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PREVENTION OF AIR POLLUTION FROM SHIPS

Draft guidelines for the simulation of ship performance to obtain the coefficient "f_W" in the new ship design CO_2 index

Submitted by Japan

SUMMARY

Executive summary:	This document provides draft guidelines for the simulation of ship performance to obtain the coefficient "f_W" in the new ship design CO_2 index
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.1 and 7.3.1.3
Action to be taken:	Paragraph 4
Related documents:	MEPC 58/4, paragraph 2.23 and annex 5; MEPC 58/4/28; MEPC 57/4/3, MEPC 57/4/11, MEPC 57/4/12 and MEPC 57/INF.12

Introduction

1 This document provides comments on document MEPC 58/4 and is submitted in accordance with paragraph 4.10.5 of the Committee's Guidelines (MSC-MEPC.1/Circ.2).

2 The Draft Guidelines on the Method of Calculation of the New Ship Design CO_2 Index (annex 5 to MEPC 58/4) contains the coefficient "f_W", which can be determined either by conducting simulation for an individual ship or by taking the default f_W value from the "standard f_W curve"; the simulation methodology should be described in the Guidelines developed by the Organization (paragraph 9 of annex 5 to MEPC 58/4). The annex to this document provides draft guidelines prescribing the simulation procedures to determine ship performance to obtain the coefficient "f_W".

3 It should be noted that most of the technique, assumptions and approximation used in these draft guidelines are well established and commonly used by various maritime research institutes and industries (e.g., shipbuilders) worldwide; therefore the methodology and outcome are verifiable by organizations having proper expertise, e.g., the classification societies.

Action requested of the Committee

4 The Committee is invited to consider the proposal on the draft guidelines for the simulation of ship performance set out in the annex and take action as appropriate.

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ANNEX

DRAFT GUIDELINES FOR THE SIMULATION OF SHIP PERFORMANCE TO OBTAIN THE COEFFICIENT "f_W" IN THE NEW SHIP DESIGN CO_2 INDEX

1 GENERAL

These guidelines are intended as guidance on conducting the simulation to obtain the f_W coefficient, which is contained in the new ship design CO_2 index, for an individual ship. These guidelines apply to ships of which ship resistance as well as brake power in a calm sea condition (no wind and no waves) is estimated by a tank test or an alternative method equivalent in terms of accuracy. The design parameters and the assumed conditions in the performance simulation should be consistent with those used in calculating the other components in the new ship design CO_2 index.

2 METHOD OF CALCULATING f_W

2.1 Calculation of f_W

f_W is calculated by dividing V_w by V_{ref} as follows:

$$f_W = V_w / V_{ref} \text{ at } P_B(V_{ref}) = P_{Bw}(V_w) \qquad (1)$$

where:

V_w is the design ship speed when the ship is in operation under the representative sea conditions.

V_{ref} is the design ship speed when the ship is in operation in calm sea condition (no wind and no waves).

Resistance in the representative sea condition, R_{Tw}, is calculated by adding ΔR_w, which is the added resistance due to wind and waves derived from the section 2.3, to the resistance R_T derived from a tank test in a calm sea condition or an alternative method equivalent in terms of accuracy. The design ship speed V_w is the value of V where the main engine power $P_{Bw}(V_w)$ under the aforementioned resistance under wind and waves equals $P_B(V_{ref})$, which is the brake power required obtaining the speed of V_{ref} in calm sea condition. In calculating P_{Bw} from the total resistance R_{Tw}, the properties for propellers and propulsion efficiency should be derived from the formulas obtained from a tank test or an alternative method equivalent in terms of accuracy.

The basic procedures in calculating the aforementioned values as well as relation between the power and f_W are shown in Figure 1 and Figure 2, respectively.

2.2 Assumed operating conditions

2.2.1 Sea conditions

- The representative sea conditions should be selected, taking into account normal operation patterns of ships.
- The long-term ocean statistics in North Atlantic Ocean[1),2)] and North Pacific Ocean[1)] show that the mean of wave height there is in the range from 2.4m to 3.4m, which corresponds to Beaufort number 6, prescribed in Beaufort scale[3)].

- The representative sea conditions are provided in Table 1 based on Beaufort scale.
- To obtain the mean wave period from Beaufort scale, the following formula derived from a frequency spectrum for fully-developed wind waves is used[4)].

$$T = 3.86\sqrt{H_{1/3}} \quad (2)$$

where, $H_{1/3}$ is significant wave height in meter and T is mean wave period in second.

- The direction of wind and waves are defined as heading direction, which has the most significant effect on the speed reduction.

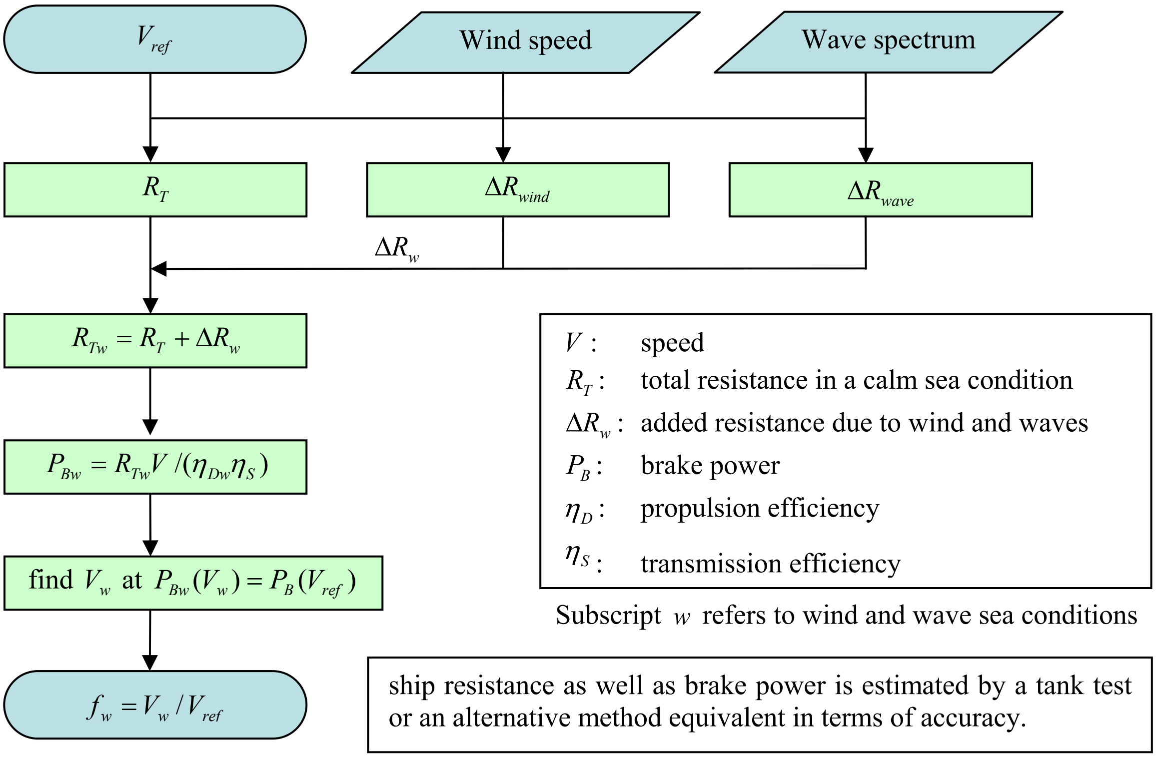

Figure 1 – Flow chart of calculation for f_W

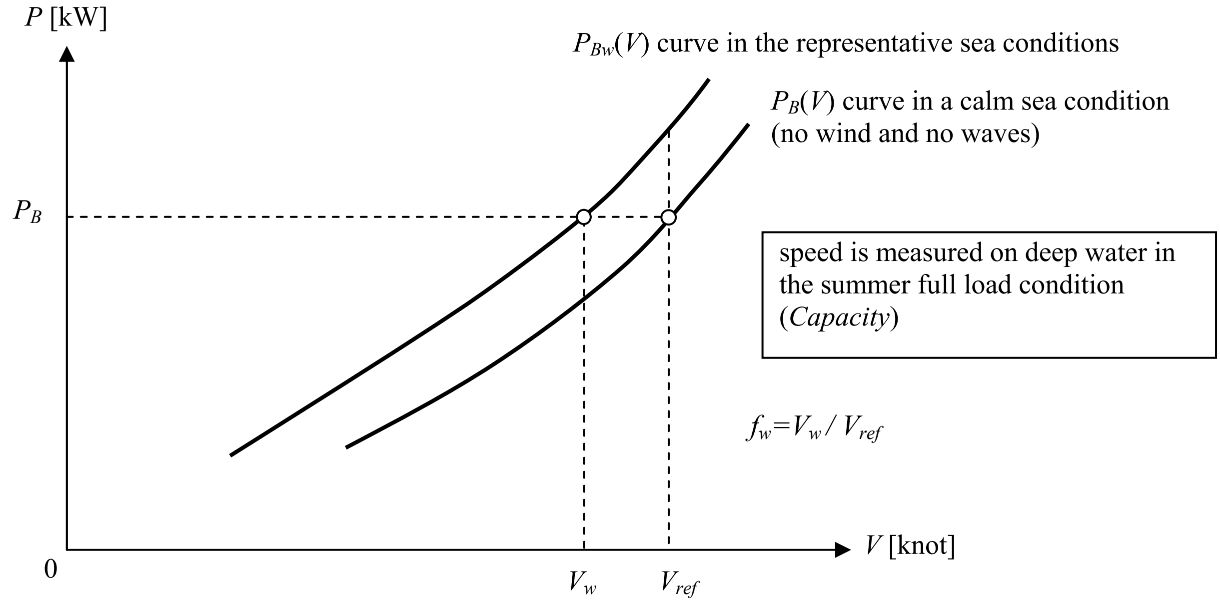

Figure 2 – Relation between power and f_W

Table 1 Representative sea conditions

Wind	Mean wind speed: 12.6 (m/s) Mean wind direction: 0 (deg.) (heading)
Wave	Significant wave height: 3.0 (m) Mean wave period: 6.7 (s) Mean wave direction: 0 (deg.) (heading)

- As ocean waves are characterized as irregular ones, the directional spectrum should be considered. The directional spectrum prescribed in IACS Rec. No.34[2)] should be applied.

2.2.2 Ship conditions

- The assumed ship conditions are summer full load, constant main engine output (e.g., 75% of MCR, to be consistent with the one used in the calculation of the design index), and operation in steady navigating condition on the fixed course.

2.3 Method of calculating added resistance due to wind and waves

Added resistance due to wind and waves acts simultaneously on the ship under the condition provided in Table 1.

2.3.1 Added resistance due to wind, ΔR_{wind}

ΔR_{wind} is calculated by formula (3) on the basis of the mean wind speed and wind direction given in Table 1. The drag coefficient, C_{Dwind} , should be determined by model tests in a wind tunnel or the equivalent formula as described in Appendix (MEPC 58/4/28).

$$\Delta R_{wind} = \frac{1}{2}\rho_a A_T C_{Dwind}\left\{\left(U_{wind} + V_w\right)^2 - V_{ref}^{\ 2}\right\} \qquad (3)$$

where:

ρ_a : air density (1.226(kg/m^3)), A_T : projected transverse area above the summer load line,
U_{wind} : mean wind speed(12.6 (m/s))

2.3.2 Added resistance due to waves, ΔR_{wave}

Irregular waves can be represented as linear superposition of the components of regular waves. Therefore ΔR_{wave} is also calculated by linear superposition of added resistance in regular waves. Added resistance in regular waves, R_{wave}, should be determined by a tank test or a formula equivalent in terms of accuracy.

In case of applying the theoretical formula, R_{wave} should be calculated from the components of R_{wm} and R_{wr}.

$$R_{wave} = R_{wm} + R_{wr} \tag{4}$$

where:

R_{wm} : added resistance due to ship motion in regular waves, calculated by Maruo's theorem[5] as described in Appendix 2 to MEPC 58/4/28.
R_{wr} : added resistance due to wave reflection in regular waves, calculated by the formula as described in Appendix 2 to MEPC 58/4/28.

References

1) British Maritime Technology: Global Wave Statistics, Unwin Brothers Limited, London, 1986.

2) International Association of Classification Societies: Standard Wave Data, IACS Rec. No.34 (Rec. 2000/Corr. 2001).

3) World Meteorological Organization: Manual on Codes International Codes, Volume I.1, Part A-Alphanumeric Codes, WMO-No. 306 (1995 edition).

4) W. G. Price and R. E. D. Bishop: Probabilistic Theory of Ship Dynamics, Chapman and Hall, London, pp.157-163, 1974.

5) H. Maruo: Resistance in Waves, Research on Seakeeping Qualities of Ships in Japan, The Society of Naval Architects of Japan, Vol.8, 1963, pp.67-102.

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