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ENERGY EFFICIENCY OF SHIPS

Finalization of the revised 2013 Interim Guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions

Submitted by ICS and RINA

SUMMARY

Executive summary: In order to assist the Committee in finalizing the draft revised 2013 *Interim guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions, as amended*, the co-sponsors provide data and analysis of minimum powering levels at a range of weather conditions and advance speeds if applying the level 2 simplified assessment method. The data and analysis demonstrates that the simplified assessment method is very sensitive to the weather conditions and advance speed used for the assessment and that it cannot be assumed that the simplified assessment method will reduce the required level of power below that required by the level 1 minimum power lines. This document provides proposals to finalize this important work.

Strategic direction, if applicable: 3

Output: 3.5

Action to be taken: Paragraph 36

Related documents: MEPC 71/5/13, MEPC 71/17, MEPC 71/INF.28; MEPC 74/5, MEPC 74/5/5, MEPC 74/18; MEPC.1/Circ.850/Rev.2 and MEPC.232(65)

Introduction

1 The Committee was advised at MEPC 71 that draft revised 2013 *Interim guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions* (resolution MEPC.232(65), as amended by resolutions MEPC.255(67) and MEPC.262(68)) (draft minimum power guidelines) were not sufficiently mature to be finalized at that session (MEPC 71/5/13, paragraph 23). This was primarily because of outstanding

concerns over the weather and advance speed conditions which would underpin the level 2 simplified assessment method.

2 The Committee has not been updated on this matter since MEPC 71 (a period of two years), meaning that the 2013 interim minimum power guidelines will now extend into EEDI Phase 2. At MEPC 71, the Committee agreed to extend the validity of the 2013 Interim guidelines to EEDI phase 2 and requested the Secretariat to revise MEPC.1/Circ.850/Rev.1 accordingly, for dissemination as MEPC.1/Circ.850/Rev.2 (MEPC 71/17, paragraph 5.47.1).

3 At MEPC 74 the Committee invited Member Governments and international organizations to submit further information and concrete proposals for limiting shaft power and encouraged interested Member Governments and international organizations to expedite work to complete the draft minimum power guidelines (MEPC 74/18, paragraph 5.110).

4 The co-sponsors draw attention to outstanding concerns which need to be addressed before finalizing the draft minimum power guidelines and provide proposals for the consideration of the Committee.

Discussion

5 The consolidated version of the *2013 Interim guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions* (MEPC.1/Circ.850/Rev.2) (2013 interim minimum power guidelines) is the only regulatory requirement which addresses the safety critical matter of ensuring that ships are provided with sufficient power to manoeuvre safely in adverse conditions.

6 The first iteration of the *2013 interim minimum power guidelines*, provided in resolution MEPC.232(65), was adopted by the Committee in May 2013. The Guidelines were concerned with minimum power required for tankers and bulk carriers, and provided two assessment methods:

- .1 level 1 minimum power lines based on installed power of the existing fleet taking the form $(a \times \text{Deadweight}) + b$; and
- .2 level 2 simplified assessment method taking into account added power in waves together with assumptions regarding severe weather likely to be encountered.

7 The level 1 minimum power lines were updated in July 2015, this revision resulted in increases to the installed power required by the minimum power lines. The current guidelines are provided in circular MEPC.1/Circ.850/Rev.2.

8 The *2013 interim minimum power guidelines* address tankers and bulk carriers as these were the ship types considered to be most at risk from being provided with insufficient power as a result of designs being optimized for lower EEDI values.

9 The levels of minimum power required by level 1 minimum power lines of MEPC.1/Circ.850/Rev.2, are considered to be sufficient. It should be noted that the July 2015 revision of the minimum power lines resulted in ships having higher EEDI values. This has been presented by some as evidence of poor design or inadequate commitment to improving efficiency rather than as a consequence of an increase in minimum power requirements to assure safety of ships.

10 Efforts to finalize the draft minimum power guidelines have been concerned with revising the level 2 simplified assessment method. The level 2 simplified assessment method assumes that ships with sufficient power to advance in waves will also be able to keep course. The advance speed required in the *2013 interim minimum power guidelines* depends on the relative size of the rudder and varies between 4 and 9 knots. The assessment assumes weather conditions equating to Beaufort Force (BF) 7 for ships below 200 m and BF8 for ships above 250 m, with the condition being linearly interpolated for ships between 200 m and 250 m. The inclusion of rudder size as a parameter is derived from an empirical relationship between rudder size and advance speed when assessing manoeuvrability.

11 To facilitate reducing installed power below that which would be required by the 2013 interim minimum power guidelines, the SHOPERA study considered alternative weather and manoeuvrability assumptions to be used for the simplified assessment method (MEPC.71/INF.28). SHOPERA considered a number of scenarios and proposed that their scenario three was the most onerous - "Weathervaning in coastal areas under strong gale condition". This scenario became the basis for the SHOPERA study. SHOPERA assumed that ships would be safe in coastal areas under strong gale conditions (BF9) if they were able to weathervane with a speed through water of at least 2 knots, following consideration of situations where ships would not be able to escape from a coastal area under gale condition. The SHOPERA assessment therefore assumes at least a 2-knot advance speed and ability to keep heading from ahead to 30 degrees off-bow and weather from head seas to 30 degrees off-bow. Weather assumptions are approximately BF8 for ships below 200 m, BF9 for ships above 250 m, and linearly interpolated in between.

12 The differences between the 2013 interim minimum power guidelines and SHOPERA assumptions are summarised in figure 1.

Parameter	2013 interim minimum power guidelines		SHOPERA	
	<200	>250	<200	>250
Ship size (m)	<200	>250	<200	>250
Wind speed (m/s)	15.7	19	19	22.6
Significant wave height (m)	4	5.5	4.5	6
Peak wave period (s)	7.0 – 15.0		7.6 – 12.0	
Approximate Beaufort number (BF)	7	8	8	9
Ship advance speed (knots)	4.0 – 9.0		2.0	

Figure 1 - Summary of differences between level 2 simplified assessment assumptions used in 2013 interim minimum power guidelines and SHOPERA study

13 From figure 1 it is apparent that SHOPERA chose a more severe weather condition, but a significantly lower advance speed.

14 The level 2 simplified assessment method is sensitive to the underpinning weather and advance speed assumptions. The SHOPERA conditions were considered by some, particularly in industry, to be not representative of adverse conditions encountered by ships and that as a result, the resulting level of minimum power was too low.

15 To demonstrate trends in powering of bulk carriers, ICS commissioned a study from Herbert Engineering Corp. (HEC). Using the IHS dataset of tankers and bulk carriers to evaluate levels of installed power relative to the power required by the 2013 interim minimum

power lines, HEC considered both MEPC.232(65) and MEPC.1/Circ.850/Rev.2. The results are presented in figures 2, 3 and 4. A value above 1 indicates that installed power is greater than minimum power; a value below 1 indicates that installed power is less than minimum power. Figure 2 demonstrates that the average installed power levels of bulk carriers are already at the minimum level allowed by MEPC.1/Circ.850/Rev.2 and that there was a downward trend broadly aligned with the introduction of the EEDI regulation. Figure 2 also demonstrates the effect of the revised 2015 minimum power lines (see paragraphs 6 and 8). In the case of tankers, figures 3 and 4 show that some ships built to the older requirements actually have less power than is now required under the revised minimum power guidelines.

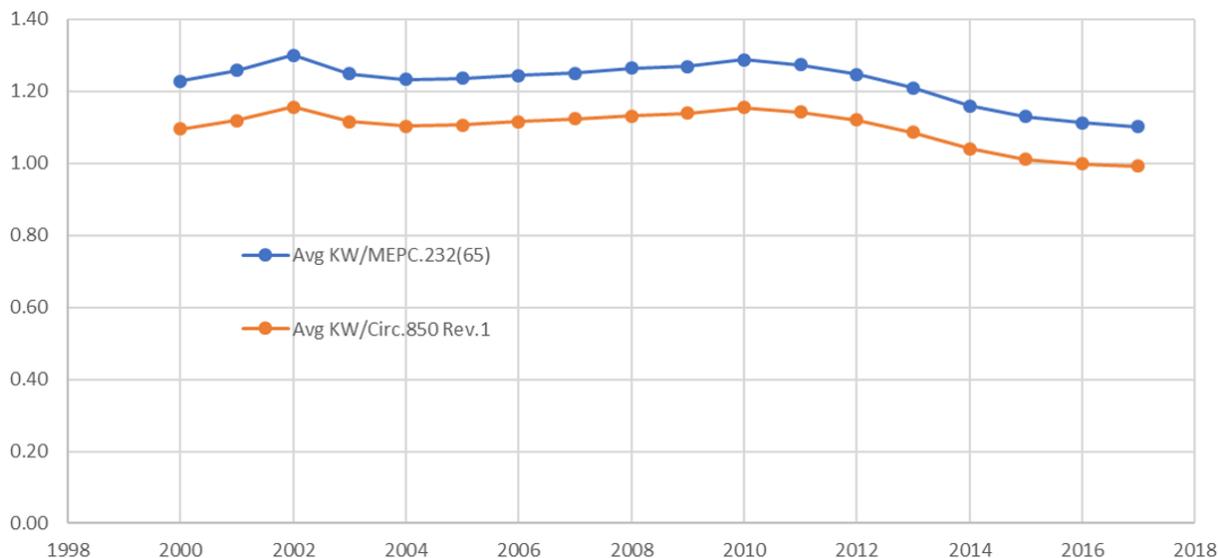


Figure 2 - Average ratio of installed power to minimum power based on level 1 minimum power lines method – bulk carriers

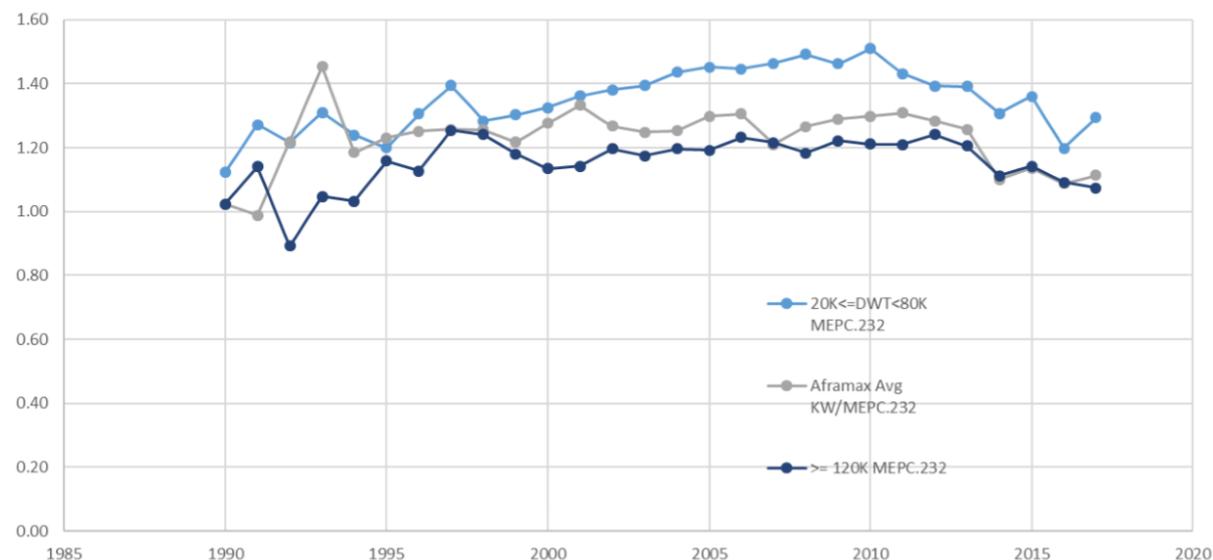


Figure 3 - Ratio of average installed power to minimum power for three size categories of tankers based on level 1 minimum power lines method of MEPC.232(65)

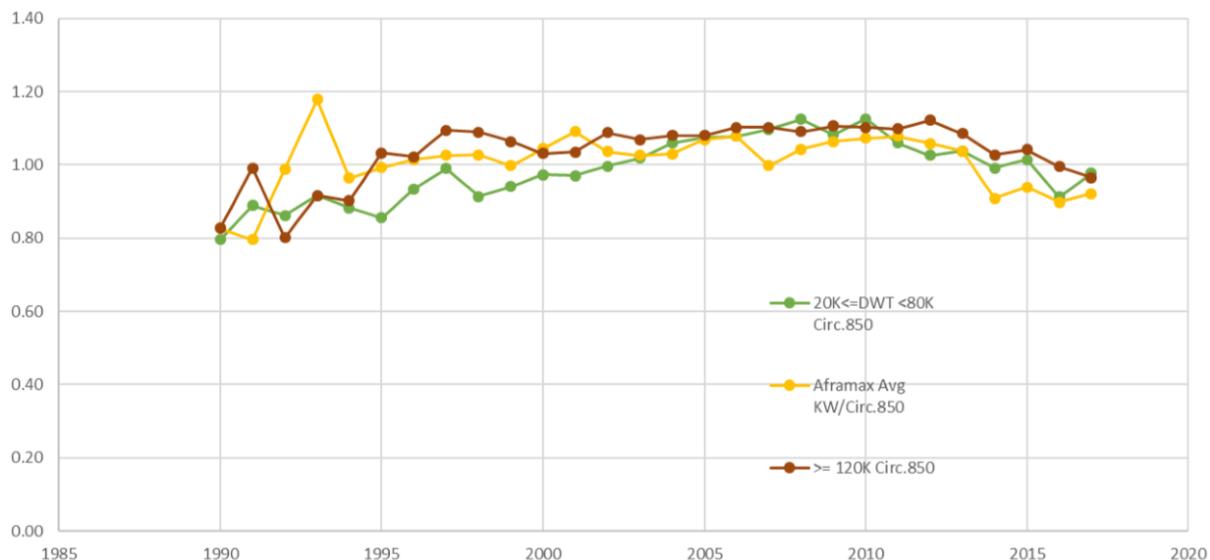


Figure 4 - Ratio of average installed power to minimum power for three size categories of tankers based on level 1 minimum power lines method of MEPC.1/Circ.850/Rev.2

16 The co-sponsors consider that it is possible that the level 2 simplified assessment method could be used to provide a lower level of installed power without unduly reducing ship safety provided that the assumptions used for the assessment are suitable and sufficient.

17 Should inappropriate assumptions be used, for example, a weather condition or advance speed which is too low, the result would be construction of underpowered ships which are unable to manoeuvre safely in adverse conditions.

18 To evaluate the sensitivity of the level 2 simplified assessment method to weather assumptions ICS commissioned HEC to evaluate a number of bulk carrier and tanker designs and assess whether they would have been provided with more or less shaft power if applying the level 2 simplified assessment method at a number of different environmental conditions. Since the objective was to evaluate the sensitivity of required shaft power to changing assumptions in the simplified assessment method, installed power of the existing ships was used as a datum point with the power required by the simplified assessment method indicated as a relative value.

19 The Beaufort Scale (BS) defines a range of wind speeds and wave heights. Scenario 3 of the SHOPERA study uses a wind speed which is within the range of BF9, but since the manoeuvring scenarios were concerned with coastal regions, the wave height was reduced from 7.0 m to 6.0 m for ships over 250 m long and from 5.5 m to 4.5 m for ships less than 200 m long. HEC were therefore asked to evaluate designs based on the scenarios shown in figure 5.

Scenario	Wind speed (m/s)	Wave height (m)	Advance speed (kts)	Equivalent Beaufort
Circ.850 Rev.2 L>250 m	19.0	5.5	4 & 9	8
Circ.850 Rev.2 L<200 m	15.7	4.0	4 & 9	7
SHOPERA >250 m	22.6	6.0	2	9
SHOPERA <200 m	19.0	4.5	2	8
Beaufort force 9, most onerous	24.4	7.0	2	9
Beaufort force 10, most onerous	28.4	9.0	2	10

Figure 5 - Simplified assessment scenarios modelled by HEC on behalf of ICS

20 ICS agreed a representative sample of ships from the HEC Cargomax database which was supplemented with two large bulk carriers (180,000 DWT and 400,000 DWT) for which data was supplied by ICS. Approximately 190 ships of 40 distinct designs were analysed. The bulk carrier designs considered were delivered between 2005 and 2017, and the tankers considered between 2001 and 2017. It should be noted that the bulk carriers analysed were considered to have average or above average installed power for their peer group, while the tankers analysed were considered to have average or below average installed power for their peer group. This reflects the designs in the HEC Cargomax database and introduces a slight bias to the results, however this was not expected to fundamentally alter the resulting conclusions.

21 Resistance was calculated using the simplified assessment method provided in document MEPC 71/INF.28. The added resistance in waves was calculated using the formula found in 14.1.1 of the annex to document MEPC 71/INF.28. Appendage resistance and wind resistance coefficients as per the SHOPERA methodology were added to the simplified assessment calculations. The powering requirements were calculated using HEC's Ship Powering Evaluation Program (SPEP). SPEP uses the Holtrop-Mennen equations to estimate the effective horsepower required to propel the vessel. HEC applied a series of factors to the Holtrop-Mennen equations to correct for modern practices and shortcomings in the original equations.

22 The results are provided in figures 6 and 7. The results are expressed as relative values. A value above 1 indicates that the simplified assessment method, at the environmental conditions modelled, would require an increase in power. A value below 1 indicates that power could be reduced below the installed power. As a sense check, and for information, results are also provided for the level 1 minimum power line method using both the original and revised 2015 minimum power lines.

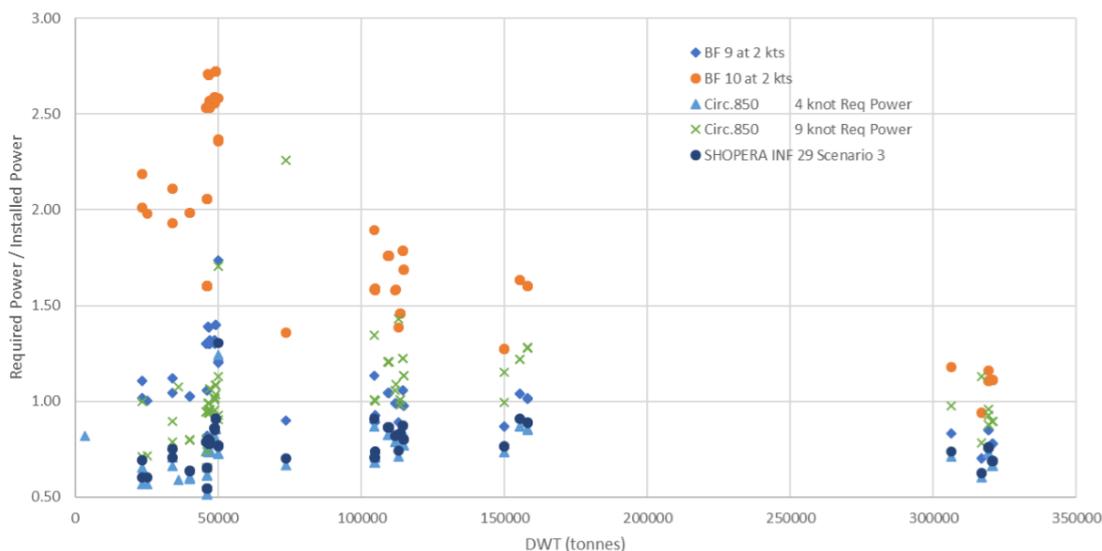


Figure 6 - Level 2 simplified assessment powering requirements, single screw tankers

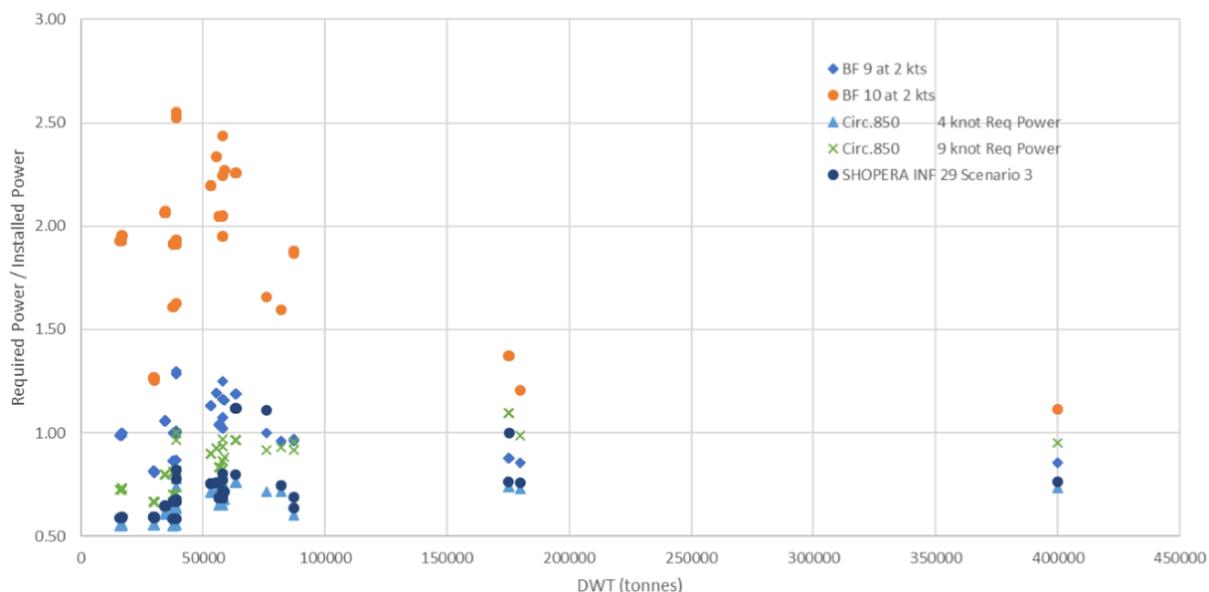


Figure 7 - Level 2 simplified assessment powering requirements, bulk carriers

- 23 Based on this analysis, a number of trends and behaviours are apparent:
- .1 the spread between minimum and maximum required power calculated for different weather conditions and advance speeds is much wider for smaller ships than for large ships;
 - .2 the difference between minimum and maximum power calculated for different weather and advance speed conditions can be huge. For smaller ships it can vary between almost a 50% reduction for the SHOPERA condition and an increase of two and a half times at BF10 and advance speed of 2 knots;
 - .3 although the spread is much narrower for large ships, even the largest ships display significant differences in the required power depending on weather condition and advance speed;

- .4 there are significant differences in required power calculated at the SHOPERA condition and if using the most severe conditions equating to BF9;
- .5 increasing the weather condition to BF10 results in a huge increase in required power for smaller ships;
- .6 results for the existing 2013 interim minimum power guidelines condition at an advance speed of 4 knots in general are quite closely correlated with results for the SHOPERA condition, however at an advance speed of 9 knots, the 2013 interim minimum power guidelines require significantly more power than the SHOPERA condition; and
- .7 contrary to assumptions that the level 2 simplified assessment method will allow lower levels of installed power, it could require a significant increase in power depending on the weather and advance speed conditions used for the assessment.

24 To illustrate the possible increases of power that the level 2 simplified assessment method might require over the level 1 minimum power lines, HEC were asked to calculate the level of installed power for the designs selected at BF9 with an advance speed of 2 knots, and to plot the results against the 2015 minimum power lines. Although the weather condition is more onerous than that used by either the 2013 interim minimum power guidelines or SHOPERA, BF9 is not considered to be an unusual or especially severe weather condition and the advance speed of 2 knots is significantly lower than for the 2013 interim minimum power guidelines. The results, shown in figure 8, show that smaller ships would require an increase in installed power beyond that required by the minimum power lines whilst for larger ships, installed power could be reduced. This is consistent with trends identified in paragraph 22.

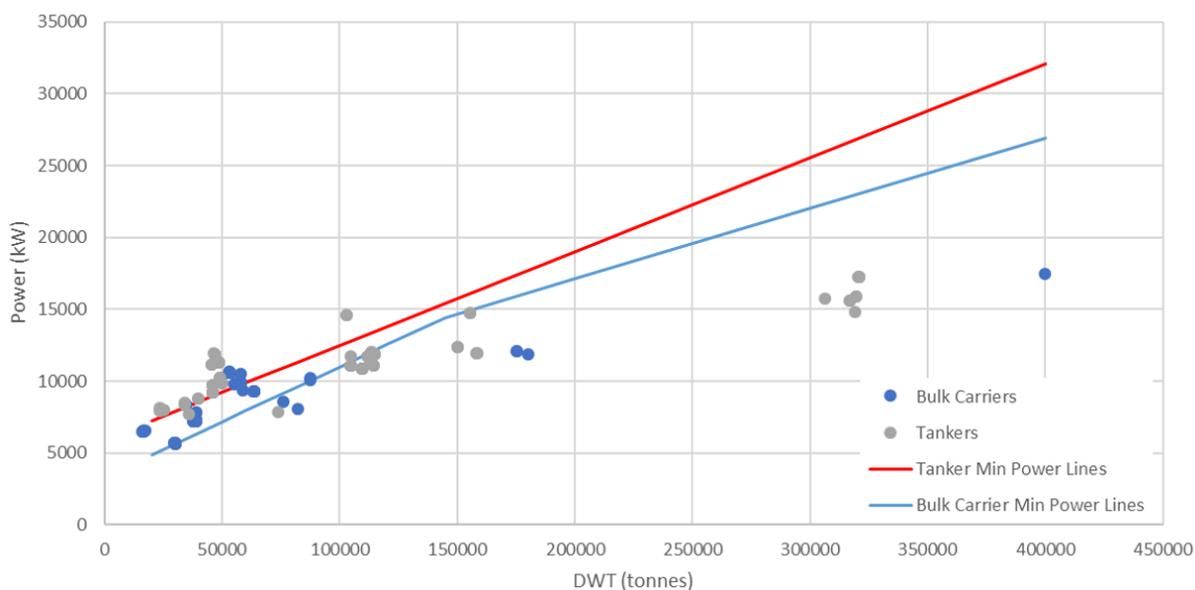


Figure 8 - Calculated minimum power at BF9 and advance speed of 2 knots, level 2 simplified assessment method, plotted against level 1 minimum power lines of MEPC.1/Circ.850/Rev.2

25 HEC then prepared an overview of required power for bulk carriers using the level 2 simplified assessment for a selection of their models at conditions between BF7 – BF12 and an advance speed of 2 knots. To aid visualisation, the results of this evaluation are expressed in kW in figure 9, with the actual installed power of the models chosen also being indicated. At BF11 and BF12, required minimum power increases massively, even for the largest ships. The magnitude of the variation in required power at different weather conditions is very apparent in figure 9.

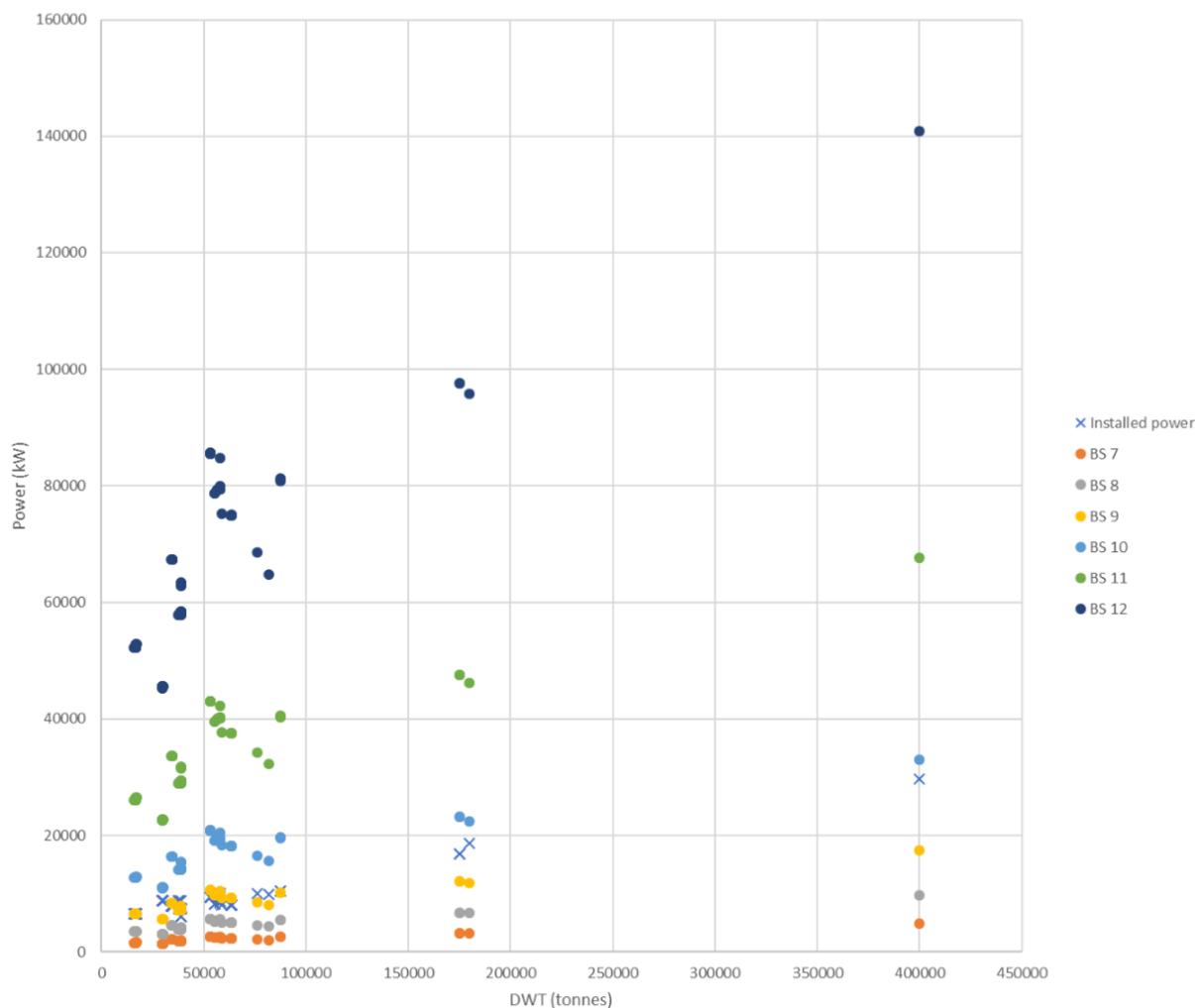


Figure 9 - Level 2 simplified assessment method, calculated minimum power required for a number of bulk carrier models at weather conditions between BF7 and BF12 and an advance speed of 2 knots. It should be remembered that this is a significantly lower advance speed than that used in the 2013 interim minimum power guidelines.

26 The evaluations completed by HEC demonstrate the sensitivity of the level 2 simplified assessment method to weather conditions and advance speed. Even moving the weather assumption for the assessment by one step on the Beaufort scale (for example from BF8 to BF9) results in a significant change in required power. This is also true for the advance speed. The weather condition and advance speed used for the level 2 simplified assessment method should be established based on consideration of what constitutes a reasonable adverse weather condition and advance speed necessary to retain sufficient ship control, not on the basis of identifying conditions which result in requiring a lower level of installed power than the minimum power lines.

27 This therefore necessitates the Committee reaching agreement on what is a reasonable adverse weather condition and advance speed. About 80 typhoons form each year globally, with most and strongest occurring in the Western North Pacific and South China Sea region, the wind speed of a typhoon equates to BF11 and above. If considering the Atlantic, there are analyses which conclude that the strongest hurricanes occurring in the North Atlantic have increased in intensity over the past two to three decades. For the continental United States in the Atlantic Basin, some models project a 45-87 percent increase in the frequency of Category 4 and 5 hurricanes. A category 4 hurricane equates to BF12+. The SHOPERA study considered that an advance speed of 2 knots would allow ship to weathervane and maintain course, however some mariners questioned by ICS and HEC considered that 4 knots would be a more appropriate value. As the evaluations undertaken by HEC demonstrate, increasing either the severity of weather condition or advance speed could result in a very significant increase in levels of required minimum power.

28 Both the 2013 interim minimum power guidelines and SHOPERA study introduce different requirements for ships up to a length of 200 m and of over 250 m. The weather conditions for the smaller size category equate to BF7 (2013 minimum power guidelines) and BF8 (SHOPERA). In the case of bulk carriers, length up to 200 m includes Handymax and Supramax size ships up to 60,000 DWT, which are large transoceanic ships, it is unclear why weather conditions as mild as BF7 (near gale) and BF8 (gale) would be considered sufficiently adverse in order to determine minimum powering requirements for such ships.

29 As a final comment, ICS would note that minimum power is not an adequate indicator of a ship's ability to maintain manoeuvrability in adverse conditions since it does not consider power delivery and conditions where torque, not power, is the limiting factor. The analysis performed by HEC included consideration of the torque limitation effect in developing the heavy running required power but only on a simple level, power application in adverse weather is a critical and requires more detailed analysis to fully evaluate. This is particularly pertinent since modern ships tend to utilise large and heavy propellers, along with very long stroke engines which have been tuned for low emissions and with reduced capability to respond to load change demands. This is exacerbated by the fact that in adverse weather conditions engines usually operate well below the design point where load responsiveness and provision of sufficient torque to maintain or increase shaft speed may be problematic even without the altered performance characteristics of modern machinery and propeller arrangements. Several issues needing further consideration were identified by IACS in document MEPC 74/5, the co-sponsors would urge the Committee to carefully consider the issues raised by IACS and recognize that further work is needed to identify and resolve the matter.

Proposals

30 The Committee should expedite finalization of the draft minimum power guidelines as a matter of urgency.

31 In order to complete the guidelines it is essential to agree appropriate weather and advance speed conditions for the level 2 simplified assessment method.

32 The weather conditions and advance speed conditions must be established on the basis of what would constitute a reasonable adverse weather condition within which ships should be able to maintain manoeuvrability, and a corresponding advance speed. The weather condition and advance speed must not be selected by identifying conditions which would allow a reduction in installed power below that required by the level 1 minimum power lines.

33 The Committee should evaluate weather conditions at sea and in near coastal areas. This evaluation should include the frequency and duration of weather conditions at BF9 and

greater, actual wave data to establish appropriate wave heights to be used and consideration of what would constitute an appropriate advance speed. This should include consideration of predicted future changes in weather patterns as a result of global climate change. It is considered that the weather condition and advance speed used by the SHOPERA study (MEPC 71/INF.28), are not appropriate and should not be adopted.

34 A compromise solution might be to retain the 2013 interim minimum power guidelines as the final, definitive guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions on the basis of experience with existing ships. One advantage of the simplified assessment method provided in these guidelines is that the relationship between advance speed and rudder size is considered to result in a sound assessment of manoeuvrability. However, it should be noted that this may provide a more conservative assessment of minimum power than might be achieved if applying the SHOPERA method, depending on the weather condition and advance speed agreed upon for the SHOPERA method.

35 In addition to finalizing the draft minimum power guidelines, the Committee should develop guidelines which address other limiting factors such as engine torque, and the technical matters identified in document MEPC 74/5.

Action requested of the Committee

36 The Committee is invited to consider the comments and proposals contained in this document and to take action as appropriate.
