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Part 3: Elastic vibration method

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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).

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 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 2, *Marine environment protection*.

A list of all parts in the ISO 20083 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

Selecting the optimum rating of a ship's main engines is important for ship owners, because it greatly affects the expenses of operations, maintenance and management as well as the ship's construction cost.

Measuring the output of the ship's main engine is important for confirming the ship efficiency, as well as for assessing the possible deterioration of the propulsion equipment or the accumulation of fouling on the hull over time. There are many methods of measuring an engine's output: (1) measuring the distortion of the shaft, (2) determining the fuel consumption, and (3) observing engine indicators such as cylinder pressure gauges.

Among these methods, ISO 20083 addresses the shaft distortion measurement with a shaft power meter, a method commonly used as the principal measurement of engine power output.

The purposes of shaft power measurement are:

— to provide a measurement of the ship's main engine output;

— to provide information regarding the ship's most efficient speed;

— to select optimum engine operational characteristics;

— to estimate maintenance and repair costs; and

— to monitor heavy propeller running.

Ships and marine technology — Determination of the shaft power of ship propulsion systems by measuring the shaft distorsion —

Part 3: Elastic vibration method

1 Scope

This document specifies a procedure to determine the shaft power of engine ships, by measuring the shaft distortion using an elastic vibration type device. It gives the principles of the measurement, the components of the device and the calculation method. It also describes the factors for determining the measuring accuracy and specifies the on-board documentation for the device.

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
shaft
propeller shaft or intermediate shaft which transmits the engine power to the propeller, and on which the shaft power meter is equipped

3.2
shaft torque
Q
turning moment transmitted to the shaft that is generated by the engine to rotate the propeller

Note 1 to entry: It is expressed in newton meters.

3.3
shaft power
P_S
power transmitted to the shaft that is generated by the engine to rotate the propeller

Note 1 to entry: It is expressed in kilowatts.

3.4
sensor
instrument containing elastic vibrating material whose natural frequency is altered due to a change in the length of the material

4 Principles of the measurement

The shaft power meter is a device that measures the shaft revolution and the torsional deformation of the shaft caused by the shaft torque. The shaft power, P_S [kW], is calculated using Formula (1).

$$Ps = \frac{2 \cdot \pi \cdot N \cdot Q}{60} \times \frac{1}{1\ 000} \tag{1}$$

where N is the rate of shaft revolutions per minute[min^{-1}].

The shaft torque, Q [Nm], is calculated from the torsional deformation angle rate at unit length of the shaft using Formula (2).

$$Q = \frac{\mathrm{G} \cdot Ip \cdot \theta'}{1\ 000} \tag{2}$$

where

G is the G-modulus [N/mm^2];

I_p is the polar moment of inertia[mm^4];

θ' is the shaft torsional deformation angle rate at unit length [1/mm].

The polar moment of inertia, I_p [mm^4], is calculated using Formula (3).

$$I_p = \frac{\pi}{32}\left(D_o{}^4 - D_i{}^4\right) \tag{3}$$

where

D_o is the outer diameter of the shaft [mm];

D_i is the diameter of the hollow shaft [mm].

The shaft torsional deformation angle rate at unit length, θ' [1/mm], is calculated using Formula (4).

$$\theta' = \frac{\theta}{l} \tag{4}$$

where

θ is the shaft torsional deformation angle [rad] as shown in Figure 1;

l is the length between the shaft rings [mm].

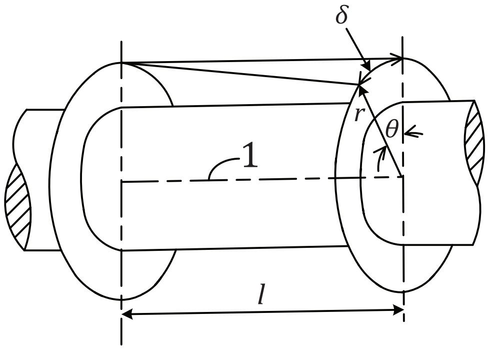
The torsional deformation angle, θ [rad], can be calculated from the displacement of the detecting point as given in Formula (5).

$$\theta = \frac{\delta}{r} \tag{5}$$

where

δ is the displacement of the detecting point [mm];

r is the distance of the detecting point from the shaft center line [mm].



Key

1 center line

θ shaft torsional deformation angle [rad]

l length between rings [mm]

δ displacement of the detecting point [mm]

r distance of the detecting point from the shaft center line [mm]

Figure 1 — Torsional deformation angle of a shaft

The elastic vibration type device calculates the displacement (δ) of a detecting point using the measured natural frequency of a sensor.

The relationship between the natural frequency and the tension of the sensor is given in Formula (6).

$$f = \frac{1}{2L}\sqrt{\frac{T}{\rho}} \tag{6}$$

where

f is the natural frequency [Hz];

T is the tension of the sensor [N];

ρ is the density of the sensor [kg/m];

L is the length of the sensor [m].

According to Formula (6), the tension (T) is proportional to the square of the natural frequency (f^2) of the sensor.

The tension (T) is also proportional to the displacement (δ) of the sensor because of the added tension being beyond the proportional limit of the material. Accordingly, the displacement (δ) of the sensor is proportional to the square of the natural frequency (f^2).

The relationship between the natural frequency (f) and the displacement (δ) of the sensor is given in Formula (7).

$$\delta = C \times \Delta f^2 \tag{7}$$

where C is a proportional constant defined as the sensitivity constant.

The sensitivity constant, C, is determined by the dedicated calibration device.

Δf^2 is the difference between the square of the natural frequency at displacement by (δ) and that at the initial condition.