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Ships and marine technology — Energy efficiency —

Part 1: Energy efficiency of individual maritime components

Navires et technologie maritime — Éfficacité énergétique —

Partie 1: Efficacité énergétique des éléments maritimes individuels

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Foreword

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

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

Environmental concerns, emission regulations, fuel prices, and emission taxes are increasing the demand for greater energy efficiency in shipping. In 2013, the International Maritime Organization (IMO) adopted the Ship Energy Efficiency Management Plan (SEEMP)[1] to significantly decrease the amount of carbon dioxide (CO_2) emissions by 10 % to 50 % per transport work in international shipping. This strategy refers to a pathway of CO_2 emissions reduction which is consistent with the goals of the Paris Agreement,[14] alongside the United Nations 2030 Agenda for Sustainable Development.[15]

Standardizing methods to evaluate energy efficiency in the maritime sector interface is valuable for a range of different stakeholders, including:

— shipowners who are looking to buy maritime systems to comply with IMO SEEMP initiatives;

— maritime equipment and engine manufacturers who are responsible for the design and production of ship systems;

— governments that are committed to environmental regulations and environmental targets such as the “levels of ambition” adopted by IMO.

The purpose of this document is to improve energy efficiency in ships by providing more energy efficient options that can be considered when replacing malfunctioning components throughout the ship lifetime.

This document allows shipowners and shipyard workers to objectively identify the most energy-efficient components for retrofits, as well as newbuilds.

The document provides a method for comparing energy performance on an objective basis to prevent energy loss and to improve cost-efficiency and environmental conditions during maritime transport. This document makes it possible for users to compare the energy efficiency of different individual maritime components based on a standardized method to measure and calculate the values.

It is a widely established that the usual combination of best efficient single systems on board do not lead in sum to the most efficient ship. It is common practice that owners instruct shipyards to meet the criteria for an optimized operating point of the respective ship system during the design phase (new build or reconstruction).

Accordingly, a shipyard checks before installation that each single system or component meets good energy efficiency values. It is not possible to calculate the ship's overall efficiency if the operating conditions are not standardized.

An example of a system or component where the efficiency depends on the operational conditions is an engine room ventilation without a given fan speed control system. If fan is designed and optimized for the tropical zone and the ship is operated under North Atlantic conditions, less power is necessary during winter times. Owing to the absence of a controller, the fan rotation speed cannot be adjusted. In sum, every single fan can operate efficiently on a test bed. An efficient performance is questionable if the ship sails under different operational conditions than what it is designed for.

To raise the overall operational energy efficiency of a ship in different operational conditions, the overall ship-individual combined system efficiency check should be performed. In addition, manufacturers, and operators should take into account the possible variations between test bed conditions and onboard test conditions when developing individual components and systems.

Ships and marine technology — Energy efficiency —

Part 1:
Energy efficiency of individual maritime components

1 Scope

This document specifies generic measuring and calculation methods to evaluate the energy efficiency of individual maritime components installed on board ships, vessels for inland navigation or offshore structures. This document only covers energy consuming components for which a “unit output” can be clearly defined and which require energy to function.

This document only covers the major energy consuming components of a typical ship. It does not cover the propulsion component of the ship (e.g. the propeller).

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 terminology databases for use in standardization at the following addresses:

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

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

3.1
energy efficiency
ratio or other quantitative relationship between an *output* (3.4) of performance, service, goods or energy, and an *input* (3.3) of energy

EXAMPLE Efficiency conversion energy; energy required/energy used; output/input; theoretical energy used to operate/energy used to operate.

Note 1 to entry: Both input and output shall be clearly specified in quantity and be measurable.

[SOURCE: ISO/IEC 13273-1:2015, 3.4.1]

3.2
component
element performing only one function whose efficiency is defined by the ratio between *input* (3.3)and *output* (3.4)

EXAMPLE Electric motor, water pump.

3.3
input
product, material or energy flow that enters a *component* (3.2)

Note 1 to entry: Products and materials include raw materials, intermediate products and co-products.

3.4
output
product, material or energy flow that leaves a *component* (3.2)

Note 1 to entry: Products and materials include raw materials, intermediate products, co-products and releases.

4 Symbols and abbreviated terms

The following symbols are used throughout the document:

EER	energy efficiency ratio used in the heating/cooling industry	non-dimensionless
E	energy consumption	J
P	power consumption	W
Q	thermal energy	J
T	temperature	K or °C
V	volume	m^3
q_V	volume flow rate	m^3/s
q_m	mass flow rate	kg/s
c_p	specific heat capacity at constant pressure	J/kg K
c_V	specific heat capacity at constant volume	J/kg K
H	enthalpy	J/kg
η	efficiency ratio	dimensionless
ρ	density of water	kg/m^3
τ	torque	N·m

5 Method to evaluate the energy efficiency of individual maritime components

5.1 General

This document focuses on the components responsible for the major energy consumption of a typical ship.

The component types are categorized into the following groups:

— pumps (Clause 6);

— fans (Clause 7);

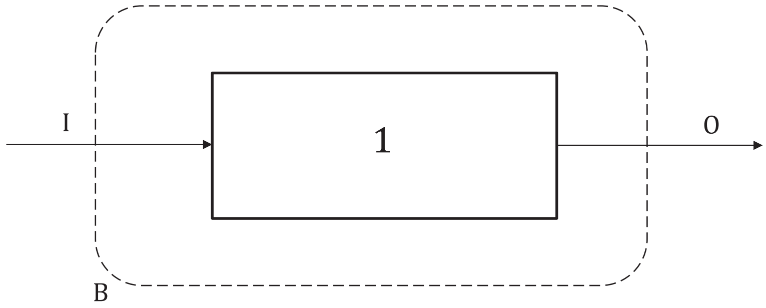
— gearboxes (mechanical power transmission) (Clause 8);

— heat exchanging (Clause 9);

— centrifuges (Clause 10).

The energy efficiency of the component is evaluated based on its expected operational purpose on board the ship and during its expected process operating window. This means that the boundary conditions on which the component is evaluated are defined to represent the normal operational pattern. This operational pattern can include the variations in ambient conditions or variations in the ship's operational pattern. This will be defined for each of the components.

The basic terminology of a maritime component is illustrated in Figure 5.1.



Key

B boundary

1 component

I input (energy, temperature, pressure, flow, concentration, force, velocity, torque, electricity)

O output (energy, temperature, pressure, flow, concentration, force, velocity, torque, electricity)

Figure 5.1 — Basic terminology of a maritime component

In relation to this document in the pursuit of simplifying the energy efficiency consideration of components, it is acknowledged that some influencing parameters are ignored, however such parameters will only have a minor impact on the result and are, hence, considered negligible unless otherwise addressed.

5.2 Measuring conditions

The actual conditions, such as ambient air temperature and shaft speed, etc. shall be recorded on the measuring report when the parameters for the energy efficiency are measured.

The parameters shall be measured by appropriately calibrated measuring instruments.

6 Pumps

6.1 General

Pumps have a wide variety of functions on a ship. For each purpose, several pump types can be used.

This document covers the energy efficiency for the following pump types.

- Positive displacement pumps:
  - reciprocating pump (piston pumps, plunger pumps etc.);
  - rotary pump (gear pump, screw pump, vane pump, lobe pump etc.).
- Dynamic pressure pumps:
  - centrifugal pump.

6.2 Definition of input and output

The definitions of the inputs and outputs are made generic for all the pump types. Each pump type has its own set of properties that affect the efficiency, but these are not accounted for in this document.

Clause 6 does not consider the efficiency of power production, such as electrical power, pneumatic power or hydraulic power.

The input and output of a pump component consists of the following:

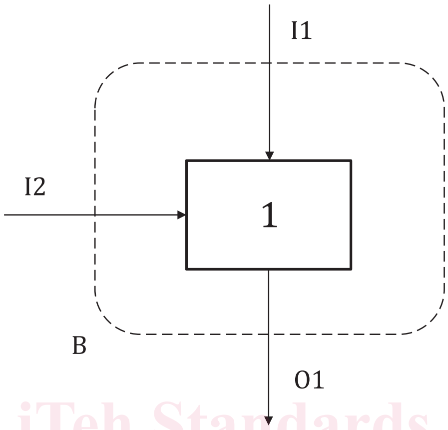
— input: liquid inlet (inlet pressure and flow), pump shaft power;

— output: liquid outlet (outlet pressure and flow).

6.3 Definitions of boundaries and media

The boundary of a pump is set to exclude the motor and any gear. These components form a complete working pump unit, and all of these elements are necessary for a functional pump unit. Any auxiliary devices, such as mechanical seal barrier systems, are also excluded from the energy efficiency consideration.

The pump component and its boundaries are shown in Figure 6.1.



Key

B boundary
I1 liquid inlet (pump suction)
I2 pump shaft power
1 pump
O1 liquid outlet (pump discharge)

Figure 6.1 — Boundaries of a pump component

6.4 Calculation method

The general formula for pump efficiency, valid for all pump types, is shown in Formula (6.1):

$$\eta_{pump} = \frac{q_V \cdot \Delta p}{P_{pump}} \quad (6.1)$$

where

q_V is the liquid flow of the pump, expressed in m^3/s;

Δp is the differential pressure – liquid outlet pressure minus liquid inlet pressure – of the pump, expressed in Pa;

P_{pump} is the pump shaft power, expressed in W.

A pump can state a liquid head (or column) height expressed in metres.

The relation between liquid head and pressure is shown in Formula (6.2):

$$p = \rho \cdot g \cdot h \quad (6.2)$$

where

p is the pressure, expressed in Pa;

ρ is the density of the liquid, expressed in kg/m^3;

g is the gravity constant 9,81 m/s^2;

h is the liquid head, expressed in m.

Combining Formulae (6.1) and (6.2), the formula for efficiency of a pump can be written as Formula (6.3):

$$\eta_{\text{pump}} = \frac{q_V \cdot \rho \cdot g \cdot \Delta h}{P_{\text{pump}}} \qquad (6.3)$$

where

q_V is the liquid flow of the pump, expressed in m^3/s;

Δh is the differential head – liquid outlet head minus liquid inlet head – of the pump, expressed in m;

ρ is the density of the liquid, expressed in kg/m^3;

g is the gravity constant 9,81 m/s^2;

P_{pump} is the pump shaft power, expressed in W.

6.5 Measuring method

To measure the pump efficiency, it is most useful to use Formula (6.1), rather than Formula (6.3), as it is easier to measure the pressure instead of head. Formula (6.1) is suitable for any pump type.

As it is difficult to measure the pump shaft power directly, the motor power should be measured and adjusted for the motor efficiency η_{motor}. This relation is shown in Formula (6.4)

$$P_{\text{pump}} = P_{\text{motor}} \cdot \eta_{\text{motor}} \qquad (6.4)$$

If shaft power is used as input, the efficiency can be found in IEC 60034-2-1[13].

Combining Formulae (6.1) and (6.4) gives an expression for pump efficiency that is easy to measure, as shown in Formula (6.5):

$$\eta_{\text{pump}} = \frac{q_V \cdot \Delta p}{P_{\text{motor}} \cdot \eta_{\text{motor}}} \qquad (6.5)$$

The measuring method is illustrated in Figure 6.2.