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PREVENTION OF AIR POLLUTION FROM SHIPS

New Ship Design CO_2 Index

Submitted by Finland and Sweden

SUMMARY

Executive summary:	The purpose of this document is to consider the possibilities of determination one of the f_j coefficients and an additional coefficient f_i with regard to ice-strengthened ships for the attained new ship design CO_2 index. Great difficulties are foreseen for the determination of standard values for the f_j and f_i coefficients for ice-strengthened ships. However, the f_i coefficient can be determined for individual ships taking into account the increase of the light weight of the ship due to ice strengthening and the f_j coefficient can be calculated to take into account the minimum engine power requirements stipulated by ice class rules, or requirement for level ice breaking capability. If level ice breaking capability is required for a cargo vessel, i.e. if the design of the hull form is based on ice-breaking requirements, even the adjustment of the f_w coefficient for an individual ship may turn out to be necessary for an ice-strengthened ship
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.3
Action to be taken:	Paragraph 20
Related document:	MEPC 58/4

Background and purpose of the document

1 The first Intersessional Meeting of the Working Group on Greenhouse Gas Emissions from Ships developed a proposal for a mandatory new ship design CO_2 index, which is presented in annex 5 of the report of the meeting.

2 In the proposed formula, f_j and f_k are correction factors to account for ship-specific design elements such as, e.g., ice strengthening, cargo gear or reefer containers. f_j and f_k refer to main and auxiliary engine, respectively; see section 8 of annex 5 to document MEPC 58/4.

3 In section 8 of annex 5 to document MEPC 58/4, it is noted that a method for determination of f_j and f_k should be prepared and prescribed. The purpose of this document is to consider the possibilities of determination of these coefficients with regard to ice-strengthened ships.

Ice strengthening of ships

4 Ships intended to be able to sail in ice-covered waters, e.g., in the Baltic Sea area during wintertime or in Arctic or Antarctic regions, need to be strengthened against ice loads. Those areas of the hull exposed to ice loads and the propulsion line have to be designed to withstand ice impact loads. This means that the light weight of ice-strengthened ships is higher and consequently the deadweight is smaller than that of ships designed for open water conditions only. For example, the steel weight of the hull can be 5-10% higher for an ice-strengthened ship compared to a ship designed for open water conditions only. This means also that an ice-strengthened ship has a higher value of the attained new ship design CO_2 index than a non-ice-strengthened ship, if the ships are otherwise identical.

5 Owing to operational and safety reasons, ice-strengthened ships also often have a higher engine power than ships designed for open water conditions only. This will also result in a higher value of the attained new ship design CO_2 index for an ice-strengthened ship than a non-ice-strengthened ship would have.

Ice class rules

6 The Finnish (FMA) and Swedish (SMA) Maritime Administrations have issued ice class rules for the ice strengthening of ships (see e.g., www.fma.fi -> FMA Bulletin -> Regulations in force -> Bulletin 13/1.10.2002, Finnish-Swedish Ice Class Rules). These rules are intended to be used for the ice strengthening of ships navigating in the Baltic Sea area, i.e. in first year ice conditions. Four ice classes for ice strengthening of ships are given: IC, IB, IA and IA Super, where IA Super is the highest ice class. Ships having ice class IA or IA Super are intended for year-round navigation in the Baltic Sea area even in the most severe ice conditions.

7 Most of the classification societies which are members of the International Association of Classification Societies (IACS) have adopted the Finnish-Swedish Ice Class Rules in their own rules for classification of ships. However, many of them also have their own ice class rules for the ice strengthening of ships. Some of them also have ice class rules for ships navigating in the Arctic, i.e. in areas where multi-year ice exists. The Arctic ice class rules have now been harmonized with the introduction of IACS PC ice classes.

8 Thus, no single standard exists for the ice strengthening of ships. Any existing rules for ice strengthening can be used. A number of equivalent ice classes to the Finnish-Swedish ice classes have been presented in the FMA Bulletin 4/2.4.2007.

Proposals for determination of the f_j correction factor and for an additional correction factor f_i for the attained new ship design CO_2 index

9 Two factors were identified above, which should be considered when ice strengthening is to be taken into account for calculation of the attained new ship design CO_2 index: The increase of light ship weight leading to a decreased cargo carrying capacity due to ice strengthening, and minimum engine power requirements stipulated in the ice class rules. The third factor is in principle that, in case the hull form of the ship has been optimized for navigation in ice, the performance of the ship in open water conditions is usually less optimal, i.e. the resistance in calm water is higher and also the decrease of speed in sea conditions may be higher than for the

ship designed for open water conditions. An ice-breaking hull form also has a smaller block coefficient (C_B) value leading to a decrease in cargo carrying capacity. This last factor can, however, be taken into account with the increased light ship weight.

10 The basis of the proposal is that the attained new ship design CO_2 index will be modified to account for the ice strengthening requirements. The modification is done by determining one of the f_j correction factors and introducing a new correction factor f_i to the capacity. Using these corrections, ice class ships are made comparable with open water ships and the same baseline index can be used. The modified form of the attained new ship design CO_2 index is thus:

Attained new ship design CO_2 index =

$$\frac{\left(\prod_{j=2}^{M} f_1 \cdot f_j\right)\left(\sum_{i=1}^{NME} C_{FMEi} \cdot SFC_{MEi} \cdot P_{MEi}\right) + \left(\prod_{k=1}^{L} f_k\right)\left(\sum_{i=1}^{NAE} C_{FAEi} \cdot SFC_{AEi} \cdot P_{AEi}\right)}{\left(f_i \cdot capacity\right) \cdot \left(V_{ref} \cdot f_W\right)}$$

where f_1 takes into account the increased propulsion power for ice performance and f_i the decreased capacity due to ice strengthening.

The increase of the light weight

11 The increase of the light weight of the ship due to ice strengthening when calculating the attained new ship design CO_2 index can be taken into account by calculating the additional weight of the ice strengthening of the hull and the propulsion line. The increase of the light weight can be compensated by giving a value of more than one for the new f_i coefficient. The increase of the weight of the ship due to ice strengthening depends on the ice class, ship size and ship type. Therefore "standard values" for f_i coefficient cannot be given, but for an individual ship the coefficient can be determined during the design process of the ship.

12 The determination of the f_i coefficient due to the increase of the light weight of the ship can be done as follows:

$$f_i = 1 + \frac{w_i}{LSW},$$

where w_i is the additional weight of the ice strengthening and *LSW* the light ship weight of an open water ship with similar main dimensions.

Minimum engine power requirements

13 In some ice class rules, e.g., Finnish-Swedish Ice Class Rules, minimum engine power requirements are given for different ice classes. The minimum engine power is the maximum output the propulsion machinery can continuously deliver to the propeller(s). Thus the minimum engine power requirement is relevant for the determination of the f_j coefficient (denoted as f_1 in the above formula in section 10). The design requirement for ice classes is a minimum speed of 5 knots in a brash ice channel with a certain thickness of the brash ice. It should be emphasized that no requirements for the hull form are given but, in principle, all hull forms used in open water for cargo ships are acceptable. The minimum engine power depends, e.g., on the ice class of the ship, the size of the ship, the number of propellers and the hull form. Therefore, a "standard value" for the f_1 coefficient cannot be given, but for an individual ship the coefficient can be determined during the design process of the ship.

14 The f_1 coefficient due to the minimum engine power requirements stipulated in the ice class rules or due to the required level ice-breaking capability of the cargo ship can be calculated as follows:

$$f_1 = \frac{P(V_{ref})}{\sum_{i=1}^{NME} P_{MEi}},$$

where V_{ref} is the design ship speed in open water and $P(V_{ref})$ is the power required to attain this speed in open water. ΣP_{MEi} is the total installed propulsion power due to ice-going capability requirements. If the engine power required for the open water speed is higher than the engine power required by ice class rules or by level ice-breaking requirement, $f_1 = 1.0$.

Hull form

15 In some ice class rules, where level ice breaking capability is required for cargo ships, usually requirements for the hull form are also given. This will limit the possibility of the designer of the ship to optimize the resistance of the ship in open water, and it may also have an effect on the decrease of speed in sea condition, i.e. on the f_w coefficient. Thus, even the adjustment of the f_w coefficient for an individual ship may turn out to be necessary for an ice-strengthened ship.

Summary

16 There is no single standard for the ice strengthening of ships, but several ice class rules are available for this purpose. Some ice class rules also have minimum engine power requirements for ice-strengthened ships.

17 The increase of the light weight of the ship due to ice strengthening can be compensated by introducing a new coefficient f_i. It is a rather laborious task to develop standard values for this coefficient due to the many different ice class rules and ice classes. The coefficient depends also on the size of the ship and its type. However, for an individual vessel, f_i coefficient can be calculated during the design process of the ship.

18 It is even more difficult to develop standard values for the f_1 coefficient to take into account minimum engine power requirements due to the fact that it depends on a wide range of parameters, e.g., on the ice class of the ship, the size of the ship, the number of propellers and the hull form. Of course, for an individual ship the f_1 coefficient can be determined.

19 If a level ice breaking capability is required for a cargo vessel, i.e. if the design of the hull form is based on ice-breaking requirements, even an adjustment of the f_w coefficient for an individual ship may turn out to be necessary for an ice-strengthened ship. The adjustment of the f_w coefficient for an ice-strengthened ship should be included in the Guidelines developed by the Organization where the determination of the f_w coefficient shall be prescribed. At this point in time, we do not have a proposal on the details of this methodology.

Action requested of the Committee

20 The Committee is invited to consider the proposals above and decide as appropriate.

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