INTERNATIONAL MARITIME ORGANIZATION

IMO

E

MARINE ENVIRONMENT PROTECTION COMMITTEE
58th session
Agenda item 4

MEPC 58/4/8
31 July 2008
Original: ENGLISH

PREVENTION OF AIR POLLUTION FROM SHIPS

Methodology for Design CO_2 Index Baselines and Recalculation thereof

Submitted by Denmark

SUMMARY

Executive summary:	This document explains the methodology establishing baselines for design CO_2 indexes and recalculation thereof cf. paragraph 2.14 of the report from the first intersessional Meeting of the Working Group on Greenhouse Gas Emissions from Ships. The baseline is one of the building blocks for a mandatory 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 22
Related documents:	MEPC 58/4; GHG-WG 1/2/1; GHG-WG 1/2/2; MEPC 57/4/3, MEPC 57/4/11, MEPC 57/4/12; MEPC 57/INF.12 and MEPC 57/WP.8

Introduction

1 MEPC 57 tasked the first intersessional Meeting of the Working Group on Greenhouse Gas Emissions from Ships (GHG-WG1) to develop a mandatory design CO_2 index for new ships and, if deemed appropriate, for approval at MEPC 58. Based on the two submissions from Denmark and Japan, the GHG-WG1 developed a concept for a mandatory design CO_2 index for new ships.

2 This document is submitted in accordance with MSC-MEPC.1/Circ.2 on Guidelines on the organization and method of work.

Objective

3 According to document MEPC 58/4, paragraphs 2.15 to 2.23, the objective of this document is to explain further the concept and methodology for establishing a baseline for a design CO_2 index, as well as presenting results. The purpose of the design CO_2 index is to provide a fair basis for comparison, to stimulate the development of more efficient engines and ships in general and to establish a minimum efficiency of ships depending on ship type and ship size. Hence, a robust methodology for developing a baseline needs to be established.

Definition of a baseline

4 A baseline is for this purpose defined as an average index value as a function of ship type and capacity. It serves as a measure for the average of index values for a large group of comparable existing ships, and it shows if an individual ship is above or below the average.

5 In order to create a reliable and realistic baseline, index values for a large sample of ships need to be calculated using the same methodology. The baseline index calculation uses simplifications, which do not reflect all aspects of the detailed, attained index, such as specific fuel consumption, sea load, and other correction factors.

6 The variation of the index values compared to the baseline should not be too high, as a comparison would become inappropriate. A consequence of this is that the capacity (size) measurement must be considered. The choice will be a compromise between a realistic cargo capacity measurement and the relevance it has towards power requirement.

Retrieving a representative part of the fleet

7 The first step is to define a dataset for the analysis. The Lloyds Register Fairplay (LRFP) database was used as source. The following criteria are set for retrieving the dataset:

.1 new buildings in the period 01 January 1995 to 31 December 2004[1];

.2 minimum of 30 ships in a selection, preferably more than 100 ships; and

.3 all the ships must have their main parameters given to be taken into account in the benchmarking (i.e. speed, capacity measurement and engine data).

8 The following ship types are considered for determination of individual baselines:

.1 dry bulk carriers;

.2 tankers;

.3 gas carriers;

.4 containerships;

.5 general cargo ships;

[1] The time period was chosen due to the availability of data from the Lloyds Fairplay Database.

.6 ro-ro cargo ships; and

.7 passenger ships, including ro-ro passenger ships, but excluding high-speed craft.

9 The LRFP database defines the following data fields used in the baseline determination:

.1 Speed: The service speed of the vessel at the maximum continuous rating of the engines (MCR), measured in knots at loaded draft;

.2 Deadweight: The maximum summer deadweight of the vessel in tonnes; and

.3 Power: The installed power of main and auxiliary engines[2] measured in kW.

10 The data provided by Lloyds Fairplay Database, with regard to speed and deadweight, may be inaccurate. For example, the speed may be either a design speed or a measured speed retrieved from the sea trials. The definition of the index values used in the baseline calculation is not exactly the same as those used in the attained index calculation, but by using consistent definitions the resulting average should not differ too much from the corresponding attained index values. Additionally, because of the large number of samples and the filtering process, these uncertainties do not influence the baseline regression significantly.

Calculating a baseline based on regression analysis

11 Based on the operation profiles and assumed average power utilization, an index can be calculated for the sample of ships. As the input is only assumed, this will only show an estimate of how other ships perform, but it is sufficient to establish an average benchmark level, and determine the variation and spread. Referring to the discussions at GHG WG1, the speed is measured in nautical miles per hour (knot), and the power of the main and auxiliary engines is set to 75% MCR. It was suggested to use a sea load factor on the auxiliary engine, for calculating a more precise baseline index. However, such an approach would be complicated to calculate in a baseline without specific knowledge about the sea load for each ship. Further, it does not change the slope of the baseline significantly, and a vertical shift could be compensated through adjusting the requirement level, as it will have to do for the other assumptions. Accordingly, the following assumptions are introduced:

.1 The carbon emission factor is constant for all engines, i.e. $C_{F,ME} = C_{F,AE} = CF =$ 3.114 g CO_2/g Fuel;[3]

.2 The specific fuel consumption for all ship types is constant for all main engines, i.e. SFC_{ME} = 190g/kWh;

.3 The specific fuel consumption for all ship types is constant for all auxiliary engines, i.e. SFC_{AE} = 210g/kWh;

.4 The load on main and auxiliary engines are set to 75% of MCR; and

---

2 Data on installed power for auxiliary engines are not available for all vessels. This effectively decreases the sample size.

3 The Carbon emission factors are under scrutiny following a submission by Intertanko (MEPC/GHG WG 1/3/1).

.5 All correction factors f_j, f_k and f_w are set to 1.

12 The equation for calculating the estimated index value is then as follows:

$$Average\ Index\ Value = 3.114 \cdot 0.75 \cdot \frac{190 \cdot \sum_{i=1}^{NME} P_{MEi} + 210 \cdot \sum_{i=1}^{NAE} P_{AEi}}{Capacity \cdot V_{ref}}$$

The unit of the index depends on the selected capacity. For example, if capacity is measured in tons, the unit of the index becomes g CO_2/(t nm).

13 The index values are the basis for calculating an exponential regression line on the following form:

$$Baseline\ value = a \cdot Capacity^{-c}$$

14 Outliers which are more than two standard deviations from the regression line are removed, and a new regression line is calculated. This ensures that special ships and erroneous data are excluded form the calculation.

Results and discussion

15 Deadweight and volume is an appropriate measure for most ship types. However, for ro-ro cargo ships and passenger ships, lane metres and number of passengers respectively were tested, but these capacity measures were found to be not consistent enough to give baseline with sufficient correlation. Gross tonnage seems to be more appropriate, even if it does not directly correspond to the capacity of the ship. For passenger and ro-ro cargo ships, samples with speed below 15 knots were excluded. These vessels had a different baseline curve because of their low speed. Further, ships with aluminium hulls were excluded as they perform significantly different from steel ships. A separate baseline was not calculated for these ship groups.

16 Because of the high-power requirements for auxiliary systems, many cruise and ropax vessels have installed a diesel-electric system in which both propulsive and auxiliary power comes from generator sets. As a consequence main and auxiliary engines can not be separated. Considering the very different nature of these ships, a separate baseline may be considered for vessels with diesel-electric power systems, treating all engines as auxiliary engines.

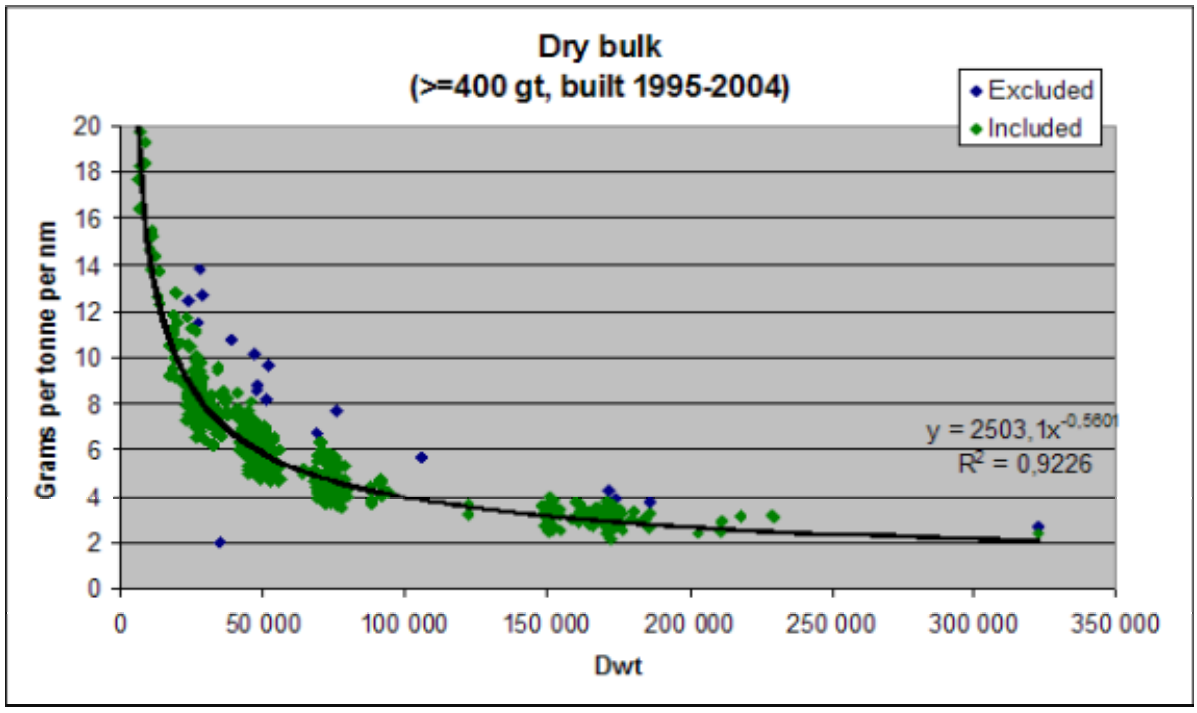
17 Calculating regression lines for ships built from 1995 to 1999 and for ships built from 2000 to 2004, showed no difference between the lines. Likewise, there were no significant differences when calculating lines for different size segments. Hence, one line for each ship type covering all sizes and including every year of build is considered adequate.

18 The following results using the methodology are obtained[4]:

Ship type	a	Capacity	c	Number of samples	Excluded	R^2
Dry Bulk	2503.2	DWT	0.5601	995	28	0.92
Tankers	2401.1	DWT	0.5400	1,209	58	0.97
Gas carriers	1649.7	Tank volume	0.4855	178	10	0.96
Container ships	105.77	DWT	0.1761	188	9	0.42
General cargo ships	280.85	DWT	0.3051	238	8	0.62
Ro-ro cargo ships	20792	GT	0.7223	205	33	0.87
Passenger ships	1517.0	GT	0.4092	192	73	0.79

The R^2 factor described the correlation of the baseline using capacity. An R^2 close to 1 or -1 means a high degree of correlation.

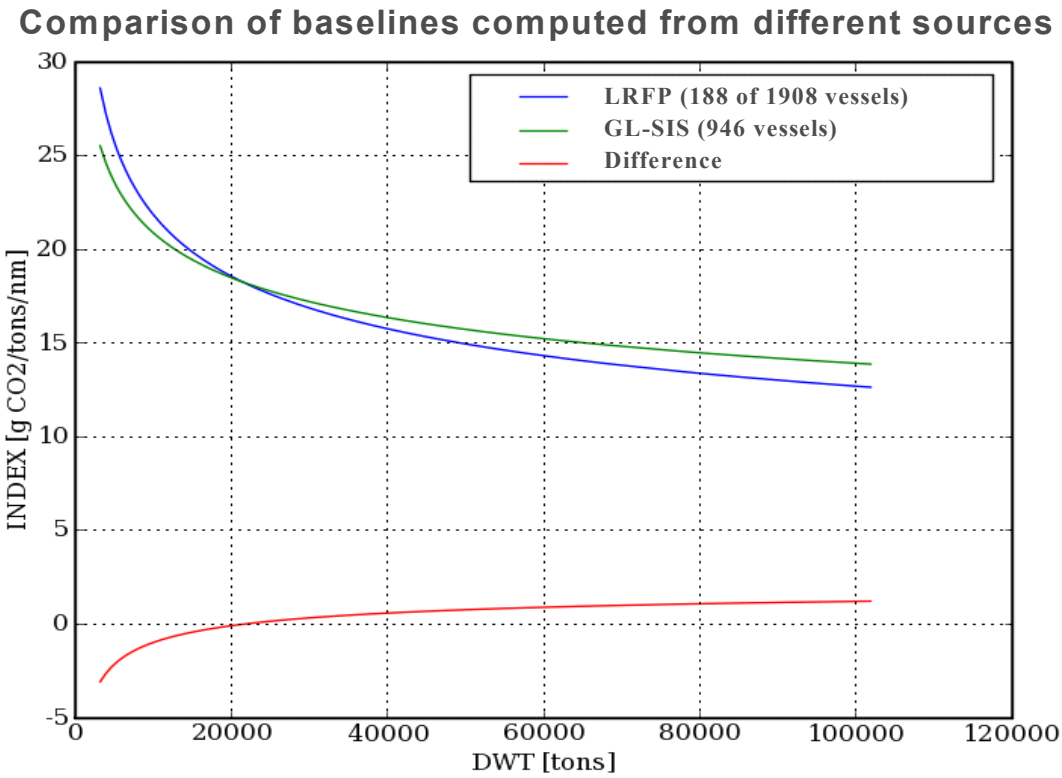
19 The figure below shows the calculated baseline for dry bulk.



20 However, the data available in Lloyds Fairplay Database for determination of the baseline for container vessels are limited. Information on auxiliary power is accessible only for 188 out of 1,908 vessels and the correlation is rather poor. Hence a parallel calculation has been carried out based on data from Germanisher Lloyd´s database (SIS) with 946 vessels to determine the baseline. Of these, 48 vessels were removed as outliers. The resultant baseline is characterized by a=191.85 and c=0.2358. The correlation factor (R^2) is 0.72. The difference in the baseline determined with data from Lloyds Fairplay Database is significant.

[4] The baselines for dry bulk ships, tankers, gas carriers, ro-ro ships, passenger and ropax were calculated by Det Norske Veritas, and for containerships and general cargo ships by Germanischer Lloyd.

21 The figure below shows the effect.



22 The Committee is invited to consider the proposal for the methodology for developing a baseline for a design CO_2 index for new ships.