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.

This document 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 this document are based on measurement equipment, information, procedures and methodologies which are generally available and internationally recognized.

Clause 4 defines the primary and secondary parameters as well as external information needed. Clause 5 defines how measurement data are to be acquired, stored and prepared. Clause 6 defines how the performance indicators are to be calculated. Clause 7 provides guidance on the expected accuracy of each performance indicator.

Annex A illustrates the process in terms of a flow chart.

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

Part 2: Default method

1 Scope

This document defines the default method for measuring changes in hull and propeller performance and calculating a set of basic performance indicators. Finally, it provides guidance on the expected accuracy of each performance indicator.

This document is applicable for commercial ship types of the displacement type driven by conventional fixed pitch propeller(s) 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

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 3046-1, *Reciprocating internal combustion engines — Performance — Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods — Additional requirements for engines for general use*

ISO 15016:2015, *Ships and marine technology — Guidelines for the assessment of speed and power performance by analysis of speed trial data*

ISO 19030-1:2016, *Ships and marine technology — Measurement of changes in hull and propeller performance — Part 1: General principles*

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
changes in hull and propeller performance
changes in delivered power required to move the ship through water at a given speed or equivalently changes in speed through water at a given delivered power, given unchanged transmission efficiency, and the same environmental conditions and operational profile

3.2
reference period
period in time of a certain length used to establish a baseline

3.3
evaluation period
period in time after the *reference period* (3.2), used for comparing with the baseline

3.4
reference conditions
set of comparable conditions of environmental and/or operational factors or a set of ranges of such conditions

3.5
tabular format
formatting data in rows and columns, to break down specific data into a quickly scanable layout

3.6
unique identifier
identifier which is guaranteed to be unique among all identifiers used for those objects and for a specific purpose

4 Measurement parameters

4.1 General

This clause describes the primary and secondary parameters for measuring changes in hull and propeller performance.

4.2 Primary parameters

In ISO 19030-1, ship speed through water, V, and delivered power, P_D, are defined as the two primary measurement parameters for measuring changes in hull and propeller performance.

Ship speed through water shall be measured directly, in knots, using a speed log with a minimum sensor accuracy of ±1 %, at 1σ[1)] of the speed of the ship, or ±0,1 knots, at 1σ (both as specified by the sensor manufacturer) whichever is greater.

NOTE Since the overall accuracy associated with measurements of hull and propeller performance is highly sensitive to uncertainties in the measurement of speed, this requirement is intentionally stricter than current SOLAS requirements.

Delivered power shall be approximated based on calculations of shaft power, P_S, from measurements of shaft torque and shaft revolutions following Annex B or, if a torque meter with required signal quality is not available and the conditions defined in Annex C are fulfilled, shall be based on calculations of brake power, P_B, from an engine-specific SFOC (specific fuel oil consumption) reference curve defined in Annex D, continuous measurements of fuel flow and temperature and bunker analysis data (calorific value, density and density change rate for the fuel being consumed).

The approaches to calculating shaft power and brake power, as well as minimum required sensors and sensor accuracies for each, are specified in Annex B and Annex C, respectively.

The same approach to approximating delivered power shall be used throughout both the reference and evaluation periods.

1) Confidence interval of 66 %.

4.3 Secondary parameters

For the isolation of comparable reference conditions and as input to data preparation (filtering, normalization), both environmental factors and the ship's operational profile shall be measured.

NOTE Not all factors influencing measured performance are addressed in this document, e.g. frequency of rudder movement or side current effects. Future revisions of this document may address such factors.

The minimum sensor requirements for the secondary measurement parameters are defined in Table 1.

Table 1 — Minimum sensor requirements, secondary measurement parameters

Parameter	Acceptable measurement device/source[a]	Unit
Relative wind speed and direction measured at the height of the anemometer	Ship anemometer — minimum sensor accuracy of ±1 m/s, ±5°	m/s, °
Speed over ground	(D) GPS	knots
Ship heading	Gyro compass, or compass — DGPS	°
Shaft revolutions	Pick-up, optical sensor, ship revs counter with minimum sensor accuracy of ±0,5 %, 1σ	rev/min
Static draught fore and aft	Information from loading or stability computer or equivalent sources for static draught. NOTE Preference for observed draught, when available.	m
Water depth	Ship echo sounder with minimum sensor accuracy of: — ±0,5 m on the 20 m range scale, respectively; — ±5 m on the 200 m range scale; — ±2,5 % of the indicated depth, whichever is greater.	m
Rudder angle	Rudder angle indicator — minimum sensor accuracy of ±1°	°
Seawater temperature	Thermometer	°C
Ambient air temperature	Thermometer	°C
Air pressure	Barometer	Pa
[a] Minimum sensor accuracy refers to the sensor manufacturer's specified accuracy.		

For rudder angle, the following convention shall be followed: values shall range from −180° to 180°, with 0° meaning amidship, positive values meaning starboard.

True wind is calculated from relative wind at the height of the anemometer according to the procedures in Annex E. Wind direction and ship heading are defined in Figure E.2.

If ambient air temperature is not measured, a constant air temperature value of 15 °C shall be used.

If air pressure is not measured, a constant air pressure value of 101,325 kPa (1 atm) shall be used.

For vessels with twin screws, shaft revolutions shall be measured on both shafts.

It is recommended to use the same sensor type on both shafts.

4.4 Sensor installation, maintenance and calibration

All sensors shall be installed, maintained and calibrated as per manufacturer specification and as per the requirements of the ship owner's planned maintenance system. The same set of sensors and the same sensor settings shall be used in the reference period and the evaluation period. Furthermore, data

shall be logged with the same precision over the reference and evaluation period and to at least three significant figures for all parameters (except time and date).

It is underlined that speed log recalibration shall only be done according to the manufacturer specification, as the accuracy of the hull and propeller performance indicator depends critically on the correct functioning of the speed through water sensor.

4.5 External information

Speed-power data shall be available for the vessel in question. These may originate from the following power estimation approaches:

— from full-scale speed trials that were conducted and analysed according to ISO 15016;

— from towing tank tests having demonstrated compliance with international standards of quality;

— from computational fluid dynamics (CFD) simulations conducted and analysed following generally accepted state-of-the-art procedures, e.g. those recommended by the International Towing Tank Conference (ITTC);

It has to be documented how the speed-power data have been obtained.

Displacement tables and/or formulae for the vessel in question shall be made available (needed to convert measured draught and trim into displacement).

The speed-power data have to cover the actual operational speed-power range of the vessel in question and it shall be available for the actual operational loading conditions (draught, trim) of the vessel in question. Data from the same approach shall be used consistently over the whole operational range of, and over both reference and evaluation periods for, the vessel in question.

If a significant change in the operational behaviour of the vessel occurs, e.g. by following a slow-steaming regime during one period but not during another period or by starting to use trim optimization, high resolution speed-power-draught-trim data shall be used to ensure that the estimated level of accuracy (see 7.2) is maintained. Annex F describes a procedure on how to obtain high-resolution speed-power-draught-trim databases.

High resolution speed-power-draught-trim data is generally recommended in case of high variability in the operational parameters.

If speed-power reference data are not available for the actual operational speed-power range of the vessel or for the actual operational loading range of the vessel, additional speed-power data have to be estimated as follows.

If speed-power reference data are available for

— displacement values within ±5 % of the actual displacement, and

— for trim values within ±0,2 % of the length between perpendiculars of the actual trim of the vessel,

the speed-power reference data for the displacement closest to the actual displacement shall be used as reference data and remaining displacement variations shall be corrected for by following the Admiralty formula [see Formula (1)]:

$$V_2 = V_1 \left(\frac{\Delta_1^{2/3}}{\Delta_2^{2/3}} \right)^{1/3} \quad (1)$$

where

V_1 is the speed at measured displacement;

V_2 is the speed at reference displacement;

Δ_1 is the measured displacement;

Δ_2 is the reference displacement.

Otherwise, additional speed-power data shall be estimated by applying the above specified power estimation approaches. It has to be documented how the data have been obtained.

If speed-power reference data are not available for the actual operational speed-power range of the vessel or the actual loading conditions of the vessel, additional speed trials, towing tank tests or CFD calculations should be performed to obtain additional speed-power data. Alternative approaches are described in ISO 19030-3:2016, 5.4.2.

For the correction for wind resistance (as detailed in Annex G) and the true wind speed and direction (as detailed in Annex E), the following quantities are needed for one reference condition (typically design condition):

— transverse projected area of windage area and height of its (estimated) centroid above water level;

— wind resistance coefficients based on transverse projected area;

— anemometer height above sea level at reference condition (typically design condition).

As basis for the correction, wind resistance coefficients from wind tunnel tests of the vessel in question shall be used. If these are not available, wind resistance coefficients for the vessel type in question shall be used following ISO 15016.

Ship width is needed for wind correction and in the filtering for reference conditions.

5 Measurement procedures

5.1 General

This clause discusses how measurement data are to be acquired, stored and prepared.

5.2 Data acquisition

Data shall be automatically and continuously collected by the data acquisition system (e.g. a data logger) as follows in Table 2.

Table 2 — Minimum data acquisition rates

	Parameter	Minimum data acquisition rate
Primary parameters	Vessel speed through water	Once every 15 s (0,07 Hz)
	Delivered power[a]	Same as for vessel speed and same time stamp as vessel speed
Secondary parameters	Shaft revolutions	Once every 15 s (0,07 Hz)
	Relative wind speed/direction	Once every 15 s (0,07 Hz)
	Speed over ground and ship heading	Once every 15 s (0,07 Hz)
	Rudder angle	Once every 15 s (0,07 Hz)
	Water depth	Once every 15 s (0,07 Hz)
	Static draught fore and aft	Whenever loading condition changes
	Water temperature	Once every 15 s (0,07 Hz)

[a] The sensor measurements needed to estimate delivered power by either Annex B or Annex C shall be logged at the minimum acquisition rate for the primary parameters and with the same time stamp.

The data sampling rate shall remain unchanged over the full measurement period (reference period and evaluation period).

NOTE Over short periods of time, the data sampling rate may coincide with the frequency of a natural phenomenon for the vessel in question (e.g. wave encounter frequency) and thereby influencing the accuracy of associated data point.

5.3 Data storage

All data collected over the measurement period shall be stored in the data acquisition system. All data shall be stored as raw data along with time stamps as time offsets from universal time coordinated (UTC)[2] indicating the point in time the data were collected.

It is recommended that data shall be backed up at an appropriate backup facility at a minimum of once every month. If the data acquisition system is kept on board the vessel, it is recommended that the backup facility is located elsewhere.

At any one time it shall be possible for the owner of the data to retrieve all data stored in the data acquisition system or at the backup facility as raw data along with the time stamps. The data shall be retrievable in a commonly used electronic format.

It is recommended that all collected data be stored in the data acquisition system and/or at the backup facility at least over the remaining life of the ship in question or as determined by the use of the standard.

NOTE Annex H recommends a format of exporting stored data.

5.4 Data preparation

5.4.1 General

Data preparation involves retrieving, compiling, filtering and validating collected data in order to provide a structure, format and quality that is suitable for further processing and in order to enable corrective measures if the collected data are found to be invalid (e.g. on account of sensor drift). It furthermore comprises the calculation of performance values (PVs) used in subsequent calculation of performance indicators (PIs).

2) UTC being defined by ISO 8601: "YYYY-MM-DDTHH:MM:SS±hh"

5.4.2 Data preparation frequency

Data shall be prepared regularly, in order to enable timely corrective measures (e.g. sensor recalibration).

It is recommended that the data are prepared at least once every month.

5.4.3 Data retrieval

Collected data should be retrieved such that a copy of the originally stored raw data is left on the data acquisition system or at the backup facility (copy not deleted). This shall ensure that a copy of the originally stored raw data will always remain available.

5.4.4 Data compilation

5.4.4.1 General

The data shall be compiled into a tabular format and sorted sequentially based on the time stamp of the primary measurement parameter data. The time stamp of the primary parameter data shall serve as unique identifier (UI).

5.4.4.2 Data preparation for data from different sampling rates

Data collected at a higher frequency than the primary measurement parameters shall be averaged over the relevant time interval. High-frequency data collected between two successive lower-frequency measurements of primary parameters shall be averaged as given in Formula (2):

$$a_{i+f^{-1}} = \frac{1}{n_k} \sum_{1}^{n_k} m_k \quad \text{for} \quad i < k \le i + f^{-1} \tag{2}$$

All high-frequency measurement values, m_k, with time stamp k, shall be averaged into an average value a if k is between the primary measurement parameter time stamp i and the subsequent time stamp $i + f^{-1}$ where f is the frequency at which the primary measurement parameters are collected (e.g. 1 signal every 15 s). The number of high-frequency measurement values in the so defined time interval is given by n_k.

Data from signals collected at a lower frequency than the primary measurement parameters shall be duplicated over the relevant time interval. The low-frequency measurement value, m_k, with time stamp k, shall be duplicated in values a_i with time stamps i from the higher frequency, primary measurement parameters, where i lies between k and the foregoing time stamp $k - t^{-1}$ [see Formula (3)]. t is the frequency at which the lower frequency measurement parameter is collected.

$$a_i = m_k \quad \text{for all } i \text{ in } k - t^{-1} < i \le k \tag{3}$$

5.4.4.3 Additional data preparation for twin screw vessels

In case of twin screw vessels, the arithmetic mean of the rpm and the sum of the delivered power of the port and starboard shafts shall be computed and added to the data set.

5.4.4.4 "Data point" and "retrieved data set"

The combination of a unique identifier (UI) and a complete set of data from all signals shall be referred to as a "data point". The complete set of retrieved data points shall be referred to as the "retrieved data set".